R.A.L.E. Reference Collection
updated November 2007

1. Beck, R., N. Elias, S. Shoval, N. Tov, G. Talmon, S. Godfrey, and L. Bentur. 2007. Computerized acoustic assessment of treatment efficacy of nebulized epinephrine and albuterol in RSV bronchiolitis. *BMC.Pediatr.* 7:22.:22.
Abstract: AIM: We evaluated the use of computerized quantification of wheezing and crackles compared to a clinical score in assessing the effect of inhaled albuterol or inhaled epinephrine in infants with RSV bronchiolitis. METHODS: Computerized lung sounds analysis with quantification of wheezing and crackles and a clinical score were used during a double blind, randomized, controlled nebulized treatment pilot study. Infants were randomized to receive a single dose of 1 mgr nebulized l-epinephrine or 2.5 mgr nebulized albuterol. Computerized quantification of wheezing and crackles (PulmoTrack) and a clinical score were performed prior to, 10 minutes post and 30 minutes post treatment. Results were analyzed with Student's t-test for independent samples, Mann-Whitney U test and Wilcoxon test. RESULTS: 15 children received albuterol, 12 received epinephrine. The groups were identical at baseline. Satisfactory lung sounds recording and analysis was achieved in all subjects. There was no significant change in objective quantification of wheezes and crackles or in the total clinical scores either within the groups or between the groups. There was also no difference in oxygen saturation and respiratory distress. CONCLUSION: Computerized lung sound analysis is feasible in young infants with RSV bronchiolitis and provides a non-invasive, quantitative measure of wheezing and crackles in these infants

2. Beeton, R. J., I. Wells, P. Ebden, H. B. Whittet, and J. Clarke. 2007. Snore site discrimination using statistical moments of free field snoring sounds recorded during sleep nasendoscopy. *Physiol Meas.* 28:1225-1236.
Abstract: The non-invasive measurement of free field snoring sounds to estimate the site of snoring is an important development in the diagnosis, treatment and management of sleep-related breathing disorders. We investigated characteristics of the probability density function by testing the sensitivity of the statistical moments to amplitude patterns in the snoring acoustic signal. Snoring sounds from 15 patients were recorded whilst performing sleep (under anaesthetic) nasendoscopy evaluation. We demonstrated, using a fuzzy 2-means clustering method, that a combination of the statistical dimensionless moment coefficients of skewness and kurtosis could discriminate between pure palatal and non-palatal snoring subject groups

3. Branco, A., S. M. Fekete, L. M. Rugolo, and M. I. Rehder. 2007. The newborn pain cry: descriptive acoustic spectrographic analysis. *Int.J Pediatr.Otorhinolaryngol.* 71:539-546.
Abstract: INTRODUCTION: Study the characteristics of pain vocal emission of newborns during venepuncture through acoustic analysis and relate it to NIPS pain scale and some variables of the newborns. METHODS: Emissions of 111 healthy term newborns were recorded, whose lifetime varied from 24 to 72 h. The acoustic analysis was realized with GRAM 5.7 software verifying the occurrence of tense strangled voice quality, sounds, concentration of acoustic energy, breaks, double harmonic breaks and frequency instability, type of phonation, vocal attack and cough. The NIPS scale was realized during venepuncture and descriptive statistical analysis and correlation through Spearman test. RESULTS: Hundred percent of the emissions had guttural sounds, vowels, hard vocal attack, frequency, breaks, double harmonic breaks and tense strangled voice quality; 34.2% higher fundamental frequency; 62.2% periods of emission absence and 100% occurrence of tracing instability, concentration of acoustic energy, inspiratory and expiratory phonation. The cough occurred in 14.4%. The signs of vocal tract constriction associated with all the parameters. There was a negative correlation between the higher fundamental frequencies and the weight of newborns and positive correlation between cough and NIPS score. CONCLUSIONS: The newborn pain emission is tense and strident, the modifications of frequency and spectrographic tracing and the presence of sounds show laryngeal and vocal tract participation. The smaller the newborn weight, the bigger the presence of higher fundamental frequency with tense strangled voice quality and the bigger the NIPS score, the more frequent the cough. Such characteristics make pain crying peculiar, helping in the evaluation of pain during a procedure

4. Brietzke, S. E. and E. A. Mair. 2007. Acoustical analysis of pediatric snoring: what can we learn? *Otolaryngol.Head Neck Surg.* 136:644-648.
Abstract: OBJECTIVE: Evaluate a database of pediatric patients who underwent snoring acoustical analysis for associations between snoring measurements, demographics, and obstructive sleep apnea/hypopnea syndrome (OSAHS) severity. STUDY DESIGN AND SETTING: A database of pediatric patients who underwent home testing with a polysomnogram device (SNAP Test, Glenview, IL) that includes acoustical snoring analysis was reviewed. RESULTS: Four hundred fifty-six patients were included (mean age, 6.87 years). Four hundred twenty-nine (94.1%) patients had measurable snoring. Snoring index (events/hr) ($r = 0.2073$; $P < 0.0001$) and maximal loudness (dB) ($r = 0.2218$; $P < 0.0001$) were directly proportional to the apnea/hypopnea index. Among patients without OSAHS (apnea index <1), increasing snoring index ($r = -0.2102$; $P < 0.0001$) and volume ($P < 0.005$ ANOVA) were associated with increasing oximetry desaturation events. CONCLUSION: The majority of children evaluated had objective snoring. Increasing snoring index and loudness are associated with increased severity of OSAHS. In the absence of OSAHS, increasing snoring is associated with oxygen desaturations. SIGNIFICANCE: Pediatric snoring is objectively related to OSAHS severity

5. Caffier, P. P., J. C. Berl, A. Muggli, A. Reinhardt, A. Jakob, M. Moser, I. Fietze, H. Scherer, and M. Holzl. 2007. Snoring noise pollution--the need for objective quantification of annoyance, regulatory guidelines and mandatory therapy for snoring. *Physiol Meas.* 28:25-40.
Abstract: Habitual snoring without episodes of apnea or hypoventilation and without respiratory related arousals is considered to be annoying and without any need for treatment. However, studies seem to suggest an enormous psychosocial impact of annoyance for the bed partner. Apart from subjective questionnaires there still exists no generally accepted mode of measurement that can describe snoring objectively. We therefore adapted methods developed for environmental medicine and established a new snore score using psycho-acoustic parameters. For quantification of snoring noise we conducted nocturnal measurements in 19 habitual snorers. Free-field snore sounds were acquired with two low-cost non-contact microphones and transferred to a PC (sampling frequency 11 kHz). The data were recorded, analysed and stored automatically using a MATLAB script. Following the analysis of sound characteristics and levels, the score was computed from relevant parameters containing the rating level (L(R)), maximum level, two percentile levels for frequent maxima (L(5)S; L(1)) and snoring time. The determined values substantially exceeded the prescribed limits defined by WHO noise guidelines, and mainly affected the equivalent continuous sound exposure level, rating level and the immission standard values of brief noise peaks, whose maximum was exceeded by up to 32 dB(A). The Berlin snore score illustrated the objective acoustic annoyance on a scale from 0 to 100. It allows inter-individual comparison and objectifies the need for therapy. The clinical applicability of evaluating the reduction of snoring after surgical therapy is discussed exemplarily. The presented measuring method was found to be suitable for quantifying snoring noise and can be easily integrated into existing polysomnographic applications. In the case of habitual snoring with objective evidence of psychosocially disturbing acoustic annoyance, health fund providers should assume the costs of mandatory medical therapy

6. Charleston-Villalobos, S., R. Gonzalez-Camarena, G. Chi-Lem, and T. jama-Corrales. 2007. Crackle sounds analysis by empirical mode decomposition. Nonlinear and nonstationary signal analysis for distinction of crackles in lung sounds. *IEEE Eng Med Biol Mag.* 26:40-47.

7. Dellinger, R. P., S. Jean, I. Cinel, C. Tay, S. Rajanala, Y. A. Glickman, and J. E. Parrillo. 2007. Regional distribution of acoustic-based lung vibration as a function of mechanical ventilation mode. *Crit Care.* 11:R26.
Abstract: INTRODUCTION: There are several ventilator modes that are used for maintenance mechanical ventilation but no conclusive evidence that one mode of ventilation is better than another. Vibration response imaging is a novel bedside imaging technique that displays vibration energy of lung sounds generated during the respiratory cycle as a real-time structural and functional image of the respiration process. In this study, we objectively evaluated the differences in regional lung vibration during different modes of mechanical ventilation by means of this new technology. METHODS: Vibration response imaging was performed on 38 patients on assist volume control, assist pressure control, and pressure support modes of mechanical ventilation with constant tidal volumes. Images and vibration intensities of three lung regions at maximal inspiration were analyzed. RESULTS: There was a significant increase in overall geographical area ($p < 0.001$) and vibration intensity ($p < 0.02$) in pressure control and pressure support (greatest in pressure support), compared to volume control, when each patient served as his or her own control while targeting the same tidal volume in each mode. This increase in geographical area and vibration intensity occurred primarily in the lower lung regions. The relative percentage increases were 28.5% from volume control to pressure support and 18.8% from volume control to pressure control ($p < 0.05$). Concomitantly, the areas of the image in the middle lung regions decreased by 3.6% from volume control to pressure support and by 3.7% from volume control to pressure control ($p < 0.05$). In addition, analysis of regional vibration intensity showed a 35.5% relative percentage increase in the lower region with pressure support versus volume control ($p < 0.05$). CONCLUSION: Pressure support and (to a lesser extent) pressure control modes cause a shift of vibration toward lower lung regions compared to volume control when tidal volumes are held constant. Better patient synchronization with the ventilator, greater downward movement of the diaphragm, and decelerating flow waveform are potential physiologic explanations for the redistribution of vibration energy to lower lung regions in pressure-targeted modes of mechanical ventilation

8. Dellinger, R. P., J. E. Parrillo, A. Kushnir, M. Rossi, and I. Kushnir. 2007. Dynamic visualization of lung sounds with a vibration response device: A case series. *Respiration* June.
Abstract: Background: The field of computer-assisted mapping of lung sounds is constantly evolving and several devices have been developed in this field. Objectives: Our objective was to evaluate a new computer-assisted lung sound imaging system, 'vibration response imaging' (VRI), that records and creates a dynamic image of breath sounds. We postulated that the VRI display format would qualitatively and quantitatively reveal breath sound distribution throughout the breathing cycle. Methods: Lung sounds were recorded from 5 healthy adults and 14 patients with various respiratory illnesses using VRI. The lung sounds were processed by the VRI software, which incorporates an algorithm to convert breath sounds in the frequency range of 150-250 Hz to a dynamic image and quantitative assessment of breath sound distribution. Results: Images and quantifications from recordings of the healthy adults showed distinct patterns for inspiration and expiration. Images and quantifications from the subjects with respiratory illness differed substantially from the images of the healthy subjects. Both healthy and pathological subjects presented some expected characteristics of breath sound distribution. Conclusions: The VRI device may provide a new perspective in acoustic imaging and

quantification of breath sounds by adding aspects of time analysis and quantification of distribution to existing methods. Further studies will be required in order to establish reliability of repeated recordings and to validate the sensitivity of the system in detecting various lung pathologies. Copyright (c) 2007 S. Karger AG, Basel

9. Flores-Tapia, D., Z. M. Moussavi, and G. Thomas. 2007. Heart sound cancellation based on multiscale products and linear prediction. *IEEE Trans Biomed Eng* 54:234-243.
Abstract: This paper presents a novel method for Heart Sound (HS) cancellation from Lung Sound (LS) records. The method uses the multiscale product of the wavelet coefficients of the original signal to detect HS-included segments. Once the HS segments are identified, the method removes them from the wavelet coefficients at every level and estimates the created gaps by using a set of linear prediction filters. It is shown that if the segment to be predicted is stationary, a final record with no audible artifacts such as clicks can be reconstructed using this approach. The results were promising for HS removal from LS records and showed no hampering of the main components of the LS. The results were confirmed both qualitatively by listening to the reconstructed signal and quantitatively by spectral analysis

10. Fragasso, G., A. Cuko, R. Spoladore, C. Montano, A. Palloshi, C. Silipigni, G. Monti, A. Castelli, F. Padiglione, A. Leonida, and A. Margonato. 2007. Validation of remote cardiopulmonary examination in patients with heart failure with a videophone-based system. *J Card Fail.* 13:281-286.
Abstract: BACKGROUND: The aim of this study was to evaluate feasibility and accuracy of a videophone-based system for remote cardiopulmonary examination of patients with heart failure. METHODS AND RESULTS: Fifty patients were examined by 2 cardiologists, 1 with a conventional stethoscope and 1 remotely with a videophone-based method, employing an electronic stethoscope and transmitting through an integrated services digital network line. During both sessions, the cardiologists filled out a 27-item questionnaire, which was then compared; concordance between standard and remote examination was evaluated. In 92% of patients, electronic and acoustic auscultation concurred. Only in 3 patients (4%) did teleauscultation not permit a correct interpretation of lung examination. In one patient, bilateral fine crepitant rales were not detected during teleauscultation. Conversely, in the second, patient bilateral fine crepitant rales were recognized during teleauscultation, which were not confirmed during real-life auscultation. In the third nonconcordant patient, moderate-degree wheezing was not detected during teleauscultation. Fine crepitant rales were present at the lungs lower fields in 12 and wheezing in 3 additional patients, and were always correctly identified during teleauscultation. Overall, sensitivity, specificity, positive, and negative predictive value of remote lung auscultation were 88%, 97%, 94%, and 94%, respectively. CONCLUSIONS: Remote cardiopulmonary examination appears as a feasible method for assessing patients with heart failure. Telestethoscopy can therefore be reliably used in the context of comprehensive telecare programs

11. Galer, C., A. Yonkers, W. Duff, and B. Heywood. 2007. Clinical significance of SNAP somnography test acoustic recording. *Otolaryngol.Head Neck Surg.* 136:241-245.
Abstract: OBJECTIVE: To examine the clinical significance of acoustic data recorded by the SNAP home polysomnography system (SNAP Laboratories, Glenview, IL). STUDY DESIGN AND SETTING: Retrospective analysis of SNAP data from 59 patients undergoing evaluation for sleep apnea at the University of Nebraska Medical Center and an associated private practice in Omaha, NE. RESULTS: Snoring did not correlate with anthropometric variables such as body mass index and neck circumference. Statistical analysis showed no correlation between respiratory disturbance index and the maximum or average loudness of snoring. Average loudness was predictive of the presence of sleep apnea. Spectral analysis of snoring sonography found that the proportion of snoring events associated with a palatal source correlated strongly with the loudness of snoring. CONCLUSION: These data suggest that analysis of snoring has limited utility in the evaluation of the patient with sleep apnea but may be able to select patients who would benefit from palatal procedures to reduce snoring

12. Gnitecki, J. and Z. M. Moussavi. 2007. Separating heart sounds from lung sounds. Accurate diagnosis of respiratory disease depends on understanding noises. *IEEE Eng Med Biol Mag.* 26:20-29.

13. Gross, V., C. Reinke, F. Dette, R. Koch, D. Vasilescu, T. Penzel, and U. Koehler. 2007. Mobile nocturnal long-term monitoring of wheezing and cough. *Biomed Tech.(Berl).* 52:73-76.
Abstract: Changes in normal lung sounds are an important sign of pathophysiological processes in the bronchial system and lung tissue. For the diagnosis of bronchial asthma, coughing and wheezing are important symptoms that indicate the existence of obstruction. In particular, nocturnal long-term acoustic monitoring and assessment make sense for qualitative and quantitative detection and documentation. Previous methods used for lung function diagnosis require active patient cooperation that is not possible during sleep. We developed a mobile device based on the CORSA standard that allows the recording of respiratory sounds throughout the night. To date, we have recorded 133 patients with different diagnoses (80 male, 53 female), of whom 38 were children. In 68 of the patients we could detect cough events and in 87 we detected wheezing. The recording method was

tolerated by all participating adults and children. Our mobile system allows non-invasive and cooperation-independent nocturnal monitoring of acoustic symptoms in the domestic environment, especially at night, when most ailments occur

14. Hadjileontiadis, L. J. 2007. Empirical mode decomposition and fractal dimension filter. A novel technique for denoising explosive lung sounds. *IEEE Eng Med Biol Mag.* 26:30-39.

15. Kalantri, S., R. Joshi, T. Lokhande, A. Singh, M. Morgan, J. M. Colford, Jr., and M. Pai. 2007. Accuracy and reliability of physical signs in the diagnosis of pleural effusion. *Respir Med* 101:431-438.
Abstract: Although pleural effusion is a common disorder among patients presenting with respiratory symptoms, there is limited evidence on the accuracy and reliability of symptoms and signs for the diagnosis of pleural effusion. In our study, conducted at a rural hospital in India, two physicians, blind to history and chest radiograph findings, and to each other's results, independently evaluated 278 patients (196 men), aged 12 and older, admitted with respiratory symptoms. We did a blind and independent comparison of physical signs (asymmetric chest expansion, vocal fremitus, percussion note, breath sounds, crackles, vocal resonance and auscultatory percussion) with the reference standard (chest radiograph). We measured diagnostic accuracy by computing sensitivity, specificity, and likelihood ratios (LRs), and inter-observer reliability by using kappa (kappa) statistic. We performed multivariate analysis to identify the clinical signs that independently predict pleural effusion. The prevalence of pleural effusion was 21% (57/278). The LRs of positive signs ranged from 1.48 to 8.14 and their 95% confidence intervals (CIs) excluded 1. Except for pleural rub, the LRs for negative signs ranged between 0.13 and 0.71. The interobserver agreement was excellent for chest expansion, vocal fremitus, percussion and breath sounds (kappa 0.84-0.89) and good for vocal resonance, crackles and auscultatory percussion (kappa 0.68-0.78). The independent predictors of pleural effusion were asymmetric chest expansion (odds ratio [OR] 5.22, 95% CI 2.06-13.23), and dull percussion note (OR 12.80, 95% CI 4.23-38.70). For the final multivariate model, the area under receiver operating characteristic curve (ROC curve) was 0.88. In conclusion, our data suggest that physical signs may be helpful to rule out but not rule in pleural effusion

16. Kraman, S. S. 2007. Transmission of Lung Sounds through Light Clothing. *Respiration*.
Abstract: Background: Doctors are exhorted to always place the stethoscope directly on the skin and never to auscultate through clothing. Nevertheless, casual observation reveals that doctors and even pulmonologists often violate this principle. Objectives: This study was designed to evaluate the sensitivity of two common stethoscopes when used through clothing. Methods: Littmann Classic and Littmann Master Cardiology stethoscopes were studied under conditions of light (60-100 g), medium (240 g) and heavy (555 g) force when placed on a lung sound test platform with one or two layers of cloth (T-shirt material and flannel) interposed between the stethoscope and the test surface. The test platform was designed to mimic the acoustic and mechanical properties of the chest wall and was driven by amplified white noise. The recorded amplitude spectra were compared over a range of 150-1,000 Hz. Results: Compared to the sensitivity on a bare test platform surface, either fabric in single or double layers attenuated the sounds by a mean of 5-18 dB under light pressure. This attenuation was nearly abolished by the addition of either medium or heavy force on the stethoscope head. Conclusions: The deleterious effect of one or two layers of indoor clothing on lung sounds acquired through a stethoscope can be negated by force on the stethoscope head making effective auscultation possible. Nevertheless, auscultation through clothing remains problematic due to the hindrance to inspection and percussion and the risk of acoustic artifacts caused by clothing. Copyright (c) 2007 S. Karger AG, Basel

17. Liu, Z. S., X. Y. Luo, H. P. Lee, and C. Lu. 2007. Snoring source identification and snoring noise prediction. *J Biomech.* 40:861-870.
Abstract: This paper investigates the snoring mechanism of humans by applying the concept of structural intensity to a three-dimensional (3D) finite element model of a human head, which includes: the upper part of the head, neck, soft palate, hard palate, tongue, nasal cavity and the surrounding walls of the pharynx. Results show that for 20, 40 and 60Hz pressure loads, tissue vibration is mainly in the areas of the soft palate, the tongue and the nasal cavity. For predicting the snoring noise level, a 3D boundary element cavity model of the upper airway in the nasal cavity is generated. The snoring noise level is predicted for a prescribed airflow loading, and its range agrees with published measurements. These models may be further developed to study the various snoring mechanisms for different groups of patients

18. Mastorocostas, P. A. and J. B. Theocharis. 2007. A dynamic fuzzy neural filter for separation of discontinuous adventitious sounds from vesicular sounds. *Comput.Biol.Med.* 37:60-69.
Abstract: This paper presents a recurrent filter that performs real-time separation of discontinuous adventitious sounds from vesicular sounds. The filter uses two Dynamic Fuzzy Neural Networks, operating in parallel, to perform the task of separation of the lung sounds, obtained from patients with pulmonary pathology. Extensive experimental results, including fine/coarse crackles and squawks, are given, and a performance comparison with a series of other models is conducted, underlining the separation capabilities of the proposed filter and its improved performance with respect to its competing rivals

19. Murphy, R. 2007. Computerized multichannel lung sound analysis. Development of acoustic instruments for diagnosis and management of medical conditions. *IEEE Eng Med Biol Mag.* 26:16-19.

20. Ng, A. K., T. S. Koh, E. Baey, and K. Puvanendran. 2007. Could formant frequencies of snore signals be an alternative means for the diagnosis of obstructive sleep apnea? *Sleep Med.* ..
Abstract: OBJECTIVE: To study the feasibility of using acoustic signatures in snore signals for the diagnosis of obstructive sleep apnea (OSA). METHODS: Snoring sounds of 30 apneic snorers (24 males; 6 females; apnea-hypopnea index, AHI=46.9+/-25.7events/h) and 10 benign snorers (6 males; 4 females; AHI=4.6+/-3.4events/h) were captured in a sleep laboratory. The recorded snore signals were preprocessed to remove noise, and subsequently, modeled using a linear predictive coding (LPC) technique. Formant frequencies (F1, F2, and F3) were extracted from the LPC spectrum for analysis. The accuracy of this approach was assessed using receiver operating characteristic curves and notched box plots. The relationship between AHI and F1 was further explored via regression analysis. RESULTS: Quantitative differences in formant frequencies between apneic and benign snores are found in same- or both-gender snorers. Apneic snores exhibit higher formant frequencies than benign snores, especially F1, which can be related to the pathology of OSA. This study yields a sensitivity of 88%, a specificity of 82%, and a threshold value of F1=470Hz that best differentiate apneic snorers from benign snorers (both gender combined). CONCLUSION: Acoustic signatures in snore signals carry information for OSA diagnosis, and snore-based analysis might potentially be a non-invasive and inexpensive diagnostic approach for mass screening of OSA

21. Ozer, M. B., S. Acikgoz, T. J. Royston, H. A. Mansy, and R. H. Sandler. 2007. Boundary element model for simulating sound propagation and source localization within the lungs. *J Acoust.Soc Am.* 122:657-661.
Abstract: An acoustic boundary element (BE) model is used to simulate sound propagation in the lung parenchyma. It is computationally validated and then compared with experimental studies on lung phantom models. Parametric studies quantify the effect of different model parameters on the resulting acoustic field within the lung phantoms. The BE model is then coupled with a source localization algorithm to predict the position of an acoustic source within the phantom. Experimental studies validate the BE-based source localization algorithm and show that the same algorithm does not perform as well if the BE simulation is replaced with a free field assumption that neglects reflections and standing wave patterns created within the finite-size lung phantom. The BE model and source localization procedure are then applied to actual lung geometry taken from the National Library of Medicine's Visible Human Project. These numerical studies are in agreement with the studies on simpler geometry in that use of a BE model in place of the free field assumption alters the predicted acoustic field and source localization results. This work is relevant to the development of advanced auscultatory techniques that utilize multiple noninvasive sensors to construct acoustic images of sound generation and transmission to identify pathologies

22. Pochekutova, I. A. and V. I. Korenbaum. 2007. [Duration of tracheal sound recordered during forced expiration: from a model to establishing standards]. *Fiziol.Cheloveka* 33:70-79.

23. Reinke, C., F. Dette, V. Gross, R. Koch, and U. Koehler. 2007. [Unclear coughing and the feeling of suffocation during sleep : Long-term nocturnal acoustic recording.]. *Internist (Berl)*.
Abstract: A 58-year old male presented with a 6-week history of increasing nocturnal cough, dyspnea and awakening. Physical examination, chest auscultation and lung function in the daytime did not show any pathological findings. Only nocturnal long-term recording of respiratory sounds was helpful: In- and expiratory wheezing, as the acoustic manifestation of airway obstruction, was found throughout the night. As the cause for nocturnal cough and distinct airway obstruction, a pansinusitis with postnasal drip syndrome was diagnosed

24. Robb, M. P., D. H. Crowell, and P. Dunn-Rankin. 2007. Cry analysis in infants resuscitated for apnea of infancy. *Int.J Pediatr.Otorhinolaryngol.* 71:1117-1123.
Abstract: OBJECTIVE: The purpose of the present study was to examine the acoustic features of crying demonstrated by infants who experienced apnea of infancy (AOI) and compare these features to a non-AOI group of infants. Based on past physiological descriptions of AOI, three predictions in regard to the influence of AOI on acoustic cry features were proposed: (1) the rate of crying would be significantly faster among infants with AOI, (2) the latency of crying onset would be significantly longer among infants with AOI and (3) the F(0) characterizing an overall episode of crying would be significantly lower among infants with AOI. PATIENTS AND METHODS: Pain-induced crying episodes were collected from a group of healthy term infants (HT) and those with AOI. One complete crying episode was obtained from each infant and analyzed acoustically with regard to durational and spectral features of the cry. RESULTS: Infants comprising the AOI group were found to demonstrate a significantly longer cry latency and lower F(0) compared to HT infants. CONCLUSIONS: The acoustic cry features measured for the AOI infants are discussed with regard to past reports of poor arousal and decreased muscle tone. A model of AOI crying is proposed whereby the autonomic nervous system and associated pathways are slower to interpret pain stimulus compared to HT infants

25. Smith, J. 2007. Ambulatory methods for recording cough. *Pulm.Pharmacol Ther.* 20:313-318.
Abstract: Recording cough sounds to objectively quantify coughing was first performed using large reel-to-reel tape recorders more than 40 years ago. Coughs were counted manually, which is an extremely laborious and time-consuming process. Current technologies including digital recording techniques, data compression and improvements in digital storage capacity should make the process of recording and counting coughs suitable for automation; however, to date no accurate, objective cough monitoring device is available. Cough sounds are easily distinguishable from other vocalizations by the human ear and hence it is reasonable to assume that coughs sounds should have characteristic, identifying acoustic properties. However, the acoustic features of spontaneously occurring cough sounds are extremely variable. Furthermore, in even the worst cases of cough, the time spent speaking is an order of magnitude greater than the time spent coughing. It follows that even an algorithm that mistakes only a very small proportion of speech as cough will still have an unacceptable false positive rate. There is a clear need for an objective measure of cough for use in clinical practice, clinical research and trials of novel treatments. In the near future automated ambulatory systems with sufficient accuracy to be of clinical use should be available

26. Sun, B., F. D. McKenzie, H. M. Garcia, T. W. Hubbard, J. A. Ullian, and G. A. Gliva. 2007. Medical student evaluation using augmented standardized patients: new development and results. *Stud.Health Technol.Inform.* 125:454-456.
Abstract: Standardized patients (SPs), individuals who realistically portray patients, are widely used in medical education to teach and assess communication skills, eliciting a history, performing a physical exam, and other important clinical skills. They are typically healthy individuals with few or no abnormal physical findings. One limitation is that each SP can only portray a limited set of physical symptoms. We have developed a functioning prototype that uses sound-based augmented reality (AR) to expand the capabilities of an SP to exhibit physically-manifested abnormalities. The previous research and evaluation of this prototype have been published in medicine meets virtual reality conference in January 2006. Current research has combined a virtual crackle sound with a healthy SP's real breath sound at end of inspiration in real time. The technology used is intended to correlate the inspiration timing of SP's. A learner will hear this simulated sound through an electronic-stethoscope wirelessly

27. Tanaka, H., H. Nishio, R. Sasanabe, and T. Shiomi. 2007. [A case of multiple systemic atrophy (MSA) analyzed by acoustic sound for nocturnal inspiratory stridor]. *Nihon Kokyuki.Gakkai Zasshi.* 45:604-608.
Abstract: A 70-year old woman was admitted because of sleep maintenance insomnia with severe respiratory sounds during sleep. Polysomnography (PSG) revealed frequent respiratory events, particularly hypopneas, throughout the night associated with severe oxygen desaturation, and inspiratory stridor, which was shown to have a high-pitched frequency by acoustic sound analysis. She also presented fine finger tremor due to parkisonism, increased bilateral tendon responses, cerebellar ataxic gait, and dysautonomia. Therefore, we concluded that she suffered from multiple systemic atrophy (MSA). Nasal continuous positive airway pressure (nCPAP) treatment was successful. Characteristic PSG findings and analysing the snoring sound are important in the early diagnosis of sleep-related disordered breathing in MSA

28. Tejman-Yarden, S., A. Zlotnik, L. Weizman, J. Tabrikian, A. Cohen, N. Weksler, and G. M. Gurman. 2007. Acoustic monitoring of lung sounds for the detection of one-lung intubation. *Anesth.Analg.* 105:397-404.
Abstract: INTRODUCTION: Monitoring methods for the early diagnosis of one-lung intubation (OLI) are nonspecific and controversial. In this study, we evaluated a new acoustic monitoring system for the detection of OLI. METHODS: Lung sounds were collected from 24 adult surgical patients scheduled for routine surgical procedures. Four piezoelectric microphones attached to the patients' backs were used to sample lung sounds during induction of anesthesia and endotracheal tube positioning. To achieve OLI, the endotracheal tube was inserted and advanced down the airway so that diminished or no breath sounds were heard on the left side of the chest. The tube was then withdrawn stepwise until equal breath sounds were heard. Fiberoptic bronchoscopy confirmed the tube's final position. Acoustic analyses were preformed by a new algorithm which assumes a Multiple Input Multiple Output system, in which a multidimensional Auto-Regressive model relates the input (lungs) and the output (recorded sounds) and a classifier, based on a Generalized Likelihood Ratio Test, indicates the number of ventilated lungs without reconstructing the original lung sounds from the recorded samples. RESULTS: This algorithm achieved an OLI detection probability of 95.2% with a false alarm probability of 4.8%. CONCLUSION: Higher detection values can be achieved at the price of a higher incidence of false alarms

29. Yadollahi, A. and Z. M. Moussavi. 2007. Acoustical respiratory flow. A review of reliable methods for measuring air flow. *IEEE Eng Med Biol Mag.* 26:56-61.

30. Alencar, A. M., E. Wolfe, and S. V. Buldyrev. 2006. Monte Carlo simulation of liquid bridge rupture: application to lung physiology. *Phys Rev E Stat.Nonlin.Soft.Matter Phys* 74:026311.
Abstract: In the course of certain lung diseases, the surface properties and the amount of fluids coating the airways changes and liquid bridges may form in the small airways blocking the flow of air, impairing gas exchange. During inhalation, these liquid bridges may rupture due to mechanical instability and emit a discrete sound event called pulmonary crackle, which can be heard using a

simple stethoscope. We hypothesize that this sound is a result of the acoustical release of energy that had been stored in the surface of liquid bridges prior to its rupture. We develop a lattice gas model capable of describing these phenomena. As a step toward modeling this process, we address a simpler but related problem, that of a liquid bridge between two planar surfaces. This problem has been analytically solved and we use this solution as a validation of the lattice gas model of the liquid bridge rupture. Specifically, we determine the surface free energy and critical stability conditions in a system containing a liquid bridge of volume Omega formed between two parallel planes, separated by a distance 2h, with a contact angle Theta using both Monte Carlo simulation of a lattice gas model and variational calculus based on minimization of the surface area with the volume and the contact angle constraints. In order to simulate systems with different contact angles, we vary the parameters between the constitutive elements of the lattice gas. We numerically and analytically determine the phase diagram of the system as a function of the dimensionless parameters hOmega(-1/3) and Theta. The regions of this phase diagram correspond to the mechanical stability and thermodynamical stability of the liquid bridge. We also determine the conditions for the symmetrical versus asymmetrical rupture of the bridge. We numerically and analytically compute the release of free energy during rupture. The simulation results are in agreement with the analytical solution. Furthermore, we discuss the results in connection to the rupture of similar bridges that exist in diseased lungs

31. Bielamowicz, S. and S. V. Stager. 2006. Diagnosis of unilateral recurrent laryngeal nerve paralysis: laryngeal electromyography, subjective rating scales, acoustic and aerodynamic measures. *Laryngoscope* 116:359-364.
Abstract: OBJECTIVE/HYPOTHESIS: To determine whether specific laryngeal electromyography (LEMG) patterns in patients with unilateral vocal fold paralysis/paresis (UVFP) are related to etiology of injury, time from onset of injury, patient perception of symptom severity, acoustic measures, and laryngeal aerodynamic measures. STUDY DESIGN: This is a retrospective review of 75 patients. METHODS: Each patient received LEMG, acoustic and aerodynamic testing, and a subjective rating scale assessment (the Glottal Closure Index). Statistical analysis by groups were performed using both chi and single-factor analysis of variance testing. RESULTS: An iatrogenic etiology was associated with poor tone on LEMG (P = .05). Those individuals evaluated after 3 months after onset demonstrated more nascent units, a sign of reinnervation, compared with individuals evaluated before 3 months (P < .02). Individuals with fewer normal motor units on LEMG had significantly higher mean translaryngeal air flows (P = .044). Individuals with poor recruitment had significantly shorter maximum phonation times (P = .034) and higher mean flows (P = .044). Individuals with better laryngeal tone as noted on LEMG had significantly lower mean flows (P = .06). CONCLUSIONS: Specific LEMG patterns are related to the etiology of the UVFP and time course since recurrent laryngeal nerve injury. LEMG appears to reflect vocal fold muscle tone as seen on laryngeal function studies. In combination, these studies provide a cohesive assessment of laryngeal function in patients with UVFP

32. Bohadana, A. B. and J. P. Michaely. 2006. Does the inclusion of wheeze detection as an outcome measure affect the interpretation of methacholine challenge tests? A study in workers at risk of occupational asthma. *Lung* 184:151-157.
Abstract: Methacholine challenge testing (MCT) is widely used to assess airway hyperresponsiveness (AHR). Traditionally, a 20% or greater decline in forced expiratory volume in 1 (FEV(1)) is the primary outcome measure. We examined whether the inclusion of wheeze detection as outcome measure influenced the categorical interpretation of MCT in workers at risk of occupational asthma (OA). We examined 28 occupationally exposed smokers with asthma-like symptoms (SympAsth), 22 asymptomatic, occupationally exposed smokers (Symp0), and 30 nonexposed, asymptomatic controls (Ctrl). MCT was done using an abbreviated technique. Spirometry and tracheal wheezes were recorded using a computerized system. MCT was considered either positive or negative using three outcome measures separately: (1) > or = 20% fall in FEV(1) (MCT("FEV1")); (2) wheeze appearance (MCT("Wheeze")); and (3) whichever among the two was present (MCT("FEV1Wheeze")). The proportion of reactors in each group were, by outcome measure, as follows: MCT("FEV1"): Ctrl = 2 (6.7%), Symp0 = 6 (27.3%), SympAsth = l2 (42.8%) (chi(2) = 10.2; p = 0.006); MCT("Wheeze"): Ctrl = 1 (3.3%), Symp0 = 4 (18.2%), SympAsth = 13 (46.4%) (chi(2) = l5.7; p = 0.001); MCT("FEV1Wheeze") Ctrl = 2 (6.7%), Symp0 = 7 (31.8%), SympAsth = 18 (64.3%) (chi(2) = 21.5; p = 0.001). Overall, including wheeze detection increased the proportion of "reactors" detected by spirometry by 30% (27 reactors vs. 20). This increase reached 50% (18 vs. 12) among workers with asthma like symptoms. In summary, the inclusion of wheeze detection as outcome measure for MCT allowed the recognition as reactors of subjects that otherwise would be "missed" by spirometry. The resulting increase in the number of true positives improved the sensitivity of MCT to detect AHR in occupationally exposed workers at risk of occupational asthma

33. Brietzke, S. E. and E. A. Mair. 2006. Acoustical analysis of snoring: can the probability of success be predicted? *Otolaryngol.Head Neck Surg.* 135:417-420.
Abstract: PURPOSE: Palatal flutter snoring is the most common form of snoring. However, other types of snoring do exist. Does identifying palatal snoring beforehand translate into improved subjective treatment success with palatal stiffening procedures? METHODS: Fifty-three patients presenting with snoring were evaluated with a commercially available device. The proportion (%) and magnitude of palatal flutter (dB) were quantified. Patients then underwent a palatal stiffening procedure and subjective success/failure was assessed. RESULTS: Overall subjective treatment success was 85% (45 of 53). The percent palatal flutter was the most predictive of success (area under ROC = 0.8556, 95% CI = .7428-.9683). Patients exceeding 68% palatal flutter had

a 95% (39 of 41) success rate (P = 0.001, Fisher's exact) and an adjusted odds ratio of treatment success of 25.2 (95% CI = 3.22-196, P = 0.002). CONCLUSION: Palatal stiffening treatments are successful in the majority of patients. However, identifying patients with predominant palatal flutter snoring significantly increases the probability of subjective treatment success. EBM rating: B-2b

34. Charleston-Villalobos, S., L. F. Dominguez-Robert, R. Gonzalez-Camarena, and A. T. jama-Corrales. 2006. Heart sounds interference cancellation in lung sounds. *Conf.Proc.IEEE Eng Med Biol Soc.* 1:1694-7.:1694-1697.
Abstract: Several attempts have been made to achieve a quantitative analysis of lung sounds mainly for two purposes: a) an understanding of their genesis, and b) an insight of their changes with pathologies for medical diagnosis. Early studies involved the collection of acoustic information at several positions on the thoracic surface or at the extra-thoracic trachea with one up to four microphones, but with a non-simultaneous acquisition. However, an increment for simultaneous acquisition points has been suggested; for example, as a consequence of multichannel acquisition acoustic visualization through computerized interpolation has emerged being helpful to analyze lung sounds (LS) origin, distribution, and relation to ventilation. Nevertheless, quantitative analysis of lung sounds requires eliminating interference signals prior to the extraction of relevant features. The acquired signals not only contain LS but also heart sounds (HS) among other interferences. HS are unavoidable and sometimes represent severe disturbing interference. This paper proposes a HS cancellation scheme as an extension of a previous effort using the Empirical Mode Decomposition (EMD) and a combination of time warping with linear adaptive FIR filtering. Simulated signals are used to evaluate the performance of the proposed scheme under known and controlled scenarios

35. Du, Y. and A. M. Al-Jumaily. 2006. Obstruction identification in branching compliant tubes with application to airway passages. *J.Biomech.* 39:1363-1370.
Abstract: A feasibility study for occlusion identification in a branched tube-like structure using the frequency spectrum of the acoustic input impedance determined at the main entrance to the network is presented. The frequency spectra for one- and two-generation models are generated to study the effect of an occlusion in one of the branches on the spectra with an application to the trachea and the first two generations of the airways. The result demonstrates that the input impedance resonant frequencies can map the location, severity and degree of an obstruction in any of the considered branches

36. Duckitt, W. D., S. K. Tuomi, and T. R. Niesler. 2006. Automatic detection, segmentation and assessment of snoring from ambient acoustic data. *Physiol Meas.* 27:1047-1056.
Abstract: Snoring is a prevalent condition with a variety of negative social effects and associated health problems. Treatments, both surgical and therapeutic, have been developed, but the objective non-invasive monitoring of their success remains problematic. We present a method which allows the automatic monitoring of snoring characteristics, such as intensity and frequency, from audio data captured via a freestanding microphone. This represents a simple and portable diagnostic alternative to polysomnography. Our system is based on methods that have proved effective in the field of speech recognition. Hidden Markov models (HMMs) were employed as basic elements with which to model different types of sound by means of spectrally based features. This allows periods of snoring to be identified, while rejecting silence, breathing and other sounds. Training and test data were gathered from six subjects, and annotated appropriately. The system was tested by requiring it to automatically classify snoring sounds in new audio recordings and then comparing the result with manually obtained annotations. We found that our system was able to correctly identify snores with 82-89% accuracy, despite the small size of the training set. We could further demonstrate how this segmentation can be used to measure the snoring intensity, snoring frequency and snoring index. We conclude that a system based on hidden Markov models and spectrally based features is effective in the automatic detection and monitoring of snoring from audio data

37. Ferreira, J. R., M. B. Monteiro, F. Tavares, I. Serrano, E. Monteiro, C. P. Mendes, M. ves-Pereira, and N. A. Branco. 2006. Involvement of central airways in vibroacoustic disease patients. *Rev Port.Pneumol.* 12:93-105.
Abstract: INTRODUCTION: Vibroacoustic disease (VAD) is the whole-body pathology caused by excessive exposure to LFN. For the past 25 years, it has been know that low frequency noise (LFN, < 500 Hz, including infrasound) targets the respiratory system. In LFN-exposed rodents, the morphological changes of respiratory tract tissue partially explained some respiratory symptoms reported by VAD patients. However, many questions remain unanswered. Recently, some volunteer VAD patients underwent bronchoscopy in order to ascertain possible damage that could be associated with their respiratory complaints. METHODS: Fourteen fully-informed and volunteer VAD patients were submitted to bronchoscopy, and biopsies were removed for analysis. RESULTS: All patients exhibited small submucosal vascular-like lesions near the spurs, consisting of increased collagen and elastin fibres. Histology disclosed cilliary abnormalities, basal membrane hyperplasia, and thickening of vessel walls. In five patients, collagen bundles appeared degenerative and disrupted. No inflammatory process was ever identified, and no differences were seen between smokers and non-smokers. DISCUSSION: Data is in accordance with what was observed in LFN-exposed animal models and also in 8 VAD patients who developed lung tumours. Collagen disruption and degeneration was also observed in electron microscopy images of the respiratory tract of LFN-exposed rodents. Thickened blood and lymphatic vessel walls have

been consistently seen in images of VAD patients and of LFN-exposed rodents. During bronchoscopy performed by other reasons, this sort of structural aspects is not frequently seen. Taken together, it is strongly suggested that these findings could be VAD-specific

38. Fiz, J. A., R. Jane, J. Izquierdo, A. Homs, M. A. Garcia, R. Gomez, E. Monso, and J. Morera. 2006. Analysis of forced wheezes in asthma patients. *Respiration* 73:55-60.
Abstract: BACKGROUND: Spirometric parameters can be normal in many stable asthma patients, making a diagnosis difficult at certain times in the course of disease. OBJECTIVES: The present study aims to find differences and similarities in the acoustic characteristics of forced wheezes among asthma patients with and without normal spirometric values. METHODS: Eleven chronic asthma patients (8 men/3 women) with moderate-to-severe airway obstruction (FEV1 48.4%), 9 stable asthma patients (6 males/3 females) with normal spirometry (FEV1 84.0%) and a positive methacholine test and 14 healthy subjects (8/6) were enrolled in the study. A contact sensor was placed on the trachea, and wheezes were detected by a modified Shabtai-Musih algorithm in a time-frequency representation. RESULTS: More wheezes were recorded in obstructive asthma patients than in stable asthma and control subjects: nonstable asthma 13.6 (13.3), stable asthma 3.5 (3.0) and control subjects 2.5 (2.1). The mean frequency of all wheezes detected was higher in control subjects than in either stable or non-stable asthma patients. The change in the total number of wheezes after terbutaline inhalation was more pronounced in nonstable asthma patients than in stable asthmatics and control subjects. CONCLUSIONS: This study confirms that wheeze recording during forced expiratory maneuvers can be a complementary measure to spirometry to identify asthma patients

39. Fonseca, M. T., R. L. Voegels, and K. M. Pinto. 2006. Evaluation of nasal volume by acoustic rhinometry before and after physical exercise. *Am J Rhinol.* 20:269-273.
Abstract: BACKGROUND: The nasal structures generate airflow resistance that can reach -50% of the total respiratory resistance. There are a series of factors that can alter the volume of these structures, among them physical exercise. The objective of this study was to determine the degree of changes in nasal volume at different levels of physical exercise, evaluating the influence of exercise intensity and duration, as well as the duration of the effect of exercise on the nasal mucosa. METHODS: Nineteen individuals were submitted to three distinct physical tests on a cycle ergometer: test 1, exercising for 5 minutes on a cycle ergometer at 50% the maximal load; test 2, exercising for 10 minutes on a cycle ergometer at 50% the maximal load; and test 3, exercising for 5 minutes on a cycle ergometer at 75% the maximal load. In each test, nasal volume was measured by acoustic rhinometry immediately after the end of exercise and 10 and 20 minutes thereafter. RESULTS: The rhinometry results showed a significant increase ($p < 0.001$) in nasal volume after physical exercise for all tests performed. At 20 minutes, nasal volume had returned close to resting levels in all three tests. Comparison of the degree of improvement of nasal volume between the three physical tests showed a significant difference ($p < 0.05$) between T1 and T2 (T2 presented gain of 8.3% more in nasal volume than T1). Test 3 showed no significant difference ($p > 0.05$) compared with the other two tests, with 5.8% higher gain in nasal volume observed compared with T1, while the increase was 2.5% lower than in T2. CONCLUSION: Physical exercise in general causes a significant increase in nasal volume, with the duration of exercise exerting a greater effect on the degree of improvement than intensity

40. Groger, U. and L. Wiegrebe. 2006. Classification of human breathing sounds by the common vampire bat, Desmodus rotundus. *BMC.Biol.* 4:18.
Abstract: BACKGROUND: The common vampire bat Desmodus rotundus is one of three bat species that feed exclusively on the blood of mammals often more than 1000 times its size. Vampire bats even feed on human blood. Moreover, they tend to feed on the same individual over consecutive nights. RESULTS: Using psychoacoustical methods, we show that vampire bats can recognize individual humans by their breathing sounds. Accompanying psychoacoustical experiments using the same stimuli and procedure but with human listeners show that even these trained and instructed listeners were unable to achieve the vampire bats' performance under the most difficult conditions, where the breathing sounds had been recorded under physical strain. CONCLUSION: It is suggested that vampire bats can make use of an individual acoustic signature imposed on breathing sounds in a way similar to that in which we identify humans by their vocalizations

41. Hannan, S. A. and B. T. Kotecha. 2006. Acoustic parameters of snoring sound to compare natural snores with snores during 'steady-state' propofol sedation. *Clin Otolaryngol.* 31:341-342.

42. Hara, H., N. Murakami, Y. Miyauchi, and H. Yamashita. 2006. Acoustic analysis of snoring sounds by a multidimensional voice program. *Laryngoscope* 116:379-381.
Abstract: OBJECTIVES: This prospective study aimed to determine whether the acoustic characteristics of snoring sounds differed between simple snorers and patients with obstructive sleep apnea syndrome (OSAS) by using a multidimensional voice program (MDVP) that analyzes various aspects of voice. METHODS: Fifty-eight patients (48 men, 10 women) with a history of snoring were included in the study. All patients underwent conventional polysomnography (PSG). Twelve subjects were diagnosed as simple

snorers and 46 subjects were diagnosed with OSAS. The mean body mass index (BMI) of simple snorers was 24.7 kg/m and that of patients with OSAS was 25.8 kg/m. Natural overnight snoring was recorded from each subject while they slept during PSG. Using the multiple token protocols of MDVP, 30 snores from each subject were analyzed automatically. For data analysis, four markers were used: peak frequency, soft phonation index (SPI), noise to harmonics ratio (NHR), and power ratio. RESULTS: The Mann-Whitney U test revealed significant differences between the SPI, NHR, and power ratio of simple snorers and patients with OSAS. Simple snorers had a high SPI value. OSAS-related snorers demonstrated a high NHR and low power ratio. CONCLUSIONS: MDVP can be used for snoring sound analysis as a noninvasive examination of sleep-related breathing disorders for differential diagnosis. However, a suitable option that is rapid and has an easy-to-use interface would be more advantageous for analyzing snoring sounds

43. Herzog, M., T. Metz, A. Schmidt, T. Bremert, B. Venohr, W. Hosemann, and H. Kaftan. 2006. The prognostic value of simulated snoring in awake patients with suspected sleep-disordered breathing: introduction of a new technique of examination. *Sleep* 29:1456-1462.
Abstract: STUDY OBJECTIVE: A clinical examination of the upper airway in patients with suspected sleep-disordered breathing (SDB) is frequently performed before nighttime polysomnography. In recent years, the findings of "static" examinations, such as dorsalization of the tongue base, the Malampatti index, and Mueller maneuver, have been determined to be of low predictive value. DESIGN: We developed a new method of "dynamic" examination of the upper airway during simulated snoring in awake patients and analyzed the method in terms of the predictive value for suspected SDB. SETTING: N/A PATIENTS: One hundred thirty-one patients were examined prior to night-time polysomnography, and the results were correlated with the apneahypopnea-index (AHI). INTERVENTIONS: N/A RESULTS: A significant correlation was detected between an increased dorsal movement of the tongue base, as well as with pharyngeal collapse at the level of the tongue base and the AHI. Pharyngeal collapse at the level of the velum did not correlate with the AHI. The patient's body position during simulated snoring did not influence the results. The "static" examinations, such as the dorsalization of the tongue base, tonsil size, Malampatti index, and Mueller maneuver, did not correlate with the AHI. Patients with a high degree of pharyngeal collapse at the level of the tongue base, in combination with dorsal movement of the tongue base during simulated snoring, revealed a probability of 75% to have an AHI more than 10 and of 92% for an AHI more than 5. CONCLUSION: The "dynamic" examination of the upper airway under simulated snoring in awake patients is an easy-to-perform method to predict the probability of SDB prior to nighttime polysomnography

44. Jones, T. M., M. S. Ho, J. E. Earis, A. C. Swift, and P. Charters. 2006. Acoustic parameters of snoring sound to compare natural snores with snores during 'steady-state' propofol sedation. *Clin Otolaryngol.* 31:46-52.
Abstract: OBJECTIVES: To investigate the acoustic similarity between natural and sedation-induced snores. DESIGN: Prospective observational study. SETTING: University Hospital Aintree, Liverpool, UK. PARTICIPANTS: Twenty-one patients, who had already had overnight snore recordings, completed a pre-operative sleep nasendoscopic examination. Endoscopic examination of the upper aero-digestive tract was performed at sequentially increasing, steady-state sedation levels, using intravenous propofol administered according to a weight/time-based algorithm to predict blood and effect site (tissue) concentrations. At each sedation level at which snoring occurred, snoring sound was recorded. From these samples, snore files, comprising the inspiratory sound of each snore were created. Similarly, from natural snores recorded pre-operatively, snore files, comprising the inspiratory sounds of the first 100 snores with the patient sleeping in a supine position, were also created. MAIN OUTCOME MEASURES: Snore duration (s), loudness (dBA), periodicity (%) and energy ratios for the frequency sub-bands 0-200, 0-250 and 0-400 Hz. RESULTS: Snore loudness increased significantly ($P < 0.0001$), whilst energy ratios for frequency bands 0-200, 0-250 and 0-400 Hz all decreased significantly as sedation level increased ($P < 0.001$). A significant difference between natural snoring and snoring induced at the lowest sedation level was shown ($P < 0.0001$). Endoscopic examination was not tolerated at this sedation level. CONCLUSIONS: The acoustic characteristics of sedation-induced and natural snores are sufficiently different to recommend the need for further research to determine whether the technique of sleep nasendoscopy is, in fact, a valid predictor of outcome of snoring surgery

45. Jones, T. M., M. S. Ho, J. E. Earis, and A. C. Swift. 2006. Acoustic parameters of snoring sound to assess the effectiveness of the Muller Manoeuvre in predicting surgical outcome. *Auris Nasus Larynx.* 33:409-416.
Abstract: OBJECTIVE: To assess the effectiveness of the Muller Manoeuvre in predicting surgical outcome in non-apnoeic snorers. METHODS: Forty-one non-apnoeic snorers performed the Muller Manoeuvre, prior to palatal surgery for snoring. Pre-operatively and between 1.0 and 4.1 months (mean 2.5 months) post-operatively, patients were admitted overnight when their sleeping position and snoring sounds were recorded. At the time of the post-operative recordings, patients were required to complete a specifically designed questionnaire. Snore files comprising the inspiratory component of the first 100 snores whilst the patient was supine, were extracted. Snore duration (s), snore loudness (dBA), snore periodicity (%) and the energy ratios for the frequency bands 0-200, 0-250 and 0-400 Hz were calculated. Only patients who showed improvements in snore periodicity and all energy ratios were considered to be surgical successes. In addition, patients were also categorised as 'successes' or 'failures' depending on their responses to specific questionnaire questions. The effectiveness of the Muller Manoeuvre in predicting surgical outcome was then tested using these categories. RESULTS: The 41 patients included 35 men and 6 women. Mean age: 47 years

(24-67 years). Mean PNIFR 145 (80-230). Median reported alcohol intake was 11-15 units/week (0 to 26-30 units/week). Mean BMI: 30.6 kg/m2 (24.3-47.2 kg/m2). Twenty-four patients underwent an uvulopalatal elevation palatoplasty and seventeen a traditional palatoplasty. Following the Muller Manoeuvre, patients were categorised as 'ideal', 'suboptimal, but acceptable' or 'unsuitable' for surgery. Using the acoustic parameters, 23/41 patients were considered a surgical success, whilst 18/41 were considered failures. Using the questionnaire responses, 14/40 patients were considered a surgical success, whilst 26/40 were considered failures. There was no correlation between the subjective and objective outcomes (rho=0.193; p=0.227). Neither pre-operative BMI, type of palatoplasty performed, patient gender, age, PNIFR or reported alcohol intake were confounders of surgical outcome. For patients considered 'ideal' and 'suboptimal, but acceptable', using acoustic outcomes, the Muller Manoeuvre had a specificity of 55.5% and a sensitivity of 30.4%, compared with a sensitivity of 57.7% and a specificity of 28.6% when questionnaire responses were used. If only patients considered 'ideal' were considered, the specificity was 66.7%, and the sensitivity 21.7% when using acoustic outcomes, compared with a sensitivity of 69.2% and a specificity of 78.6% when questionnaire responses were used. CONCLUSION: The Muller Manoeuvre appears to have no role in the pre-operative assessment of palatal surgery for non-apnoeic snorers

46. Jones, T. M., P. Walker, M. S. Ho, J. E. Earis, A. C. Swift, and P. Charters. 2006. Acoustic parameters of snoring sound to assess the effectiveness of sleep nasendoscopy in predicting surgical outcome. *Otolaryngol.Head Neck Surg.* 135:269-275.
Abstract: OBJECTIVE: To assess the effectiveness of two grading systems used to predict surgical outcome in nonapneic snorers. STUDY DESIGN: A prospective observational study. Prior to undergoing palatal surgery, 20 patients completed a sleep nasendoscopic examination involving sequential steady-state sedation with intravenous propofol. Using a combination of acoustic parameters of snoring sound as an objective outcome measurement, and the answers to a specifically designed questionnaire as a subjective outcome measurement, the effectiveness of each grading system in predicting surgical outcome was examined. RESULTS: Depending on the outcome measurement used, sensitivity in predicting success of surgery for snoring varied from 16.7% to 50.0% and specificity from 38.5% to 62.5% for the Pringle and Croft system, while sensitivity varied from 91.7% to 100% and specificity from 30.8% to 31.5% for the Camilleri system. CONCLUSION: Sleep nasendoscopy using these classifications cannot be recommended as a reliable predictor of surgical outcome in nonapneic snorers. EBM rating: C-4

47. Kraman, S. S., G. R. Wodicka, G. A. Pressler, and H. Pasterkamp. 2006. Comparison of lung sound transducers using a bioacoustic transducer testing system. *J.Appl.Physiol* 101:469-476.
Abstract: Sensors used for lung sound research are generally designed by the investigators or adapted from devices used in related fields. Their relative characteristics have never been defined. We employed an artificial chest wall with a viscoelastic surface and a white noise signal generator as a stable source of sound to compare the frequency response and pulse waveform reproduction of a selection of devices used for lung sound research. We used spectral estimation techniques to determine frequency response and cross-correlation of pulses to determine pulse shape fidelity. The sensors evaluated were the Siemens EMT 25 C accelerometer (Siemens); PPG 201 accelerometer (PPG); Sony ECM-T150 electret condenser microphone with air coupler (air coupler; with cylindrical air chambers of 5-, 10-, and 15-mm diameter and conical air chamber of 10-mm diameter); Littman classic stethoscope head (Littman) connected to an electret condenser microphone; and the Andries Tek (Andries) electronic stethoscope. We found that the size and shape of the air coupler chamber to have no important effect on the detected sound. The Siemens, air coupler, and Littman performed similarly with relatively flat frequency responses from 200 to 1,200 Hz. The PPG had the broadest frequency response, with useful sensitivity extending to 4,000 Hz. The Andries' frequency response was the poorest above 1,000 Hz. Accuracy in reproducing pulses roughly corresponded with the high-frequency sensitivity of the sensors. We conclude that there are important differences among commonly used lung sound sensors that have to be defined to allow the comparison of data from different laboratories

48. Kraman, S. S., G. A. Pressler, H. Pasterkamp, and G. R. Wodicka. 2006. Design, construction, and evaluation of a bioacoustic transducer testing (BATT) system for respiratory sounds. *IEEE Trans.Biomed.Eng* 53:1711-1715.
Abstract: Many different transducers are employed for recording respiratory sounds including accelerometers and microphones in couplers. However, there is no standard lung sound transducer or any device to compare transducers so that measurements from different laboratories can be determined to be of physiologic origin rather than technical artifacts of the transducers. To address this problem, we designed and constructed a prototype of a device that can be used to compare accelerometers, microphones enclosed in couplers, and stethoscopes. The prototype device consists of a rigid chamber containing a loudspeaker that opens to an antechamber covered by a viscoelastic material with mechanical properties similar to human skin and subcutaneous tissue. When driven by a white noise source, we found the sound output at the surface to be useful to comparatively evaluate sensors between 100 and 1200 Hz where lung sounds have most of their spectral energy. We compared the viscoelastic layer to similar thicknesses of fresh meat and fat and found them to produce similar acoustic spectra. This device allows air-coupled transducers, accelerometers, and stethoscopes used in respiratory sounds measurements to be compared under physical conditions similar to their intended use

49. Liu, S. A., M. C. Su, and R. S. Jiang. 2006. Nasal patency measured by acoustic rhinometry in East Asian patients with sleep-disordered breathing. *Am J Rhinol.* 20:274-277.
Abstract: BACKGROUND: Nasal obstruction is thought to be a risk factor in obstructive sleep apnea (OSA). However, the relationship between nasal patency and sleep-disordered breathing remains controversial. The aim of this study was to examine the association between acoustic rhinometry findings and results of overnight polysomnography. METHODS: From February to October 2003, patients who underwent overnight polysomnography assessment were enrolled in the study. We excluded patients who were under 20 years old, had severe deviated nasal septum, had previously received nasal or palatal surgery, or could not complete sleep test or acoustic rhinometry examination. Participants' basic data including age, gender, neck circumference, and body mass index (BMI) were collected. All participants received acoustic rhinometry before overnight polysomnography. The results along with sleep-test outcomes were recorded and analyzed. RESULTS: A total of 87 patients were included in this study. Patients with respiratory disturbance index (RDI) less than 5/h (n = 26) or with RDI of 5-30/h (n = 28) tended to have larger minimal cross-sectional area (MCA) compared with those of patients whose RDI was more than 30/h (n = 33) (P = 0.001). A stepwise multiple regression analysis showed that BMI, male gender, and MCA were contributing factors in RDI. The R2 value of the multiple regression analysis was 0.406. CONCLUSION: Patients with severe OSA tended to have smaller MCA when compared with patients with RDI less than 30/h. However, it was hard to predict whether patients had OSA from acoustic rhinometry examination

50. Mastorocostas, P. A. and J. B. Theocharis. 2006. A stable learning algorithm for block-diagonal recurrent neural networks: application to the analysis of lung sounds. *IEEE Trans.Syst.Man.Cybern.B Cybern.* 36:242-254.
Abstract: A novel learning algorithm, the Recurrent Neural Network Constrained Optimization Method (RENNCOM) is suggested in this paper, for training block-diagonal recurrent neural networks. The training task is formulated as a constrained optimization problem, whose objective is twofold: (1) minimization of an error measure, leading to successful approximation of the input/output mapping and (2) optimization of an additional functional, the payoff function, which aims at ensuring network stability throughout the learning process. Having assured the network and training stability conditions, the payoff function is switched to an alternative form with the scope to accelerate learning. Simulation results on a benchmark identification problem demonstrate that, compared to other learning schemes with stabilizing attributes, the RENNCOM algorithm has enhanced qualities, including, improved speed of convergence, accuracy and robustness. The proposed algorithm is also applied to the problem of the analysis of lung sounds. Particularly, a filter based on block-diagonal recurrent neural networks is developed, trained with the RENNCOM method. Extensive experimental results are given and performance comparisons with a series of other models are conducted, underlining the effectiveness of the proposed filter

51. Melo, F. N. and M. M. Damasceno. 2006. [Building an educational software about the auscultation of breathing sounds]. *Rev Esc Enferm.USP.* 40:563-569.
Abstract: The aim of this study was to discuss the experience of building an educational software about the auscultation of breathing sounds. In the process, Lev Semenovic Vygotsky's pedagogic theoretical framework was used, and the content was delimited so as to encompass the auscultation method step by step. The objective of the auscultation was to classify normal and strange sounds and their particular stethoacoustic characteristics. For the development of the system was used 3D technology, including virtual personification of the patients, nurses and objects. A virtual environment for the auscultation using simulation procedures was used as well. It was concluded that initiatives such as that, although facing many difficulties, bring important contributions to teaching-learning of contents related to nursing education

52. Mendes, A., M. ves-Pereira, and N. A. Castelo Branco. 2006. Voice acoustic patterns of patients diagnosed with vibroacoustic disease. *Rev.Port.Pneumol.* 12:375-382.
Abstract: BACKGROUND: Long-term low frequency noise exposure (LFN) (< or = 500 Hz, including infrasound) may lead to the development of vibroacoustic disease (VAD), a systemic pathology characterized by the abnormal growth of extra-cellular matrices. The respiratory system is a target for LFN. Fibrosis of the respiratory tract epithelia was observed in VAD patients through biopsy, and confirmed in animal models exposed to LFN. Voice acoustic analysis can detect vocal fold variations of mass, tension, muscular and neural activity. Frequency perturbation (jitter), amplitude perturbation (shimmer) and harmonic-to-noise ratio (HNR) are used in the evaluation of the vocal function, and can be indicators of the presence and degree of severity of vocal pathology. Since the respiratory system is the energy source of the phonation process, this raises questions about the effects of VAD on voice production. The purpose of this study was to determine if voice acoustic parameters of VAD patients are different from normative data. METHODS: Nine individuals (5 males and 4 females) diagnosed with VAD were recorded performing spoken and sung tasks. The spoken tasks included sustaining vowels and fricatives. The sung tasks consisted of maximum phonational frequency range (MPFR). Voice acoustic parameters ana- lysed were: fundamental frequency (F0), jitter, shimmer, HNR and temporal measures. RESULTS: Compared with normative data, both males and females diagnosed with VAD exhibited increased F0, shimmer and HNR. Jitter, MPFR and one temporal measure were reduced. CONCLUSIONS: VAD individuals presented voice acoustic parameter differences in spectral, temporal and perturbation measures, which may be indicative of small morphological changes in the phonatory system

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Abstract: BACKGROUND: Nasal continuous positive airway pressure (nCPAP) is usually the first-line intervention for obstructive sleep apnea, but up to 50% of patients are unable to tolerate therapy because of discomfort-usually nasal complaints. No factors have been definitively correlated with nCPAP tolerance, although nasal cross-sectional area has been correlated with the level of CPAP pressure, and nasal surgery improves nCPAP compliance. This study examined the relationship between nasal cross-sectional area and nCPAP tolerance. METHODS: We performed acoustic rhinometry on 34 obstructive sleep apnea patients at the time of the initial sleep study. Patients titrated to nCPAP were interviewed 18 months after starting therapy to determine CPAP tolerance. Demographic, polysomnographic, and nasal cross-sectional area data were compared between CPAP-tolerant and -intolerant patients. RESULTS: Between 13 tolerant and 12 intolerant patients, there were no significant differences in age, gender, body mass index, CPAP level, respiratory disturbance index, or subjective nasal obstruction. Cross-sectional area at the inferior turbinate differed significantly between the two groups ($p = 0.03$). This remained significant after multivariate analysis for possibly confounding variables. A cross-sectional area cutoff of 0.6 cm2 at the head of the inferior turbinate carried a sensitivity of 75% and specificity of 77% for CPAP intolerance in this patient group. CONCLUSION: Nasal airway obstruction correlated with CPAP tolerance, supporting an important role for the nose in CPAP, and providing a physiological basis for improved CPAP compliance after nasal surgery. Objective nasal evaluation, but not the subjective report of nasal obstruction, may be helpful in the management of these patients

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Abstract: Cough consisting of an initial deep inspiration, glottal closure, and an explosive expiration accompanied by a sound is one of the most common symptoms of respiratory disease. Despite its clinical importance, standard methods for objective cough analysis have yet to be established. OBJECT: We investigated the characteristics of cough sounds acoustically, designed a program to discriminate cough sounds from other sounds, and finally developed a new objective method of non-invasive cough counting. In addition, we evaluated the clinical efficacy of that program. SUBJECTS AND METHODS: We recorded cough sounds using a memory stick IC recorder in free-field from 2 patients and analyzed the intensity of 534 recorded coughs acoustically according to time domain. First we squared the sound waveform of recorded cough sounds, which was then smoothed out over a 20 ms window. The 5 parameters and some definitions to discriminate the cough sounds from other noise were identified and the cough sounds were classified into 6 groups. Next, we applied this method to develop a new automatic cough count program. Finally, to evaluate the accuracy and clinical usefulness of this program, we counted cough sounds collected from another 10 patients using our program and conventional manual counting. And the sensitivity, specificity and discriminative rate of the program were analyzed. RESULTS: This program successfully discriminated recorded cough sounds out of 1902 sound events collected from 10 patients at a rate of 93.1%. The sensitivity was 90.2% and the specificity was 96.5%. CONCLUSION: Our new cough counting program can be sufficiently useful for clinical studies

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Abstract: It was hypothesised that the recruitment of atelectatic lung areas is signified by changes in the airway and tissue mechanics, and by the appearance of crackle activity attributed to the sudden reopening of collapsed airways. The authors also assumed that the acoustic activity is an earlier indicator of lung recruitment than the change in the overall mechanical state of the lungs. Six thoracotomised and mechanically ventilated mini-pigs were studied. Low-frequency pulmonary impedance was measured at end-expiratory pauses at transpulmonary pressures of 4 and 1 hPa to estimate airway resistance (Raw) and the coefficient of lung tissue elastance (H), and tracheal sounds were recorded during subsequent slow inflations to 30 hPa, in the control state and following increasing doses of i.v. methacholine (Mch). Raw and H were higher at baseline and increased more in response to Mch at 1 hPa than at 4 hPa. The crackles detected during the subsequent inflations were concentrated around and associated with the development of the lower knee of the pressure-volume curve. The number of crackles increased faster following the Mch doses and reached statistical significance earlier than Raw and H. Crackle recording during mechanical ventilation can be employed as a simple method with which to monitor lung recruitment-derecruitment

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Abstract: The influence of asingle diving in equipment of the closed type using respiratory gas mixture with a risen concentration of oxygen on the external respiration function of divers having small experience of underwater works is investigated by means of a tracheal forced expiratory noise analysis. 16 divers and a control group consisting of 13 men (with the age from 19 to 24 years) were inspected. Duration of tracheal forced expiratory noise was measured. Spirographic indices were registered. 10 divers were inspected in dynamics - before diving and immediately after it. T, FVC and FEV1 changes were tested. Significant differences in T and spirographic indices among groups of divers (before diving) and the control one were not detected. On the whole after diving

the only significant reduction of indices in the group of divers was connected with FEV1. Significant individual dynamics of spirographic indices was not found. 2 examined divers showed considerable increase in T reflecting bronchial patency aggravation

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Abstract: During lung sound recordings, heart sounds (HS) interfere with clinical interpretation of lung sounds over the low frequency components which is significant especially at low flow rates. Hence, it is desirable to cancel the effect of HS on lung sound records. In this paper, a novel HS cancellation method is presented. This method first localizes HS segments using multiresolution decomposition of the wavelet transform coefficients, then removes those segments from the original lung sound record and estimates the missing data via a 2D interpolation in the time-frequency (TF) domain. Finally, the signal is reconstructed into the time domain. To evaluate the efficiency of the TF filtering, the average power spectral density (PSD) of the original lung sound segments with and without HS over four frequency bands from 20 to 300 Hz were calculated and compared with the average PSD of the filtered signals. Statistical tests show that there is no significant difference between the average PSD of the HS-free original lung sounds and the TF-filtered signal for all frequency bands at both low and medium flow rates. It was found that the proposed method successfully removes HS from lung sound signals while preserving the original fundamental components of the lung sounds

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Abstract: We evaluated the acoustic frequency response of endotracheal tubes (ETs) to assess their effect on respiratory system sound transmission studies. White noise 150-3300 Hz was introduced into 4.0-, 6.0-, and 8.0-mm ETs and recorded at their proximal and distal ends. Four tubes of each size were studied at their original and normalized lengths, in straight and bent configurations, and at circuit pressures from 0 to 20 cmH2O. The characteristics of the sound transmission were compared using an analysis of variance for repeated measures. The average transmission amplitude varied directly with tube diameter. The position of peaks and troughs on the amplitude frequency distribution depended on tube length but not on tube diameter. The angle of the phase-frequency plot correlated well with the length of the tube and was independent of its diameter. A 90 degrees bend in the tube had no effect on its sound transmission. Increasing the circuit pressure above ambient modified the frequency response only if volume changes occurred in the test lung. When used to conduct sound into the respiratory system an ET affects the incident signal predictably depending on its length and diameter but not on its curvature or circuit pressure

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Abstract: Rene Theophile Hyacinthe Laennec (1781-1826) was a French physician who, in 1816, invented the stethoscope. Using this new instrument, he investigated the sounds made by the heart and lungs and determined that his diagnoses were supported by the observations made during autopsies. Laennec later published the first seminal work on the use of listening to body sounds, De L'auscultation Mediate (On Mediate Auscultation). Laennec is considered the father of clinical auscultation and wrote the first descriptions of bronchiectasis and cirrhosis and also classified pulmonary conditions such as pneumonia, bronchiectasis, pleurisy, emphysema, pneumothorax, phthisis and other lung diseases from the sounds he heard with his invention. Laennec perfected the art of physical examination of the chest and introduced many clinical terms still used today

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Abstract: The authors described acoustic spiroanalyzer with data processing through probabilistic neuronal networks. Application of the spiroanalyzer for respiratory diseases diagnosis proved possibility of occupational diseases identification: classification reliability was 78% for diseased and 77% for healthy miners

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Abstract: BACKGROUND: Little is known of the language healthcare professionals use to describe cough sounds. We aimed to examine how they describe cough sounds and to assess whether these descriptions suggested they appreciate the basic sound qualities (as assessed by acoustic analysis) and the underlying diagnosis of the patient coughing. METHODS: 53 health professionals from two large respiratory tertiary referral centres were recruited; 22 doctors and 31 staff from professions allied to medicine. Participants listened to 9 sequences of spontaneous cough sounds from common respiratory diseases. For each cough they selected patient gender, the most appropriate descriptors and a diagnosis. Cluster analysis was performed to assess which cough sounds attracted similar descriptions. RESULTS: Gender was correctly identified in 93% of cases. The presence or absence

of mucus was correct in 76.1% and wheeze in 39.3% of cases. However, identifying clinical diagnosis from cough was poor at 34.0%. Cluster analysis showed coughs with the same acoustics properties rather than the same diagnoses attracted the same descriptions. CONCLUSION: These results suggest that healthcare professionals can recognise some of the qualities of cough sounds but are poor at making diagnoses from them. It remains to be seen whether in the future cough sound acoustics will provide useful clinical information and whether their study will lead to the development of useful new outcome measures in cough monitoring

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Abstract: BACKGROUND: Little is known about cough frequency in adults with cystic fibrosis (CF). This study aimed to determine (1) daytime and overnight cough rates in patients with CF at the beginning and end of a course of antibiotics for treatment of an exacerbation; (2) the relationship between cough frequencies and standard clinical measures of disease; and (3) the relationship between objective cough rates and the subjective assessment of cough. METHODS: Nineteen adult patients admitted with a pulmonary exacerbation performed daytime and overnight sound recordings on admission; 13 had repeat recordings prior to discharge. Coughs were manually quantified in cough seconds (time spent coughing). Patients subjectively scored their cough using a visual analogue scale (VAS) and numerical score. Lung function, C-reactive protein (CRP) levels, and sputum weights were recorded. RESULTS: Cough rates fell substantially with treatment; median fall in cough rate was 51.3% (IQR 32.3-77.5) ($p<0.001$) for daytime and 72.2% (28.6-90.1) ($p = 0.049$) for overnight. Multivariate regression analyses showed that forced expiratory volume in 1 second and CRP levels predicted overnight cough rates on admission. On discharge, sputum volume predicted daytime cough rates. Only the change in overnight VAS correlated with the change in objective cough rates. CONCLUSIONS: The cough rate significantly decreases with treatment of a pulmonary exacerbation in adults with CF. Lung function, sputum volume, and CRP influences the cough rate, with the effects differing from day to night and between admission and discharge. Subjective reporting of a nocturnal cough may indicate a pulmonary exacerbation of CF in adults

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Abstract: OBJECTIVE: To evaluate the practicability of Odiosoft-Rhino (OR), a new experimental method for assessing the nasal airflow and resistance, in normal subjects and to compare the results with acoustic rhinometry (AR) findings. STUDY DESIGN AND SETTING: OR and AR were carried out in 72 healthy subjects. Their visual analogue scales of nasal obstruction, minimal cross sectional areas (MCA(1) and MCA(2)), and nasal expiration sounds were analyzed and noted for both nasal cavities. RESULTS: Statistically significant correlations ($P < 0.05$) were found between OR and AR in 2,000 to 4,000 Hz and 4,000 to 6,000 Hz with MCA(1) and MCA(2). CONCLUSIONS: OR is a noninvasive and rapid test. It is easy to carry out and requires little patient cooperation. It seems that it may give compatible results with other reliable methods that assess nasal airflow. SIGNIFICANCE: We assume that OR is a sensitive method for evaluating nasal airflow in normal subjects in an easy way. EBM rating: A-1b

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Abstract: Wheezes, as being abnormal breath sounds, are observed in patients with obstructive pulmonary diseases, such as asthma. The aim of this study was to capture and analyze the nonlinear characteristics of asthmatic wheezes, reflected in the quadrature phase coupling of their harmonics, as they evolve over time within the breathing cycle. To achieve this, the continuous wavelet transform (CWT) was combined with third-order statistics/spectra. Wheezes from patients with diagnosed asthma were drawn from a lung sound database and analyzed in the time-bi-frequency domain. The analysis results justified the efficient performance of this combinatory approach to reveal and quantify the evolution of the nonlinearities of wheezes with time

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Abstract: One-lung intubation (OLI) is among the most common complications of endotracheal intubation. None of the monitoring tools now available has proved effective for its early detection. In this study we investigated the efficacy of acoustic analysis for the detection of OLI. We collected lung sounds from 11 patients undergoing thoracic surgery requiring the placement of a double-lumen tube. Recordings of separate lung ventilation were performed after induction and confirmation of adequate tube positioning, before surgery. Samples of lung sounds were collected by three piezoelectric microphones, one on each side of the chest and one on the right forearm, for background noise sampling. The samples were filtered, the signals' energy envelopes were calculated, and segmentation to breath and rest periods was performed. Each respiration was classified into one of the three categories: bilateral ventilation, selective right-lung ventilation, or selective left-lung ventilation, on the basis of the ratio between the energy signals of each lung. OLI was accurately identified in 10 of the 11 patients during right OLI and in all 11 patients during left OLI. This study suggests that acoustic monitoring is effective for the detection of selective lung ventilation and may be useful for early diagnosis of OLI

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Abstract: Computerized lung sounds analysis offers a new technique to monitor regional ventilation during spontaneous breathing. The purpose of the present study was to assess the acoustic behaviour of the respiratory system in healthy pigs during mechanical ventilation when a positive end-expiratory pressure (PEEP) is applied. Lung sounds were recorded during mechanical ventilation and different PEEP levels of 0, 5, 10, 15 and 20 cm H(2)O were applied. The increase in end-expiratory lung volume (EELV) related to the PEEP application was also measured and the correlation between changes in EELV (DeltaEELV) and sound amplitude (DeltaA) was examined. The amplitude of normal lung sounds was reduced by application of PEEP >or=10 cm H(2)O (P<0.05). The increase in PEEP from 0 to 20 cm H(2)O reduced the acoustic energy of lung sounds recorded at ZEEP by 0.3 dB (PEEP 5), 2 dB (PEEP 10), 5 dB (PEEP 15) and 7 dB (PEEP 20), which corresponds to 1%, 6%, 14% and 21% in acoustic attenuation, respectively. The variations in DeltaA correlated with changes in lung volume (P<0.05) and with changes in compliance of the respiratory system (P<0.05), but were not correlated with changes of the resistance of respiratory system. The frequency analysis showed a downward shifting of the spectra at frequencies between 150 and 600 Hz for PEEP levels >or=10 cm H(2)O and frequencies between 75 and 600 Hz for PEEP levels >or=15 cm H(2)O. The application of increasing levels of PEEP reduced the amplitude and changed the spectral characteristics of normal lung sounds

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Abstract: The relationship between respiratory sounds and flow is of great interest for researchers and physicians due to its diagnostic potentials. Due to difficulties and inaccuracy of most of the flow measurement techniques, several researchers have attempted to estimate flow from respiratory sounds. However, all of the proposed methods heavily depend on the availability of different rates of flow for calibrating the model, which makes their use limited by a large degree. In this paper, a robust and novel method for estimating flow using entropy of the band pass filtered tracheal sounds is proposed. The proposed method is novel in terms of being independent of the flow rate chosen for calibration; it requires only one breath for calibration and can estimate any flow rate even out of the range of calibration flow. After removing the effects of heart sounds (which distort the low-frequency components of tracheal sounds) on the calculated entropy of the tracheal sounds, the performance of the method at different frequency ranges were investigated. Also, the performance of the proposed method was tested using 6 different segment sizes for entropy calculation and the best segment sizes during inspiration and expiration were found. The method was tested on data of 10 healthy subjects at five different flow rates. The overall estimation error was found to be 8.3 +/- 2.8% and 9.6 +/- 2.8% for inspiration and expiration phases, respectively

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Abstract: Heart sounds are the main unavoidable interference in lung sound recording and analysis. Hence, several techniques have been developed to reduce or cancel heart sounds (HS) from lung sound records. The first step in most HS cancellation techniques is to detect the segments including HS. This paper proposes a novel method for HS localization using entropy of the lung sounds. We investigated both Shannon and Renyi entropies and the results of the method using Shannon entropy were superior. Another HS localization method based on multiresolution product of lung sounds wavelet coefficients adopted from was also implemented for comparison. The methods were tested on data from 6 healthy subjects recorded at low (7.5 ml/s/kg) and medium 115 ml/s/kg) flow rates. The error of entropy-based method using Shannon entropy was found to be 0.1 +/- 0.4% and 1.0 +/- 0.7% at low and medium flow rates, respectively, which is significantly lower than that of multiresolution product method and those of other methods reported in previous studies. The proposed method is fully automated and detects HS included segments in a completely unsupervised manner

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Abstract: SUMMARY: We present a comprehensive, functional analysis of clinical voice data derived from both high-speed digital imaging (HSDI) of the larynx and simultaneously acquired acoustic recordings. The goals of this study are to: (1) correlate dynamic characteristics of the vocal folds derived from direct laryngeal imaging with indirectly acquired acoustic measurements; (2) define the advantages of using a combined imaging/acoustic approach for the analysis of voice condition; and (3) identify new quantitative measures to evaluate the regularity of the vocal fold vibration and the complexity of the vocal output-these measures will be key to successful diagnosis of vocal abnormalities. Image- and acoustic-based analyses are performed using an analytic phase plot approach previously introduced by our group (referred to as 'Nyquist' plot). Fast Fourier Transform (FFT) spectral analyses are performed on the same data for a comparison. Clinical HSDI and acoustic recordings from subjects having normal and specific voice pathologies, including muscular tension dysphonia (MTD) and recurrent respiratory papillomatosis (RRP) were analyzed

using the Nyquist plot approach. The results of these analyses show that a combined imaging/acoustic analysis approach provides better characterization of the vibratory behavior of the vocal folds as it correlates with vocal output and pathology

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Abstract: Obstructive sleep apnea (OSA) is a highly prevalent disease in which upper airways are collapsed during sleep, leading to serious consequences. The gold standard of diagnosis, called polysomnography (PSG), requires a full-night hospital stay connected to over ten channels of measurements requiring physical contact with sensors. PSG is inconvenient, expensive and unsuited for community screening. Snoring is the earliest symptom of OSA, but its potential in clinical diagnosis is not fully recognized yet. Diagnostic systems intent on using snore-related sounds (SRS) face the tough problem of how to define a snore. In this paper, we present a working definition of a snore, and propose algorithms to segment SRS into classes of pure breathing, silence and voiced/unvoiced snores. We propose a novel feature termed the 'intra-snore-pitch-jump' (ISPJ) to diagnose OSA. Working on clinical data, we show that ISPJ delivers OSA detection sensitivities of 86-100% while holding specificity at 50-80%. These numbers indicate that snore sounds and the ISPJ have the potential to be good candidates for a take-home device for OSA screening. Snore sounds have the significant advantage in that they can be conveniently acquired with low-cost non-contact equipment. The segmentation results presented in this paper have been derived using data from eight patients as the training set and another eight patients as the testing set. ISPJ-based OSA detection results have been derived using training data from 16 subjects and testing data from 29 subjects

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Abstract: This study examined pre-hospital intubations performed by paramedics, which were later determined to be non-tracheal upon arrival at an urban, academic emergency department (ED). The aim was to characterize the various confirmation techniques used among these unrecognized non-tracheal intubations. A retrospective review of the emergency medical services (EMS) quality assurance database was conducted over a period of 65 months. Paramedic patient care reports and hospital medical records were reviewed with regard to techniques used for airway evaluation. Simple descriptive statistics are used to summarize the data. During this study period, paramedics intubated 1643 patients. There were 35 (2%) intubations that were ultimately determined to be non-tracheal by receiving physicians. Among these, 20 (57%) were intubations for trauma indications. Seven patients (20%) were children (< 10 years). Fifteen patients (43%) did not have a pulse before intubation attempts. Overall, 21 (60%) had multiple confirmatory techniques employed by paramedics. The most commonly documented was 'equal lung sounds' (91%), followed by 'visualized cords' (52%). Per protocol, colorimetric end tidal CO2 was used selectively among patients with pulses, 9/20 (45%). Aspiration techniques were not used among this study population. Based on paramedic documentation, 17 (49%) of the non-tracheal intubations were potentially recognizable. An unrecognized, non-tracheal intubation is a potentially devastating consequence of failed airway management. We report a small, but important experience with failed pre-hospital airway management. In this EMS system, more frequent use of multiple confirmatory techniques (including end tidal CO2 detection) may help to reduce the incidence of this potentially life-threatening scenario

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Abstract: We studied the mechanisms by which turbulent flow induces tracheal wall vibrations detected as tracheal breath sounds (TRBSs). The effects of flow rate at transitional Reynold's numbers (1300-10,000) and gas density on spectral patterns of TRBSs in eight normal subjects were measured. TRBSs were recorded with a contact sensor during air and heliox breathing at four flow rates (1.0, 1.5, 2.0, and 2.5 l/s). We found that normalized TRBSs were proportional to flow to the 1.89 power during inspiration and to the 1.59 power during expiration irrespective of gas density. The amplitude of TRBSs with heliox was lower than with air by a factor of 0.33 +/- 0.12 and 0.44 +/- 0.16 during inspiration and expiration, respectively. The spectral resonance frequencies were higher during heliox than air breathing by a factor of 1.75 +/- 0.2-approximately the square root of the reciprocal of the air/heliox wave propagation speed ratio. In conclusion, the flow-induced pressure fluctuations inside the trachea, which cause tracheal wall vibrations, were detected as TRBSs consist of two components: (1) a dominant local turbulent eddy component whose amplitude is proportional to the gas density and nonlinearly related to the flow; and (2) a propagating acoustic component with resonances whose frequencies correspond to the length of the upper airway and to the free-field sound speed. Therefore, TRBSs consist primarily of direct turbulent eddy pressure fluctuations that are perceived as sound during auscultation

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Abstract: Although the option for vaginal delivery is most physiological, the achievement of cesarean section is very common in Brazil. The neonate cry represents the beginning of both processes, physiological adaptation and human vocal communication. The cry emission depends on the functioning of respiratory and laryngeal muscles, which are controlled by the nervous system.

The acoustic analysis of neonate cry is useful in the assessment of healthy babies and can be used to characterize the signals of diseases through a previously multidisciplinary diagnosis, with immediate medical intervention. The present study compared the acoustic cry characteristics of 30 healthy newborn after a cesarean section and 30 healthy newborn after a vaginal delivery, of both genders, from the exact moment of birth until the first 5 min of life. Using the softwares VOXMETRIA and GRAM, it was possible to analyze the duration, frequency, intensity, occurrence, localization and inspiratory phonation, besides the type of spectrographic tracings. The acoustic cry characteristics of newborns after a C section and a vaginal delivery could evidence not only harmonic, expiratory, acute and strong emissions, but also emissions rich in sounds and varied in types of melody. The differences found can be related to the physiology of birth

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Abstract: Respiratory sound analysis can offer important information related to pulmonary diseases. Wheezes have been reported as adventitious respiratory sounds in asthmatic or obstructive patients, during forced exhalation maneuvers. In this work, we propose a method for monitoring and analysis of respiratory sounds in frequency domain, during spontaneous ventilation. The database analyzed was acquired during spontaneous ventilation for 120 seconds (DBsv), of 26 asthmatics patients. Using an autoregressive model (AR, order 16), the Power Spectral Density (PSD) was calculated for every phase of expiration and inspiration and the maximum frequency (fp) was estimated. From this parameter we study the time duration of the wheezes. The effect of bronchodilator inhalation in asthmatic patients was studied analyzing the duration of the wheezes in the bandwidth 600-2000 Hz (HFband). The wheeze duration is evaluated as the number of consecutive segments, with fp is inside of HFband, (for 3 or more segments in a cycle). The difference of the wheeze duration inside the respiratory cycles (Dwheez), before and after bronchodilator inhalation (POST) was evaluated. It was found a good correlation between Dwheez and FEV<inf>1</inf>% improvement (FEV<inf>1</inf>%_imp), for FEV<inf>1</inf>%_imp > 8%, whereas values FEV<inf>1</inf>%_imp < 8% did not show any change of Dwheez. This last result suggests no difference in the wheeze duration between the baseline and POST records. This method could predict the FEV<inf>1</inf>%_imp by means of estimation of Dwheez during spontaneous ventilation

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Abstract: INTRODUCTION: Asthma and rhinitis frequently co-exist in the same patient. It may exist a specific condition witch affects the general respiratory activity and also able to produce symptoms into upper and/ or lower airways. PURPOSE: To analyze the alteration and functional burst of upper and lower airways before and after oral corticoid. METHODS: From July of 2000 to August of 2002, sixteen (69 % was female), acute asthmatics patients with rhinitis symptom assisted in the pneumology department, were analyzed through cross-sectional study using: symptoms questionnaire, physical examination, radiogram, spirometry, acoustic rhinometry, and rhinomanometry. RESULTS: Sixteen patients presented compromising symptoms of the upper airways. In the spirometry, FEV1, FEV1/FVC e FEF25-75%, presented major statistically differences. The acoustic rhinometry presented important statistical differences in the minimal cross- sectional area 1 e 2 in the left side and total nasal volume, after medicine intervention. CONCLUSIONS: The functional evaluations upon lower and upper airways, improvements in FEV1, FEV1/FVC e FEF25-75%, were observed through spirometry and total nasal volume, analyzing the acoustic rhinometry after oral corticoid

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Abstract: Lung sound analysis is of a major importance in diagnostic malfunctions of the respiratory system. In normal subjects, it is known that these sounds are caused by the interaction of the respiratory flows with the bronchial tree structure. However, the detailed knowledge of the reasons for the spectral characteristics of such sounds remains to be elucidated. In this paper we propose a model for normal lung sound production based on a discretization of air flow in particle-like elements. Their transport with the involved interactions is implemented using a pseudo-molecular dynamics Monte Carlo procedure. General physical principles were considered for the interaction of these elements with the bronchial tree as well as a two-body interaction potential. The particle-tree interactions and the particle-particle interactions represent the flow-tree and the internal flow interactions, respectively. According to the model, sound is produced in each bronchus with the pitch frequency inversely proportional to its dimensions and with amplitude proportional to the intensity of the interaction, also a function of the bronchus dimensions. The lung sound is then the composition of the sounds produced in each bronchus. The model was successful in approximating the spectral characteristics reported by Gavriely et al (1981, 1995) as a direct consequence of the fractal properties of the bronchial tree and the considered internal fluid interactions. Thus, the reported high-frequency spectrum with its affine property as well as the low-frequency irregularity could be reproduced

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Abstract: STUDY OBJECTIVES: To identify upper airway changes in snoring using CT scanning, to clarify the snoring mechanism, and to identify the key structures involved. PARTICIPANTS: Forty patients underwent CT examination of the head and neck region according to snoring habits; patients were classified into non-snoring (n = 14), moderately loud snoring (n = 13), and loud snoring (n = 13) groups. DESIGN: Comparative analysis. MEASUREMENTS: Using CT images, areas, the anteroposterior and transversal distances of the pharyngeal space at different levels, and the thickness and length of the soft palate and uvula and their angle against the hard palate were measured; evidence of impaired nasal passages was noted; the extent of pharyngeal inspiratory narrowing was the ratio between the area at the hard palate level and most narrow area; and expiratory narrowing was the ratio between the area behind the root of the tongue and the most narrow area. RESULTS: Greater pharyngeal inspiratory narrowing (p = 0.0015) proportional to the loudness of snoring (p = 0.0016), and a longer soft palate with uvula (p = 0.0173) were significant for snoring. Impaired nasal breathing was significantly related (p = 0.029) only to the loud snoring group. The body mass index and age of snoring persons were also significantly higher. CONCLUSIONS: Snoring is associated with typical changes that can be revealed by CT scanning. Greater pharyngeal narrowing is the most important factor. Given the "Venturi tube" shape of the pharynx, the Bernoulli pressure principle plays a major role in snoring. The key structure in snoring is the soft palate: it defines the constriction and is sucked into vibrating by negative pressure that develops at this site. Its repetitive closures present an obstruction to breathing, producing the snoring sound, and should therefore be the target for causal treatment of snoring. Obstacles in the upper airway that increase negative inspiratory pressure could not be confirmed as important for the development of snoring, although they may increase its loudness

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Abstract: The purpose of this study was to add to the extant data base of acoustic cry studies by profiling the condition of laryngomalacia. We hypothesized that the acoustic characteristics of crying produced by an infant with laryngomalacia would differ compared to previously reported cry data for normal infants. An entire episode of crying was audio recorded and acoustically analyzed for the occurrence of expiratory and inspiratory cry segments, as well as the long-time average spectral (LTAS) characteristics. Results obtained for the infant were found to be considerably different from what has been previously reported for normal infants. The overall duration of the infant's crying episode was longer, with proportionately fewer expiratory phonations and more inspiratory phonations compared to normal infants. The LTAS results were reflective of aperiodic components in the glottal source spectrum. Collectively, the infant's unusual crying aspects were not limited solely to those acoustic features resulting from a prolapse of supraglottic soft tissue, and therefore provide new insight into the vocal fold vibratory behavior characterizing infantile laryngomalacia

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Abstract: Bronchial reactivity to inhaled agents in preschool children can be undertaken by auscultating the lungs to detect wheezing, but there is a lack of information on when wheeze first appears at the endpoint of the challenge and on the acoustic characteristics of the wheeze. We recorded breath sounds continuously during tidal breathing inhalation challenges with adenosine 5'-monophosphate, using sensors attached over each upper lobe in 80 preschool children. In 35 children, the challenge was considered positive by a pediatrician who determined the endpoint by detecting wheeze on auscultation after an inhalation. Using acoustic analysis, we determined that the first wheeze appeared during the 2-min period of nebulization in 31% of positive challenges; it was unilateral in 37%, and only inspiratory in 46%. A running window of 6 sec was used to detect at least two wheezes without reference to phase of breathing, and this index had a sensitivity of 97.6% and specificity of 99.7% for determining the endpoint of a challenge. Detecting wheeze acoustically adds safety to the technique by enabling the challenge to be stopped earlier, while the lack of a need to document the phase of breathing simplifies the technique

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phases are combined using a nonlinear decision combination function to form a final decision on each subject. Furthermore a new regularization scheme is applied to the data to stabilize training and consultation

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Abstract: The application of the wavelet transform-fractal dimension-based (WT-FD) filter of Part I of this paper to real bioacoustic data, which include explosive lung sounds (ELS) and explosive bowel sounds (EBS) recorded from patients with pulmonary or gastrointestinal dysfunction, respectively, is presented in this paper. The objective of the latter is the evaluation of the performance of the WT-FD filter on different types of bioacoustic signals, varying not only in their structural morphology but also in the degree of their noise contamination. As it is thoroughly described in Part I of this paper, the WT-FD filter uses the fractal dimension to form an efficient way of thresholding the WT coefficients at different resolution scales, keeping, thus, only those that can contribute to the accurate reconstruction of the ELS and EBS signals. Quantitative and qualitative analysis of the experimental results show an efficient performance of the WT-FD filter to circumvent the noise presence (100% detectability rate, 100% sensitivity, 100% specificity) by faithfully extracting the authentic structure of ELS and EBS from the background noise. The WT-FD filter does not require any noise reference signal or noise reference templates. The results from a noise stress test (mean cross-correlation index of the original and the estimated signal converging to 100%; mean normalized maximum amplitude error converging to 0.7%) prove its robustness to various noise levels (0-20 dB), enabling its potential use in similar noise cases met in everyday clinical medicine. Furthermore, the efficient performance of the WT-FD filter facilitates the physician to better interpret the auscultation findings. Due to its simplicity and low computational cost, the WT-FD filter can possibly be implemented in a real-time context to serve as a tool for the continuous ELS and EBS screening

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Abstract: To investigate the effectiveness of palatal surgery for nonapnoeic snoring, 35 patients were block randomised to undergo one of two different palatoplasty procedures. Patients were admitted pre-operatively for audio recording of snoring sound and video recording of sleeping position, and between 1.0 and 4.1 months (mean 2.5) and between 5.9 and 17.5 months (mean 9.7) post-operatively. Sound files, comprising the inspiratory sound of the first 100 snores whilst sleeping in a supine position, were analysed using specifically designed software. Snore duration (s), loudness (dBA), periodicity (%) and energy ratios for the

frequency bands 0-200 Hz, 0-250 Hz and 0-400 Hz were calculated. Subjective outcomes were noted. Operation type, body mass index, age, peak nasal inspiratory flow rate, Epworth sleep score and alcohol intake were considered as confounding variables. No patient was cured from snoring. Paired t-test analysis demonstrated statistically significant changes between pre- and early post-operative recordings for snore periodicity and energy ratios in the frequency ranges 0-200 Hz, 0-250 Hz and 0-400 Hz. In conclusion, only the 0-250-Hz energy ratio measurements maintained a statistically significant improvement at the time of the late post-operative recording, despite an obvious drift back to pre-operative levels. No confounding variables were identified. The subjective and objective results correlated poorly. Post-operative changes in the acoustic parameters of snoring sound, following palatal surgery, are demonstrable but short-lived

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Abstract: Traditionally, auscultation is applied to the diagnosis of either respiratory disturbances by respiratory sounds or cardiac disturbances by cardiac sounds. In addition, for sleep apnea syndrome diagnosis, snoring sounds are also monitored. The present study was aimed at synchronous detection of all three sound components (cardiac, respiratory, and snoring) from a single spot. The sounds were analyzed with respect to the cardiorespiratory activity, and to the detection and classification of apneas. Sound signals from 30 subjects including 10 apnea patients were detected by means of a microphone connected to a chestpiece which was applied to the heart region. The complex nature of the signal was investigated using time, spectral, and statistical approaches, in connection with self-defined time-based and event-based characteristics. The results show that the obstruction is accompanied by an increase of statistically relevant spectral components in the range of 300 to 2000 Hz, however, not within the range up to 300 Hz. Signal properties are discussed with respect to different breathing types, as well as to the presence and the type of apneas. Principal component analysis of the event-based characteristics shows significant properties of the sound signal with respect to different types of apneas and different patient groups, respectively. The analysis reflects apneas with an obstructive segment and those with a central segment. In addition, aiming for an optimum detection of all three sound components, alternative regions on the thorax and on the neck were investigated on two subjects. The results suggest that the right thorax region in the seventh intercostal space and the neck are optimal regions. It is concluded that for patient assessment, extensive acoustic analysis offers a reduction in the number of required sensor components, especially with respect to compact home monitoring of apneas

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Abstract: Increased wheeze and asthma diagnosis in obesity may be due to reduced lung volume with subsequent airway narrowing. Asthma (wheeze and airway hyperresponsiveness), functional residual capacity (FRC) and airway conductance (Gaw) were measured in 276 randomly selected subjects aged 28-30 yrs. Data were initially adjusted for smoking and asthma before examining relationships between weight and FRC (after adjustment for height), and between body mass index (BMI = weight.height(-2)) and Gaw (after adjustment for FRC) by multiple linear regression, separately for females and males. For males and females, BMI (+/-95% confidence interval) was 27.0+/-4.6 kg.m(-2) and 25.6+/-6.0 kg.m(-2) respectively, Gaw was 0.64+/-0.04 L.s(-1).cmH2O(-1) and 0.57+/-0.03 L.s(-1).cmH2O(-1), and FRC was 85.3+/-3.4 and 84.0+/-2.9% of predicted. Weight correlated independently with FRC in males and females. BMI correlated independently and inversely with Gaw in males, but only weakly in females. In conclusion, obesity is associated with reduced lung volume, which is linked with airway narrowing. However, in males, airway narrowing is greater than that due to reduced lung volume alone. The mechanisms causing airway narrowing and sex differences in obesity are unknown

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Abstract: Alterations in normal breath sounds are an important indication of pathophysiological processes in the bronchial system and the lung. In the presence of non-specific symptoms like dyspnea, wheezing or cough while sleeping it seems reasonable to make a nocturnal long-term recording of breath sounds. Thus specific auscultation phenomena can be recorded qualitative and particularly quantitative in the course. A mobile recording system provides a non-invasive monitoring at home which is independent of vigilance. Furthermore it can be used for follow-up examinations of medical interventions

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Abstract: BACKGROUND: In daily routine, physicians use history, physical examination and technology-based information such as laboratory tests and imaging studies to diagnose the patients' disease. We determined the diagnostic value of lung auscultation in patients admitted to the Medical emergency room with chest symptoms. METHODS: Two-hundred-and forty-three consecutive patients (137 males), mean age 59.2 years were included. Internal Medicine registrars had to make a presumptive diagnosis, 1) after having taken the history and 2) after having auscultated the lungs. Thereafter, routine diagnostic procedures were performed. The estimated diagnosis was compared with the final diagnosis based on the written report to the Family Practitioner. RESULTS: Two-hundred-eighty-seven diagnoses were made. Eighteen percent of patients suffered from left heart failure, 13% from unexplained chest pain, 10.5% from chest wall pain, and 10.5% from pneumonia. Forty-one percent of the diagnoses were already correct when based only on the patient's history. Lung auscultation improved the diagnostic yield only in 1% and worsened it in another 3%. By multiple logistic regression, normal lung auscultation (OR 0.12 [95CI% 0.053-0.29]) was the independent predictor for not having a lung or heart disease. However, elevation of B-type natiuretic peptide (BNP) (OR 1.16 per 100 pg/ml (95CI% 1.004-1.35), wheezing (OR 0.023 [0.002-0.33]) and pCO2 (OR 0.25 (0.10-0.621) were independent predictors for having a heart disease, whereas wheezing (OR 7.41 [3.26-16.83]) and CRP (OR 1.008 per 10 units [1.003-1.014]) were risk factors for having a lung disease. CONCLUSION: In contrast to history taking, abnormal lung auscultation does not appear to contribute considerably to the final diagnosis in patients presenting with chest symptoms in an emergency room setting. However, normal lung auscultation is a valuable predictor for not having a lung or heart disease, whereas wheezing is a predictor for having a lung disease and not having a heart disease

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Abstract: Endotracheal tubes (ETTs) are used to establish airway access in patients with ventilatory failure and during general anaesthesia. Tube malpositioning can compromise respiratory function and can be associated with increased morbidity and mortality. Clinical assessment of ETT position normally involves chest auscultation, which is highly skill-dependent and can be misleading. The objective of this pilot study was to investigate breath sound changes associated with ETT malpositioning. Breath sounds were acquired in six human subjects over each hemithorax and over the epigastrium for tracheal, bronchial and oesophageal intubations. When the ETT was in the oesophagus, the acoustic energy ratio between epigastrium and chest surface increased in all subjects ($p < 0.04$). In addition, ETT placement in the right mainstem bronchus decreased the acoustic energy ratio between the left and right hemithoraxes in all subjects ($p < 0.04$). A baseline measurement of this energy ratio was needed for bronchial intubation identification. However, using this ratio after bandpass filtering (200-500 Hz) did not require a baseline value, which would increase the utility of this method for initial ETT placement. These results suggest that computerised analysis of breath sounds may be useful for assessment of ETT positioning. More studies are needed to test the feasibility of this approach further

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Abstract: An experiment was conducted to determine the response of the human lung to water-borne sound in the range of 20 to 500 Hz. A small pool inside a hyperbaric chamber was used to simulate four ambient pressure conditions spanning the range of recreational diving depths. Ten subjects were tested on two occasions each using three separate measures to evaluate the response of the subjects' lungs. With some notable exceptions, results were consistent between subjects and between measures. These indicate that human lungs can be reasonably modeled as a lumped single-degree-of-freedom system over the lower portion of the band of interest. Here, the surrounding fluid provides the dominant mass and the dominant stiffness is provided by the entrapped air with a small additional contribution from tissue elasticity. Measured resonances increase with the square root of ambient pressure from an average of 40 Hz with a quality factor of 1.8 at near-surface pressure to 73 Hz with a quality factor of 2.6 at an equivalent depth of 36.4 m. There is evidence of other resonances within or near the band of interest that may be attributable to nonvolumetric chest/lung modes, Helmholtz resonance, and/or resonance of gastrointestinal bubbles

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Abstract: This work proposes multichannel acquisition of lung sounds by a microphone array, feature extraction by a multivariate AR (MAR) model, dimensionality reduction of the feature vectors (FV) by SVD and PCA and, their classification by a supervised neural network. A microphone array of 25 sensors was attached on the thoracic surface of the subjects, who were breathing at 1.5 L/sec. The supervised neural network used the backpropagation learning algorithm based on the Levenberg-Marquardt rule. Figures of merit for the classification task by the neural net include the percentage of correct classification during training, testing and validation phases as well as sensitivity, specificity and performance. MAR in combination with PCA provided the best average percentage of correct classification with acoustic information not seen by the neural network during the training phase (87.68%). The results state the advantages of a microphone array for the classification of normal and abnormal acoustic pulmonary information in diffuse interstitial pneumonia and for this goal, the authors assume that not only the crackles and their number indicates the severity of the disease, but the basal respiratory signal could be also affected

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Abstract: BACKGROUND: The relationship between nasal airway function and sleep-disordered breathing (SDB) remains unclear. Although correction of nasal obstruction can significantly improve nighttime breathing in some patients, nasal obstruction may not play a role in all cases of SDB. An effective method of stratifying these patients is needed. Acoustic rhinometry (AR) is a reliable, noninvasive method of measuring the dimensions of the nasal airway. METHODS: In 44 patients, we performed acoustic rhinometric measurements of nasal airway cross-sectional area, followed by hospital-based polysomnography and nasal continuous positive airway pressure (nCPAP) level titration. We compared anatomic nasal obstruction to perceived nasal obstruction, as well as respiratory distress index and nCPAP titration level, using the Pearson correlation and multiple linear regression analysis within body mass index groups. RESULTS: Perceived nasal obstruction correlated significantly with objective anatomic obstruction as measured by AR ($r = 0.45$, $p < 0.01$). For certain subgroup analyses in patients with a body mass index below 25, AR measurements correlated significantly with both nCPAP titration pressure ($r = 0.85$, $p < 0.01$) and respiratory distress index ($r = 0.67$, $p = 0,03$). CONCLUSION: Nasal airway function may be a significant component of SDB in some patients, perhaps playing a larger role in patients who are not overweight. The best responders to nasal surgery for SDB may be nonoverweight patients with nasal obstruction. AR along with nasal examination may be helpful in the evaluation and treatment of the SDB patient

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Abstract: Endotracheal tube (ETT) malpositioning into a mainstem bronchus or the esophagus may result in significant hypoxemia. Current methods to determine correct ETT position include auscultation, radiography, and bronchoscopy, although the current acceptable standard procedure for proper endotracheal (versus esophageal) intubation is detection of end-tidal carbon dioxide

(ETco(2)) by capnography, capnometry, or colorimetric ETco(2) devices. Unfortunately, capnography may be unavailable or unreliable in nonhospital/emergency settings or in low cardiac output states, and it does not detect endobronchial intubation. The purpose of this study was to quantify and assess breath sound characteristics using electronic stethoscopes placed over each hemithorax and epigastrium to determine their ability to detect ETT malposition. We recorded breath sounds in 19 healthy, non-obese adults before general surgical procedures. After intubation of the trachea, the ETT was bronchoscopically positioned 3 cm above the carina, after which 3 breaths of 500 mL were given and breath sounds were recorded. A second ETT was placed in the esophagus and the same series of breaths and recordings were performed. Finally, the tracheal ETT was advanced into the right mainstem bronchus and breath sounds were recorded. Using computerized analysis, breath sounds were digitized and filtered to remove selected frequencies, and acoustic signals and energy ratios were obtained for all 3 positions. Total energy ratios using band-pass filtering of the acoustic signals accurately identified all esophageal and endobronchial intubation ($P < 0.001$). These preliminary results suggest that this technique, when incorporated into a 3-component, electronic stethoscope-type device, may be an accurate, portable mechanism to reliably detect ETT malposition in adults when ETco(2) may be unavailable or unreliable

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Abstract: The objective was to test the robustness of an acoustic method to estimate respiratory rates (RR) during treadmill test. The accuracy was assessed by the comparison with simultaneous estimates from a capnograph, using as a common reference a pneumotachometer. Eight subjects without any pulmonary disease were enrolled. Tracheal sounds were acquired using a contact piezoelectric sensor placed on the subject's throat and analyzed using a combined investigation of the sound envelope and frequency content. The capnograph and pneumotachometer were coupled to a face mask worn by the subjects. There was a strong linear correlation between all three methods (r²ranged from 0.8 to 0.87), and the SEE ranged from 1.97 to 2.36. As a conclusion, the accuracy of the respiratory rate estimated from tracheal sounds on adult subjects during treadmill stress test was comparable to the accuracy of a commercial capnograph. The heart rate (HR) estimates can also be derived from carotid pulse using the same single sensor placed on the subject's throat. Compared to the pulse oximeter the results show an agreement of acoustic method with r²=0.76 and SEE = 3.51

102. Qiu, Y., A. R. Whittaker, M. Lucas, and K. Anderson. 2005. Automatic wheeze detection based on auditory modelling. *Proc.Inst.Mech.Eng [H.]* 219:219-227.
Abstract: Automatic wheeze detection has several potential benefits compared with reliance on human auscultation: it is experience independent, an automated historical record can easily be kept, and it allows quantification of wheeze severity. Previous attempts to detect wheezes automatically have had partial success but have not been reliable enough to become widely accepted as a useful tool. In this paper an improved algorithm for automatic wheeze detection based on auditory modelling is developed, called the frequency- and duration-dependent threshold algorithm. The mean frequency and duration of each wheeze component are obtained automatically. The detected wheezes are marked on a spectrogram. In the new algorithm, the concept of a frequency- and duration-dependent threshold for wheeze detection is introduced. Another departure from previous work is that the threshold is based not on global power but on power corresponding to a particular frequency range. The algorithm has been tested on 36 subjects, 11 of whom exhibited characteristics of wheeze. The results show a marked improvement in the accuracy of wheeze detection when compared with previous algorithms

103. Raphael, D. T., P. Crookes, D. Arnaudov, and M. Benbassat. 2005. Acoustic reflectometry esophageal profiles minimally affected by massive gas ventilation. *Am J Emerg.Med* 23:747-753.
Abstract: Acoustic reflectometry can be used to distinguish between breathing tube placement in an esophagus vs the trachea via characteristic area-distance profiles for both cavities. In the cardiopulmonary resuscitation setting, capnography may be useless because the patient has little or no pulmonary circulation. With the breathing tube in the esophagus, can massive ventilation with a manual resuscitation bag, as might occur in the cardiopulmonary resuscitation setting, markedly alter the form of the obtained esophageal reflectometry profile? Nine hounds were induced, endotracheally intubated, mechanically ventilated, and anesthetized. Area-distance profiles were obtained with a 2-microphone acoustic reflectometer customized to measure areas up to 50 cm. Acoustic reflectometer profiles were obtained in intubated esophagi as follows: (1) baseline nonventilated state, (2) after aggressive 2-handed manual ventilation with high inspiratory pressures, rapid respiratory rates, and large tidal volumes for periods of 0.5, 1, and 1.5 minutes, upon detachment of the resuscitation bag, and (3) after esophagogastric decompression. We hypothesized that massive gas ventilation has no effect on the esophageal peak areas (null hypothesis), and used a paired t test for statistical significance ($P < .05$). For times of 0.5, 1.0, and 1.5 minutes, the ventilation volumes (mean +/- SD) were 25 +/- 7, 49 +/- 8, and 70 +/- 18 L. Massive gas ventilation caused minimal broadening and slight distal spread of the basal "hump". The mean peak area change was 0.18 +/- 0.35 cm2. For a paired t test ($n = 9$, $df = 8$), the corresponding t value was 1.54, with a P value of .16, which was incompatible with the null hypothesis. The experimental observations indicate a minimal effect of massive gas ventilation on the acoustic reflectometry esophageal profile. Hence, operator recognition of the altered canine acoustic

reflectometer profile as that of an esophageal cavity is maintained, indicating that acoustic reflectometry may be useful in correctly identifying the site of breathing tube placement in out-of-hospital cardiac arrest situations despite massive esophageal ventilation

104. Rasanen, J. and N. Gavriely. 2005. Response of acoustic transmission to positive airway pressure therapy in experimental lung injury. *Intensive Care Med.* 31:1434-1441.
Abstract: OBJECTIVE: To evaluate the effect of positive end-expiratory pressure on the sound filtering characteristics of injured lungs. DESIGN AND SETTING: Prospective experimental study in the animal laboratory in an academic medical center. PATIENTS AND PARTICIPANTS: Six 35- to 45-kg anesthetized, intubated pigs.INTERVENTIONS: Acute lung injury with intravenous oleic acid. MEASUREMENTS AND RESULTS: We injected a multifrequency broad-band sound signal into the airway while recording transmitted sound at three locations bilaterally on the chest wall. Oleic acid injections effected a severe pulmonary edema predominantly in the dependent lung regions, with an average increase in venous admixture from 16+/-14% to 57+/-13% and a reduction in static respiratory system compliance from 31+/-6 to 16+/-3 ml/cm H(2)O. A significant concomitant increase in sound transfer function amplitude was seen in the dependent and lateral lung regions; little change occurred in the nondependent areas. The application of PEEP resulted in a decrease in venous admixture, increase in respiratory system compliance, and return of the sound transmission to preinjury levels. CONCLUSIONS: Acute lung injury causes regional acoustic transmission abnormalities that are reversed during alveolar recruitment with PEEP

105. Rempel, G. and Z. Moussavi. 2005. The effect of viscosity on the breath-swallow pattern of young people with cerebral palsy. *Dysphagia* 20:108-112.
Abstract: In this observational pilot study, we investigated the effect of swallowing pudding and liquids of different viscosity on the breath-swallow pattern of young people with quadriparetic cerebral palsy (CP) and normal controls. A noninvasive acoustical technique was used to monitor breaths and swallows while the individuals were drinking thin and thick liquids and consuming pudding. The results showed that subjects with CP had a significantly higher rate of post-swallow inspiration than controls when they were drinking thin liquid but not when they were consuming thick liquid or pudding. Subjects with CP had greater variability and duration of deglutition apnea than controls. Whether the differences seen in breath-swallow pattern and deglutition apnea in young people with CP contribute to aspiration risk remains to be determined. Further clarification of these results by a carefully controlled study of individuals with cerebral palsy undergoing concurrent videofluoroscopic swallowing evaluation and acoustical monitoring of the breath-swallow pattern is required to verify these preliminary results and assess their clinical applicability

106. Russi, E. W. 2005. Lung auscultation - a useless ritual? *Swiss.Med.Wkly.* 135:513-514.

107. Sanchez, I., C. Vizcaya, D. Garcia, and E. Campos. 2005. Response to bronchodilator in infants with bronchiolitis can be predicted from wheeze characteristics. *Respirology.* 10:603-608.
Abstract: OBJECTIVE: Lung sounds analysis has been used for clinical care. Our objectives were to characterize the spectral pattern of lung sounds and their relation to bronchodilator effects in acute bronchiolitis (AB). We hypothesized that patients with sinusoidal wheezes (SW) would show a more significant bronchodilator response. METHODOLOGY: We studied 22 asleep hospitalized infants (14 boys, eight girls), aged 5.2 +/- 1 months, 16 with a positive respiratory syncytial virus test, during their first 3 days after admission. Patients breathed spontaneously through a face mask connected to a pneumotachograph during normal breathing, and only target flows of 0.1 +/- 0.02 L/s were analyzed. Sounds were obtained using two contact sensors attached over both posterior lower lobes. For inspiratory and expiratory sounds, we determined the frequencies below which 25% (F25), 50% (F50), 75% (F75) and 99% (SEF99) of the spectral power between 100 and 1000 Hz was contained. We repeated the measurements 20 min after bronchodilator therapy in all patients. RESULTS: We found classic SW in 11 patients, while the other 11 had complex wheezes (CW). There were positive bronchodilator responses in 9/11 with SW and 3/11 with CW ($P < 0.01$). Patients who responded to salbutamol showed an increase in power at low frequencies after medication ($P < 0.01$), and a positive correlation between wheezing and the increase in the power spectra measured by F50 and SEF99 ($P < 0.001$). CONCLUSIONS: We conclude that sinusoidal and complex wheezes occur in patients with AB, that a positive response to bronchodilator is significantly more common in those with classic SW and that lung sounds analysis is a reproducible, safe and non-invasive method for assessing wheeze in infants

108. Sezen, A. S., S. Sivaramakrishnan, S. Hur, R. Rajamani, W. Robbins, and B. J. Nelson. 2005. Passive wireless MEMS microphones for biomedical applications. *J.Biomech.Eng* 127:1030-1034.
Abstract: This paper introduces passive wireless telemetry based operation for high frequency acoustic sensors. The focus is on the development, fabrication, and evaluation of wireless, battery-less SAW-IDT MEMS microphones for biomedical applications. Due to the absence of batteries, the developed sensors are small and as a result of the batch manufacturing strategy are inexpensive which enables their utilization as disposable sensors. A pulse modulated surface acoustic wave interdigital transducer (SAW-IDT) based sensing strategy has been formulated. The sensing strategy relies on detecting the ac component of the acoustic pressure signal only and does not require calibration. The proposed sensing strategy has been successfully implemented

on an in-house fabricated SAW-IDT sensor and a variable capacitor which mimics the impedance change of a capacitive microphone. Wireless telemetry distances of up to 5 centimeters have been achieved. A silicon MEMS microphone which will be used with the SAW-IDT device is being microfabricated and tested. The complete passive wireless sensor package will include the MEMS microphone wire-bonded on the SAW substrate and interrogated through an on-board antenna. This work on acoustic sensors breaks new ground by introducing high frequency (i.e., audio frequencies) sensor measurement utilizing SAW-IDT sensors. The developed sensors can be used for wireless monitoring of body sounds in a number of different applications, including monitoring breathing sounds in apnea patients, monitoring chest sounds after cardiac surgery, and for feedback sensing in compression (HFCC) vests used for respiratory ventilation. Another promising application is monitoring chest sounds in neonatal care units where the miniature sensors will minimize discomfort for the newborns

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Abstract: The objective was to compare the accuracy of estimations of respiratory rate (RR), based on tracheal sounds, with simultaneous estimations from a capnograph, using as a common reference a pneumotachometer. Five subjects without pulmonary diseases were enrolled. Tracheal sounds were acquired using a contact piezoelectric sensor placed on the subject's throat and analyzed using a combined investigation of the sound envelope and frequency content. The capnograph and pneumotachometer were coupled to a face mask worn by the subjects. There was a strong linear correlation (r²= 0.98) between the acoustic method and the pneumotachometer and also between the capnograph and the pneumotachometer (r²= 0.98). The SEE obtained by the acoustic method was 1.11 and the SEE obtained by the capnograph was 1.23. As a conclusion, the accuracy of the respiratory rate estimated from tracheal sounds on adult subjects was comparable to the accuracy of a commercial capnograph, using as a common reference a pneumotachometer

110. Thamrin, C., P. D. Sly, and Z. Hantos. 2005. Broadband frequency dependence of respiratory impedance in rats. *J.Appl.Physiol* 99:1364-1371.
Abstract: Past studies in humans and other species have revealed the presence of resonances and antiresonances, i.e., minima and maxima in respiratory system impedance (Zrs), at frequencies much higher than those commonly employed in clinical applications of the forced oscillation technique (FOT). To help understand the mechanisms behind the first occurrence of antiresonance in the Zrs spectrum, the frequency response of the rat was studied by using FOT at both low and high frequencies. We measured Zrs in both Wistar and PVG/c rats using the wave tube technique, with a FOT signal ranging from 2 to 900 Hz. We then compared the high-frequency parameters, i.e., the first antiresonant frequency (far,1) and the resistive part of Zrs at that frequency [Rrs(far,1)], with parameters obtained by fitting a modified constant-phase model to low-frequency Zrs spectra. The far,1 was 570 +/- 43 (SD) Hz and 456 +/- 16 Hz in Wistar and PVG/c rats, respectively, and it did not shift with respiratory gases of different densities (air, heliox, and a mixture of SF(6)). The far,1 and Rrs(far,1) were relatively independent of methacholine-induced bronchoconstriction but changed significantly with increasing transrespiratory pressures up to 20 cmH(2)O, in the same way as airway resistance but independently of changes to tissue parameters. These results suggest that, unlike the human situation, the first antiresonance in the rat is not primarily dependent on the acoustic dimensions of the respiratory system and can be explained by interactions between compliances and inertances localized to the airways, but this most likely does not include airway wall compliance

111. Vyshedskiy, A., F. Bezares, R. Paciej, M. Ebril, J. Shane, and R. Murphy. 2005. Transmission of crackles in patients with interstitial pulmonary fibrosis, congestive heart failure, and pneumonia. *Chest* 128:1468-1474.
Abstract: OBJECTIVE: Patients with interstitial pulmonary fibrosis (IPF) often have diffusely abnormal findings on chest radiographs, making it difficult to detect evidence of superimposed congestive heart failure (CHF) or pneumonia. The goal of this study was to determine whether the crackles of IPF differed in their transmission and frequency from crackles of CHF and pneumonia in the hope of improving diagnosis and monitoring of these patients. METHODS: A multichannel lung sound analyzer was used to collect 20-s samples of sound from 25 patients with pneumonia, 17 patients with CHF, and 19 patients with IPF. We calculated a crackle transmission coefficient (CTC) by quantifying the distance a crackle spreads using a technique that cross-correlated the signal containing the highest amplitude crackle with the corresponding signal on all other ipsilateral channels: CTC, 0% = no transmission; CTC, 100% = equal transmission to all channels. RESULTS: Both the CTC and the crackle frequency in IPF were statistically different from that in CHF and pneumonia ($p < 0.0001$). The CTC averaged 24 +/- 5% for pneumonia, 25 +/- 8% for CHF, and 14 +/- 4% for IPF. The crackle frequency averaged 302 +/- 47 Hz for pneumonia, 311 +/- 62 Hz for CHF, and 462 +/- 50 Hz for IPF (+/- SD). CONCLUSION: These differences in CTC and crackle frequency offer the promise of helping guide treatment in IPF patients

112. Yadollahi, A. and Z. Moussavi. 2005. Measuring minimum critical flow for normal breath sounds. *Conf.Proc.IEEE Eng Med Biol Soc* 3:2726-2729.
Abstract: Relationship between respiratory sounds and flow has always been of interest for researchers and physicians. However,

the flow-sound relationship at very low flow rate has been questionable because breath sounds must exceed a minimum flow in order to be audible and different from the background noise. This study aimed to find the minimum critical flow rates for respiratory sounds to be audible and different from background noise. Tracheal and lung sound signals of healthy subjects in two groups of adults (12 subjects) and children (9 subjects) were studied. The values of minimum critical flow were determined comparing the spectrogram of the respiratory sounds at very low flow with that of during breath hold. The values of minimum critical flow for tracheal sounds were found to be 3.7.. 1.7 ml/s/kg and 2.7 .. 1.7 ml/s/kg for adults and children, respectively. The minimum critical flows for lung sounds were found as 6.2 .. 1.8 ml/s/kg and 4.0 .. 2.9 ml/s/kg for adults and children, respectively

113. Yadollahi, A. and Z. Moussavi. 2005. Robust Respiratory Flow Estimation Using Statistical Properties of Tracheal Sounds. *Conf.Proc.IEEE Eng Med Biol Soc* 2:1106-1109.
Abstract: For any respiratory sound analysis or assessment, respiratory flow must also be measured simultaneously with the sounds. However, due to difficulties and/or inaccuracy of the most flow measurement techniques, several researchers have attempted to estimate flow from respiratory sounds. However, all of the proposed methods heavily depend on the availability of different rates of flow for calibration of the model, which makes their use limited by a large degree. In this paper, a robust and novel method for estimating flow using entropy of the band pass filtered tracheal sounds is proposed. The proposed method is independent of the flow rate chosen for calibration; it requires only one breath for calibration and can estimate any flow rate even out of the range of calibration flow. The method was tested on data of 10 healthy subjects at three different flow rates above 15 ml/s/kg. The estimation error was found to be 7.3 ± 2.0% and 7.4 ± 3.2% for inspiration and expiration phases, respectively

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Abstract: In this study, wavelet networks are used to model pulmonary crackles with a view to extract features for the classification analysis of crackles obtained from subjects with a wide spectrum of pulmonary disorders. Crackles are very common adventitious sounds which are transient in character and whose characteristics, such as type, number of occurrence and pitch, convey information regarding the type and severity of the pulmonary disease. Crackles generally start with a sharp deflection and continue with a damped and progressively wider sinusoidal wave. In this study, due to the capability of time-frequency representation of wavelet functions, wavelet network (WN) is employed to characterize crackles, and the parameters acquired from wavelet nodes are used to distinguish them into two clinical classes, i.e. fine and coarse. For this purpose, a wavelet function (complex Morlet) in the first node is trained to fit the crackles and the second wavelet node is tuned to represent the error of the first node. Both of the nodes are, then, trained to minimize the total representative error. The five parameters of the WN node, i.e. scaling, time-shifting, frequency and two weight factors of sinus and cosines components are used as features in the classification analysis of crackles. The crackle information is strongly represented by the first wavelet node, therefore, the parameters belonging to the first node are used in the classification of crackles

115. Yeon, S. C., H. C. Lee, H. H. Chang, and H. J. Lee. 2005. Sound signature for identification of tracheal collapse and laryngeal paralysis in dogs. *J Vet.Med Sci.* 67:91-95.
Abstract: The aims of this study were to investigate whether upper airway sounds of dogs with laryngeal paralysis and tracheal collapse have distinct sound characteristics, compared with unaffected dogs. The sounds of 5 dogs with laryngeal paralysis and 5 dogs with tracheal collapse were recorded. Honking sound appeared as predominant clinical signs in dogs with tracheal collapse. Laryngeal stridors appeared as predominant clinical signs in dogs with experimentally produced laryngeal paralysis by resection of laryngeal nerve, in which two types of stridor, I and II, were recorded. All these sounds were analyzed using sound spectrogam analysis. There were significant differences in duration (sec), intensity (dB), pitch (Hz), first formant (Hz), second formant (Hz), third formant (Hz), fourth formant (Hz) of sounds between the normal bark and two types of stridor or honking sound, indicating that the sound analysis might be a useful diagnostic modality for dogs with tracheal collapse and laryngeal paralysis

116. Aboofazeli, M. and Z. Moussavi. 2004. Automated classification of swallowing and breadth sounds. *Conf.Proc.IEEE Eng Med Biol Soc* 5:3816-3819.
Abstract: The goal of this study was to develop an automated and objective method to separate swallowing sounds from breath sounds. Swallowing sound detection can be utilized as part of a system for swallowing mechanism assessment and diagnosis of swallowing dysfunction (dysphagia) by acoustical means. In this study, an algorithm based on multilayer feed forward neural networks is proposed for decomposition of tracheal sound into swallowing and respiratory segments. Among many features examined, root-mean-square of the signal, the average power of the signal over 150-450 Hz and waveform fractal dimension were selected features applied to the neural network as inputs. Findings from previous studies about temporal and durational patterns of swallowing and respiration were used in a smart algorithm for further identification of the swallow and breath segments. The proposed method was applied to 18 tracheal sound recordings of 7 healthy subjects (ages 13-30 years, 4 males). The results were validated manually by visual inspection using airflow measurement and spectrogram of the sounds and auditory means. The

algorithm was able to detect 91.7% of swallows correctly. The average of missed swallows and average of false detection were 8.3% and 9.5%, respectively. With additional preprocessing and post processing, the proposed method may be used for automated extraction of swallowing sounds from breath sounds in healthy and dysphagic individuals

117. Allen, G. M., B. P. Shortall, T. Gemci, T. E. Corcoran, and N. A. Chigier. 2004. Computational simulations of airflow in an in vitro model of the pediatric upper airways. *J Biomech.Eng* 126:604-613.
Abstract: In order to understand mechanisms of gas and aerosol transport in the human respiratory system airflow in the upper airways of a pediatric subject (male aged 5) was calculated using Computational Fluid Dynamic techniques. An in vitro reconstruction of the subject's anatomy was produced from MRI images. Flow fields were solved for steady inhalation at 6.4 and 8 LPM. For validation of the numerical solution, airflow in an adult cadaver based trachea was solved using identical numerical methods. Comparisons were made between experimental results and computational data of the adult model to determine solution validity. It was found that numerical simulations can provide an accurate representation of axial velocities and turbulence intensity. Data on flow resistance, axial velocities, secondary velocity vectors, and turbulent kinetic energy are presented for the pediatric case. Turbulent kinetic energy and axial velocities were heavily dependant on flow rate, whereas turbulence intensity varied less over the flow rates studied. The laryngeal jet from an adult model was compared to the laryngeal jet in the pediatric model based on Tracheal Reynolds number. The pediatric case indicated that children show axial velocities in the laryngeal jet comparable to adults, who have much higher tracheal Reynolds numbers than children due to larger characteristic dimensions. The intensity of turbulence follows a similar trend, with higher turbulent kinetic energy levels in the pediatric model than would be expected from measurements in adults at similar tracheal Reynolds numbers. There was reasonable agreement between the location of flow structures between adults and children, suggesting that an unknown length scale correlation factor could exist that would produce acceptable predictions of pediatric velocimetry based off of adult data sets. A combined scale for turbulent intensity as well may not exist due to the complex nature of turbulence production and dissipation

118. Bahoura, M. and C. Pelletier. 2004. Respiratory sounds classification using cepstral analysis and Gaussian mixture models. *Conf.Proc.IEEE Eng Med Biol Soc* 1:9-12.
Abstract: The Cepstral analysis is proposed with Gaussian Mixture Models (GMM) method to classify respiratory sounds in two categories: normal and wheezing. The sound signal is divided in overlapped segments, which are characterized by a reduced dimension feature vectors using Mel-Frequency Cepstral Coefficients (MFCC) or subband based Cepstral parameters (SBC). The proposed schema is compared with other classifiers: Vector Quantization (VQ) and Multi-Layer Perceptron (MLP) neural networks. A post processing is proposed to improve the classification results

119. Bentur, L., R. Beck, D. Berkowitz, J. Hasanin, I. Berger, N. Elias, and N. Gavriely. 2004. Adenosine bronchial provocation with computerized wheeze detection in young infants with prolonged cough: correlation with long-term follow-up. *Chest* 126:1060-1065.
Abstract: BACKGROUND: Chronic cough in babies is often associated with bronchial hyperreactivity (BHR). The objective documentation of BHR in babies is difficult, and acoustic methods have been described (provocative concentration of a substance causing wheeze) for conducting bronchial provocation tests (BPTs). We conducted a study to evaluate automatic computerized wheeze detection (CWD) in determining BHR in young infants with prolonged cough, and its correlation with the subsequent development of wheezing. METHODS: Infants aged < 24 months with prolonged cough (ie, > 2 months) underwent acoustic BPTs with the response determined by CWD and auscultation by a physician. Telephone interviews with parents were conducted after 1 month and yearly for the next 3 years. RESULTS: A total of 28 infants who were 4 to 24 months old with prolonged cough were included in the study. Twenty of these infants (71.4%) had BHR as determined by a positive acoustic BPT result. In 11 of these 20 tests, the CWD occurred earlier, and in 9 tests it occurred at the same step as auscultation by a physician. Rhonchi or whistles often preceded wheezes. Seventeen of the 20 patients with BHR completed 3 years of follow-up. Of these, 14 had recurrent episodes of wheezing and shortness of breath, and 3 were well. Six of the eight adenosine-negative patients completed 3 years of follow-up and had no symptoms of BHR. CONCLUSIONS: Acoustic BPT is a technically feasible test for the detection of BHR in young infants. CWD provides an earlier detection of wheeze than stethoscope auscultation. In our group of infants, a positive acoustic BPT result had high correlation with symptoms compatible with BHR over the next 3 years

120. Boque, M. C., B. Gualis, A. Sandiumenge, and J. Rello. 2004. Endotracheal tube intraluminal diameter narrowing after mechanical ventilation: use of acoustic reflectometry. *Intensive Care Med.* 30:2204-2209.
Abstract: OBJECTIVE: To quantify the incidence and degree of endotracheal tube intraluminal obstruction after mechanical ventilation and its relation to time of intubation. DESIGN: Prospective observational study. SETTING: A 14-bed medical-surgical intensive care unit at a university-affiliated teaching hospital. PATIENTS: Ninety-four endotracheal tubes used in 80 patients requiring mechanical ventilation for more than 12 h. INTERVENTIONS AND RESULTS: Acoustic reflectometry was performed in every endotracheal tube after patient extubation to measure its volume reduction. The intraluminal volumes of used endotracheal tubes in mechanically ventilated patients were significantly lower than those of unused tubes of the same size (5.52+/-0.92 ml(3) versus 6.54+/-0.79 ml(3), $p<0.05$). The mean difference in endotracheal tube segment volumes was 15.2% (range 0-66%). Volume

reduction was above 10% in 60.8% of the tubes. In 22% of endotracheal tubes the remaining inner diameter was less than 7 mm. Reduction below this figure was less frequent (9.3%) in tubes 8 mm or more ($p<0.05$). The percentage of endotracheal tube volume reduction was not associated with the duration of intubation ($r=-0.09$, p= n.s.) Peak pressure measured before extubation did not predict obstruction ($r=0.11$, p= n.s.). CONCLUSIONS: Inadvertent endotracheal tube obstruction was common in patients requiring mechanical ventilation and may be significant as early as at 24 h. Moderate obstruction in endotracheal tube lumens should be suspected in cases of difficulties in weaning, even in patients who were ventilated for less than 1 day

121. Brown, J. A., F. J. Derksen, J. A. Stick, W. M. Hartmann, and N. E. Robinson. 2004. Effect of laryngoplasty on respiratory noise reduction in horses with laryngeal hemiplegia. *Equine Vet.J* 36:420-425.
Abstract: REASONS FOR PERFORMING STUDY: Laryngoplasty is the technique of choice for treatment of laryngeal hemiplegia, with the aim of improving airway function and/or eliminating respiratory noise. However, there are no quantitative data in the literature describing the effect of laryngoplasty on upper airway noise or its relationship to upper airway mechanics in horses with laryngeal hemiplegia. OBJECTIVES: To determine whether laryngoplasty reduces respiratory noise in exercising horses with laryngeal hemiplegia; and to establish whether the degree of upper airway obstruction can be predicted by upper airway noise, or the degree of arytenoid abduction correlated with airway obstruction and noise production. METHODS: Six Standardbred horses with normal upper airways during maximal exercise were used. Respiratory sounds and inspiratory transupper airway pressure (Pui) were measured in all horses before and after induction of laryngeal hemiplegia and 30, 60 and 90 days after laryngoplasty. Inspiratory sound level (SL) and the sound intensity of the 3 inspiratory formants (F1, F2 and F3, respectively) were measured using a computer-based sound analysis programme. The degree of abduction was graded by endoscopic visualisation 1, 30, 60 and 90 days post operatively. Linear regression analysis was used to determine correlations between Pui, sound indices and grades of arytenoid abduction. RESULTS: In laryngeal hemiplegia-affected horses, Pui, inspiratory SL and the sound intensity of F1, F2 and F3 were significantly increased. At 30 days following laryngoplasty, the sound intensity of F1 and Pui returned to baseline values. The sound intensities of F2, F3 and SL were significantly improved from laryngeal hemiplegia values at 30 days post operatively, but did not return to baseline at any measurement period. Sound level, F2 and F3 were significantly correlated with Pui ($P<0.05$), but the correlations were weak ($r2 = 0.26$, 035 and 0.40, respectively). Grade of abduction and F2 were positively and significantly correlated ($P<0.006$, $r2 = 0.76$). Grade of arytenoid abduction and Pui were not correlated ($P = 0.12$). CONCLUSIONS: Laryngoplasty reduced inspiratory noise in laryngeal hemiplegia-affected horses by 30 days following surgery, but did not return it to baseline values. While upper airway noise and Pui were correlated, this relationship was insufficiently strong to predict Pui from noise in individual animals. The degree of arytenoid abduction was not correlated with Pui, but was positively correlated with noise production. POTENTIAL RELEVANCE: Laryngoplasty reduces upper airway noise in horses with laryngeal hemiplegia, but is not as effective as bilateral ventriculocordectomy in this regard, although respiratory noise reduction occurs more rapidly than with bilateral ventriculocordectomy. Residual noise during exercise cannot be used as a predictor of improvement in upper airway function in individual horses following laryngoplasty. The degree of arytenoid abduction obtained following surgery does not affect upper airway flow mechanics. Interestingly, we found that the greater the arytenoid abduction, the louder the respiratory noise

122. Charleston-Villalobos, S., S. Cortes-Rubiano, R. Gonzalez-Camarena, G. Chi-Lem, and T. jama-Corrales. 2004. Respiratory acoustic thoracic imaging (RATHI): assessing deterministic interpolation techniques. *Med.Biol.Eng Comput.* 42:618-626.
Abstract: As respiratory sounds contain mechanical and clinical pulmonary information, technical efforts have been devoted during the past decades to analysing, processing and visualising them. The aim of this work was to evaluate deterministic interpolating functions to generate surface respiratory acoustic thoracic images (RATHIs), based on multiple acoustic sensors. Lung sounds were acquired from healthy subjects through a 5 x 5 microphone array on the anterior and posterior thoracic surfaces. The performance of five interpolating functions, including the linear, cubic spline, Hermite, Lagrange and nearest neighbour method, were evaluated to produce images of lung sound intensity during both breathing phases, at low (approximately 0.5ls(-1)) and high (approximately 1.0ls(-1)) airflows. Performance indexes included the normalised residual variance nrv (i.e. inaccuracy), the prediction covariance cv (i.e. precision), the residual covariance rcv (i.e. bias) and the maximum squared residual error semax (i.e. tolerance). Among the tested interpolating functions and in all experimental conditions, the Hermite function (nrv=0.146 +/- 0.059, cv= 0.925 +/- 0.030, rcv = -0.073 +/- 0.068, semax = 0.005 +/- 0.004) globally provided the indexes closest to the optimum, whereas the nearest neighbour (nrv=0.339 +/- 0.023, cv = 0.870 +/- 0.033, rcv= 0.298 +/- 0.032, semax = 0.007 +/- 0.005) and the Lagrange methods (nrv = 0.287 +/- 0.148, cv = 0.880 +/- 0.039, rcv = -0.524 +/- 0.135, semax = 0.007 +/- 0.0001) presented the poorest statistical measurements. It is concluded that, although deterministic interpolation functions indicate different performances among tested techniques, the Hermite interpolation function presents a more confident deterministic interpolation for depicting surface-type RATHI

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Abstract: In this study, adaptive filtering techniques have been used in an attempt to model the respiratory system. The respiratory system has been considered as a dynamic system for which input-output relationship is to be defined. Simultaneous measurement

of the respiratory sounds over the trachea and posterior chest were made, with the signal from the trachea forming the input to a finite impulse response filter and the signal from the posterior chest forming the desired response of the filter. The chest cavity was stimulated with speech sounds. Least-mean square algorithm was used to update filter coefficients. The learning curves of the filter are presented in the paper. It can be concluded that adaptive filtering is a promising way to characterize transmission characteristics of the respiratory system and further improvement may be obtained if anatomical information is integrated in the modeling process

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Abstract: In a rural community in South Africa historically exposed to asbestos environmentally and occupationally, 200 women who had worked with asbestos and applied for medical examination to determine compensable asbestos disease were evaluated. Clinical and radiologic evaluation, sputum collection, and microscopic analysis were done. A questionnaire elicited type of exposure, duration, decade of first work exposure, and environmental exposure. Crackles were present in the lungs of 166 women and asbestos fibers and ferruginous bodies were present in 122. Asbestosis was identified in 26 and plural plaques in 62. Auscultation for crackles (rales) is useful in the initial examination of former asbestos workers in rural communities of developing countries

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Abstract: A general scheme is proposed to explain the observed spectral properties of high-frequency human respiratory sounds in terms of the interaction between the respiratory flux and a bronchial tree of fractal properties. The air flux is treated as composed of discrete decoupled elements while the tree is assumed to have a Cantor-based geometry. According to this model, the affine behavior often observed in the high-frequency (log-log) spectral range is a direct consequence of the fractal geometry of the bronchial tree in both qualitative and quantitative aspects. This strongly indicates that the dynamics underlying the high-frequency sound generation must have at most nondominant couplings between the relevant fluid components

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Abstract: OBJECTIVE: To investigate the validity and reliability of computerised acoustic analysis in the detection of abnormal respiratory noises in infants. METHODS: Blinded, prospective comparison of acoustic analysis with stethoscope examination. Validity and reliability of acoustic analysis were assessed by calculating the degree of observer agreement using the kappa statistic with 95% confidence intervals (CI). RESULTS: 102 infants under 18 months were recruited. Convergent validity for agreement between stethoscope examination and acoustic analysis was poor for wheeze (kappa = 0.07 (95% CI, -0.13 to 0.26)) and rattles (kappa = 0.11 (-0.05 to 0.27)) and fair for crackles (kappa = 0.36 (0.18 to 0.54)). Both the stethoscope and acoustic analysis distinguished well between sounds (discriminant validity). Agreement between observers for the presence of wheeze was poor for both stethoscope examination and acoustic analysis. Agreement for rattles was moderate for the stethoscope but poor for acoustic analysis. Agreement for crackles was moderate using both techniques. Within-observer reliability for all sounds using acoustic analysis was moderate to good. CONCLUSIONS: The stethoscope is unreliable for assessing respiratory sounds in infants. This has important implications for its use as a diagnostic tool for lung disorders in infants, and confirms that it cannot be used as a gold standard. Because of the unreliability of the stethoscope, the validity of acoustic analysis could not be demonstrated, although it could discriminate between sounds well and showed good within-observer reliability. For acoustic analysis, targeted training and the development of computerised pattern recognition systems may improve reliability so that it can be used in clinical practice

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Abstract: BACKGROUND: Fractal structures or processes, many of which are found in nature, are marked by the presence of a formal pattern that repeats itself even as the scale changes, a property termed 'self-similarity'. The bronchial tree is structurally a fractal system and inspiration is a fractal process. Our objective was to show that the dynamic process of emptying air from the bronchi as measured by tracheal sounds should also behave fractally over the period of time during which exhalation takes place. MATERIAL/METHODS: Twenty non-smoking patients (9 males and 11 females) aged 53.6+/-16.3 years with persistent but clinically stable moderate to severe asthma and a control group of 11 healthy non-smoking subjects (6 males and 5 females) aged 46.0+/-12.5 years were enrolled. Respiratory sounds were registered using a microphone held by an elastic band directly against the patient's skin at the level of the cricoid cartilage. Analysis was done on the average of three forced expirations made after a deep inspiration. The Hurst's coefficient was computed by Hurst's rescaled range analysis (H) and by analysis of the variance-time relationship of the aggregated process (H_v). RESULTS: Values of H and H_v were around 0.75, indicating that the sound signals were fractal over time. The responses of controls and patients to bronchodilator administration of 1 mg terbutaline were similar

(p>0.05). Mean intra-subject variation coefficients were less than 15%. CONCLUSIONS: This analysis of tracheal sound during forced expiratory maneuvers confirms the dynamic fractal behavior of the respiratory system

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Abstract: Despite extensive research in the area of identification and discrimination of tracheal-bronchial breath sounds by computer analysis, the process of identifying auscultated sounds is still subject to high estimation uncertainties. Here we assess the performance of the relatively new constructive probabilistic neural network (CPNN) against the more common classifiers, namely the multilayer perceptron (MLP) and radial basis function network (RBFN), in classifying a broad range of tracheal-bronchial breath sounds. We present our data as signal estimation models of the tracheal-bronchial frequency spectra. We have examined the trained structure of the CPNN with respect to the other architectures and conclude that this architecture offers an attractive means with which to analyse this type of data. This is based partly on the classification accuracies attained by the CPNN, MLP and RBFN which were 97.8, 77.8 and 96.2%, respectively. We concluded that CPNN and RBFN networks are capable of working successfully with this data, with these architectures being acceptable in terms of topological size and computational overhead requirements. We further believe that the CPNN is an attractive classification mechanism for auscultated data analysis due to its optimal data model generation properties and computationally lightweight architecture

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Abstract: REASONS FOR PERFORMING STUDY: To develop the technique of respiratory sound analysis for the diagnosis of dorsal displacement of the equine soft palate. OBJECTIVES: To show that 1) the displaced soft palate can spontaneously vibrate in the presence of expiratory airflow; 2) the observed frequency of vibration can be detected in respiratory sound recordings; and 3) the frequency of vibrations measured in cadaveric specimens are similar to those obtained from audio spectra in exercising horses with DDSP. METHODS: Palatal movements and respiratory sounds were recorded from artificially ventilated cadaveric heads. The fundamental mode of palate vibrations calculated from high-speed videoendoscopic recordings was compared with frequencies detected in the audio spectra and with data collected from exercising horses with DDSP. RESULTS: Palate vibrations occurred when air was blown through the trachea. The fundamental mode of vibrations was present in the audio spectra and was not significantly different from those recorded in vivo. CONCLUSIONS: Vibrations of the soft palate are the probable source of expiratory sounds recorded in horses with DDSP. POTENTIAL RELEVANCE: This study strengthens the case for the application of respiratory sound analysis in the diagnosis of DDSP in exercising horses

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Abstract: The present study was designed to compare the clinical finding of wheeze by auscultation with an objective evaluation by acoustic means at the endpoint of a bronchial challenge in preschool children. Challenges were undertaken using a tidal breathing method in 51 preschool children as part of the investigation of possible asthma. An electronic stethoscope was used for auscultation of each lung and for the simultaneous recording of the acoustic sonogram for analysis. In 24 children, the pediatrician determined that the challenge was positive, and in 22 of these, he heard wheezing at the endpoint of the challenge. In 2 children the challenge was considered positive, based on a modest fall in saturation. The acoustic record was scanned manually for presence of wheeze defined in terms of duration, and power spectrum without reference to auscultatory findings. In positive challenges, the mean wheeze rate was 28.1% (95% CI, 19.5-36.8%), while no wheeze was detected acoustically in negative challenges. Using a cutoff wheeze rate (duration of wheeze/duration of breath phase x100) of 10% for the whole group, clinical wheezing detected by the pediatrician had a sensitivity of 100% (no false negatives) and a specificity of 91%. In conclusion, the clinical observation of wheeze agrees very well with its detection by acoustic measurement at the endpoint of a bronchial challenge in preschool children

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Abstract: The fundamental frequency of vocal fold oscillation (F(0)) is controlled by laryngeal mechanics and aerodynamic properties. F(0) change per unit change of transglottal pressure (dF/dP) using a shutter valve has been studied and found to have nonlinear, V-shaped relationship with F(0). On the other hand, the vocal tract is also known to affect vocal fold oscillation. This study examined the effect of artificially lengthened vocal tract length on dF/dP. dF/dP was measured in six men using two mouthpieces of different lengths. Results: The dF/dP graph for the longer vocal tract was shifted leftward relative to the shorter one. Conclusion: Using the one-mass model, the nadir of the "V" on the dF/dP graph was strongly influenced by the resonance around the first formant frequency. However, a more precise model is needed to account for the effects of viscosity and turbulence

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Abstract: The aim of this study was to test the hypothesis that the mechanism of recruitment and the lower knee of the pressure-volume curve in the normal lung are primarily determined by airway reopenings via avalanches rather than simple alveolar recruitments. In isolated dog lung lobes, the pressure-volume loops were measured, and crackle sounds were recorded intrabronchially during both the first inflation from the collapsed state to total lobe capacity and a second inflation without prior degassing. The inflation flow contained transients that were accompanied by a series of crackles. Discrete volume increments were estimated from the flow transients, and the energy levels of the corresponding crackles were calculated from the sound recordings. Crackles were concentrated in the early phase of inflation, with the cumulative energy exceeding 90% of its final value by the lower knee of the pressure-volume curve. The values of volume increments were correlated with crackle energy during the flow transient for both the first and the second inflations (r(2) = 0.29-0.73 and 0.68-0.82, respectively). Because the distribution of volume increments followed a power law, the correlation between crackle energy and discrete volume increments suggests that an avalanche-like airway opening process governs the recruitment of collapsed normal lungs

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Abstract: The objective of the present work was to detect and analyze wheezes by means of a highly sensitive time-frequency algorithm. Automatic measurements were compared with clinical auscultation for forced exhalation segments from 1.2 to 0 liters/second (l/s). Sensitivities between 100% and 71%, as a function of flow level related to wheezing segments detection, were achieved. Time-frequency wheeze parameters were measured for the flow range from 1.2 to 0.2 l/s. Wheezes were detected in both analyzed groups; asthmatics (N = 16) and control subjects (N = 15). Significant differences between groups were found for the mean number of wheezes detected at basal condition ($p = 0.0003$). Frequency parameter differences were also significant ($0.0112 < p < 0.0307$). All these parameters were also studied after applying a bronchodilator drug (Terbutaline). Significant differences between patient groups were found when studying the changes in the number of wheezes for each patient ($p = 0.0195$). Finally, limited bandwidth parameters, which measure the bronchodilator response, were also studied

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Abstract: Respiratory sound analysis can offer important information related to pulmonary diseases. Wheezes have been reported as adventitious respiratory sounds in asthmatic or obstructive patients, during forced exhalation maneuvers. In this work, we propose a method for analysis of respiratory sounds in frequency domain, during spontaneous ventilation. Two databases were analyzed: signals acquired during spirometry (DBspir), composed by 23 subjects (N=15 asthmatics, N=8 control); and signals acquired during spontaneous ventilation for 120 seconds (DBsv), composed by 26 asthmatics. Using an autoregressive model (AR, order 16), it was calculated the Power Spectral Density (PSD) for each expiration and the peak frequency (fp) was estimated. Higher values of fp were found in asthmatic patients with severe obstruction in relation to light obstruction or control subjects. The effect of bronchodilator inhalation in asthmatic patients was studied in the database DBsv, analyzing contribution of wheezes in the bandwidth 600-2000 Hz (HFband)., Differences of number of respiratory cycles with wheezes (Dwheez index), before and after bronchodilator inhalation were evaluated. It was found a good correlation between Dwheez and FEV1% improvement (FEV1>%_imp), for FEV1%_imp > 10%. This method could predict the FEV1%_imp by means of estimation of Dwheez index during spontaneous ventilation

135. Kamal, I. 2004. Test-retest validity of acoustic pharyngometry measurements. *Otolaryngol.Head Neck Surg.* 130:223-228.
Abstract: BACKGROUND: Acoustic reflectometry is a relatively new technique that quantifies upper airway obstruction. The oropharyngeal airway is geometrically complex and variable; therefore establishing a standard operating protocol and understanding the possible sources of artifacts are of great importance in obtaining reliable results. This work aims at assessing the repeatability of pharyngeal cross-sectional area measurements obtained from normal and snoring individuals. METHODS: Twenty adult normal volunteers (16 men and 4 women; mean age, 35.9 years) and 10 adult snorers (9 men and 1 woman; mean age, 36.4 years) were examined by acoustic reflectometry following the developed standard operating protocol. RESULTS: Measurements of pharyngeal cross-sectional area are analyzed in 2 groups. In normal subjects where mean pharyngeal cross-sectional area in the first session was 3.187 cm(2), in the second session (same-day test-retest), the mean pharyngeal cross-sectional area was 3.239 cm(2), and in the third session 7 to 10 days later (day-to-day test-retest), it was 3.245 cm(2) ($P > 0.4$). In a second group of snoring patients where mean pharyngeal cross-sectional area in the first session was 2.244 cm(2), in the second session, mean pharyngeal cross-sectional area was 2.237 cm(2), and mean pharyngeal cross-sectional area in the third session (7 to 10 days later) was 2.238 cm(2) ($P > 0.9$). CONCLUSIONS: These results show that repeatability of acoustic reflection results can be achieved following the standard operating protocol. SIGNIFICANCE: The study results add to the reliability of this technique in assessing the pharyngeal airway in patients with snoring and obstructive sleep apnea

136. Kamal, I. 2004. Acoustic pharyngometry patterns of snoring and obstructive sleep apnea patients. *Otolaryngol.Head Neck Surg.* 130:58-66.
Abstract: OBJECTIVE: Anatomic narrowing of the pharyngeal airway increases the relative negative pressure generated during inspiration, thus affecting the dynamic behavior of the upper airway. The aim of this work was to measure pharyngeal area in snoring patients with and without obstructive sleep apnea (OSA), as categorized by polysomnography and by acoustic pharyngometry, and to analyze the different curve patterns obtained from patients of both groups. METHODS: We examined 50 snorers who were divided into 2 groups matched for age, gender, and body mass index. RESULTS: Mean Apnea Index (AI) in nonapneic snorers (group 1) was 4, and mean pharyngeal area was 2.41 cm(2). In snoring patients with OSA (group 2), mean AI was 25.9 with a mean pharyngeal area of 1.589 cm(2) ($P < 0.001$). In both groups, the dependent variable (AI) can be predicted from a linear relation with the independent variable (pharyngeal area) with normality and constant variance tests passed. In group 1, the resulting curve can be 1 of 2 types depending on the relative area of the pharyngeal segment to the velopharyngeal area. In group 2, the curve pattern can be categorized into 3 patterns depending on the possible pathology of pharyngeal obstruction. CONCLUSION: The acoustic reflection technique is reproducible, noninvasive, and free from potential side effects. The good correlation between AI and pharyngeal area adds to the potential of acoustic pharyngometry. Careful study of the pharyngeal cross-sectional area and curve topography may give a good idea about the site of upper airway obstruction

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Abstract: Electronic auscultation is an efficient technique to evaluate the condition of respiratory system using lung sounds. As lung sound signals are non-stationary, the conventional method of frequency analysis is not highly successful in diagnostic classification. This paper deals with a novel method of analysis of lung sound signals using wavelet transform, and classification using artificial neural network (ANN). Lung sound signals were decomposed into the frequency subbands using wavelet transform and a set of statistical features was extracted from the subbands to represent the distribution of wavelet coefficients. An ANN based system, trained using the resilient back propagation algorithm, was implemented to classify the lung sounds to one of the six categories: normal, wheeze, crackle, squawk, stridor, or rhonchus

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Abstract: Cervical auscultation is experiencing a renaissance as an adjunct to the clinical swallowing assessment. It is a controversial technique with a small evidence base. We have aimed to establish whether cervical auscultation interpretation is based on the actual sounds heard or, in practice, influenced by information gleaned from other aspects of the clinical assessment, medical notes, or previous knowledge. We sought to determine (a) rater reliability and its impact on the clinical value of cervical auscultation and (b) how judgments compare with the "gold standard": videofluoroscopy. Swallow sounds were computer recorded via a Littmann stethoscope. Sounds were sampled from 10 healthy control swallows with no aspiration/penetration and 10 patient swallows with aspiration/penetration, all recorded during simultaneous videofluoroscopy. The system generated sound quality similar to "live" bedside listening, a feature rarely seen in cervical auscultation studies. The 20 sound clips were classified as "normal" or "abnormal" by 19 volunteer speech-language pathologists with experience in cervical auscultation. After at least four weeks, 11 of these judges rated the sounds rerandomized on a new CD. Intrarater reliability kappa ranged from -0.12 to 0.71. Individual reliability did not correlate with years of experience, practice pattern, or frequency of use. Interrater reliability kappa = 0.17. Comparison with radiologically defined aspiration/penetration yielded 66% specificity, 62% sensitivity, and majority consensus gave 90% specificity, 80% sensitivity. There was a significant relationship between individual reliability and true positive rate ($r(s) = 0.623$, $p = 0.040$). The reliability of individual judges varied widely and thus, inevitably, agreement between judges was poor. Validity is dependent upon reliability: Improving the poor raters would improve the overall accuracy of this technique in predicting abnormality in swallowing. The group consensus correctly identified 17 of the 20 clips so we may speculate that the swallow sound contains audible cues that should in principle permit reliable classification

139. Levy, M. L., S. Godfrey, C. S. Irving, A. Sheikh, W. Hanekom, A. Bush, and P. Lachman. 2004. Wheeze detection: recordings vs. assessment of physician and parent. *J.Asthma* 41:845-853.
Abstract: BACKGROUND: Parental and professional agreement as to the presence of wheezing in infants and preschool children has been shown to be poor. Agreement on the absence or presence of physical signs on chest examination in these populations is far from perfect, even among experienced physicians. OBJECTIVES: We sought to compare the assessment of a parent, nurse, and physician with the "gold standard" of acoustic analysis for the presence of wheezing in infants and preschool children attending a hospital clinic. SETTING AND SUBJECTS: Urban district general hospital in North London, England. Wheezy children under 6 years old attending a "walk-in" emergency pediatric ambulatory care unit. RESULTS: Comparisions were completed on 31 children (age range 4-62 months). The severity of wheeze was independently evaluated by a parent, nurse, and experienced pediatrician, and these were compared with breath sounds recorded and analyzed by acoustic techniques for the presence and severity of wheezing. In only 10 of 31 (32%) children did the parent and the physician agree on the wheeze severity score. In 13 infants, the parent scored higher than the doctor and in 8 the parent scored lower. In 16 (52%) of the children, there was complete

agreement as to the severity of wheezing by the nurse and the physician. In 24 of the 31 children (77%), the acoustic wheeze score agreed with the physician wheeze score; in 6 children the acoustic score was lower and in 1 it was higher. CONCLUSIONS: The physician was able reliably to judge the severity of wheeze measured objectively, whereas nurses and parents were not. This study has important implications for the interpretation of parental questionnaire studies of asthma prevalence and severity

140. Lowe, L., C. S. Murray, L. Martin, J. Deas, E. Cashin, G. Poletti, A. Simpson, A. Woodcock, and A. Custovic. 2004. Reported versus confirmed wheeze and lung function in early life. *Arch Dis Child* 89:540-543.
Abstract: AIMS: To investigate the relation between parentally reported wheeze (unconfirmed), physician confirmed wheeze, and subsequent lung function. METHODS: Children at risk of allergic disease (one parent atopic) were recruited antenatally and followed prospectively from birth. During the first three years of life parents were asked to contact the study team if their child was wheezy. The presence of wheeze was confirmed or not by the primary care or study physician. Respiratory questionnaire and specific airway resistance measurement (sR(aw), body plethysmograph) were completed at age 3 years. RESULTS: A total of 454 children were followed from birth to 3 years of age. One hundred and eighty six (40.9%) of the parents reported their child wheezing in the first three years of life, and in 130 (28.6%) the wheeze was confirmed. A total of 428 children attended the three year clinic review, of whom 274 (64%) successfully carried out lung function tests. There was no significant difference in sR(aw) (kPa.s; geometric mean, 95% CI) between children who had never wheezed (n = 152; 1.03, 1.00 to 1.06) and those with a parentally reported but unconfirmed wheeze (n = 36; 1.02, 0.96 to 1.07, p = 1.00). sR(aw) was significantly higher in children with a physician confirmed wheeze (n = 86; 1.17, 1.11 to 1.22, $p < 0.001$) compared to those with no history of wheeze or with unconfirmed wheeze. CONCLUSIONS: Children with physician confirmed wheeze have significantly poorer lung function compared to those with parentally reported but unconfirmed and those who have never wheezed. A proportion of parents may have little understanding of what medical professionals mean by the term "wheeze"

141. Luo, X. Y., J. S. Hinton, T. T. Liew, and K. K. Tan. 2004. LES modelling of flow in a simple airway model. *Med Eng Phys* 26:403-413.
Abstract: Detailed information about the flow field pattern is highly important in accurately predicting particle deposition sites in the human airway. Flow in the upper airway during heavy breathing can have a Reynolds number as high as 9300, and therefore presents turbulent features. Although turbulence is believed to have an important effect on the airflow and other transport processes in the bronchial tree, to date both theoretical and numerical studies have predominantly assumed the flow to be laminar. In this paper, transitional/turbulent flow during inspiration is studied using a large eddy simulation (LES) in a single asymmetric bifurcation model of human upper airway. The influence of the non-laminar flow on the patterns and the particle paths is investigated in both 2D and 3D models. Throughout the investigation, comparisons with the laminar and conventional k- models for the same configuration and flow conditions are made. The LES model is also carefully validated against published experimental data in a stenotic tube model. The results demonstrate that the LES model is capable of capturing instantaneous eddy formation and flow separation in (almost) laminar, transitional and turbulent flow regimes, and hence may be used as a powerful and practical tool to provide much of the detailed flow information required for tracing the particle trajectories and particle deposition in human airways

142. Marques, V. C. and W. T. nselmo-Lima. 2004. Pre- and postoperative evaluation by acoustic rhinometry of children submitted to adenoidectomy or adenotonsillectomy. *Int.J Pediatr.Otorhinolaryngol.* 68:311-316.
Abstract: INTRODUCTION: Nasal obstruction is a common symptom in children and its etiology includes septal deviation, choanal atresia, allergic rhinitis and hypertrophy of the adenoids. Hypertrophy of the adenoids and hypertrophic rhinitis are the most frequent causes of nasal obstruction in the pediatric population, with adenoidectomy being the main surgery carried out during childhood. OBJECTIVE: To analyze the rhinograms of children with nasal obstruction before and after surgery and to compare them with those obtained for children without respiratory complaints. STUDY DESIGN: A clinical prospective study. METHODS: Thirty-five patients with adenoid or adenotonsillar hypertrophy were submitted to otolaryngologic examination and acoustic rhinometry before and 30-60 days after surgery. The control group consisted of 18 children without nasal complaints. RESULTS: Significant differences in the rhinograms were observed before and after surgery, but not between patients and the control group. CONCLUSION: We conclude that acoustic rhinometry is well tolerated by children, and is a rapid and noninvasive method. The technique is valuable for interindividual comparisons, but not for the assessment of different groups

143. Murphy, R. L., A. Vyshedskiy, V. A. Power-Charnitsky, D. S. Bana, P. M. Marinelli, A. Wong-Tse, and R. Paciej. 2004. Automated lung sound analysis in patients with pneumonia. *Respir.Care* 49:1490-1497.
Abstract: OBJECTIVE: To determine whether objectively detected lung sounds were significantly different in patients with pneumonia than those in asymptomatic subjects, and to quantify the pneumonia findings for teaching purposes. METHODS: At a community teaching hospital we used a multi-channel lung sound analyzer to examine a learning sample of 50 patients diagnosed with pneumonia and 50 control subjects. Automated quantification and characterization of the lung sounds commonly recognized to be associated with pneumonia were used to generate an "acoustic pneumonia score." These were examined in the learning

sample and then prospectively tested in 50 patients and 50 controls. RESULTS: The acoustic pneumonia score averaged 13 in the learning sample and 11 in the test sample of pneumonia patients. The scores were 2 and 3 in the controls. The positive predictive value of a score higher than 6 was 0.94 in the learning sample and 0.87 in the test sample. The sensitivities in the 2 groups were 0.90 and 0.78, and the specificities were 0.94 and 0.88, respectively. Adventitious sounds were more common in pneumonia patients (inspiratory crackles 81% vs 28%, expiratory crackles 65% vs 9%, rhonchi 19% vs 0%). CONCLUSION: Our lung sound analyzer found significant differences between lung sounds in patients with pneumonia and in asymptomatic controls. Computerized lung sound analysis can provide objective evidence supporting the diagnosis of pneumonia. We believe that the lung-sound data produced by our device will help to teach physical diagnosis

144. Nakano, H., M. Hayashi, E. Ohshima, N. Nishikata, and T. Shinohara. 2004. Validation of a new system of tracheal sound analysis for the diagnosis of sleep apnea-hypopnea syndrome. *Sleep* 27:951-957.
Abstract: STUDY OBJECTIVES: To evaluate the validity of a novel method of using tracheal sound analysis for the diagnosis of sleep apnea-hypopnea syndrome. DESIGN: Retrospective analysis in consecutive patients. SETTING: A sleep clinic in a general hospital. PATIENTS: A total of 383 patients who were referred for suspected sleep apnea-hypopnea syndrome and underwent diagnostic polysomnography with sufficient quality. INTERVENTIONS: N/A. MEASUREMENTS AND RESULTS: Ordinary polysomnography with simultaneous tracheal sound recording was performed. The apnea-hypopnea index (AHI) was calculated as the number of apnea and hypopnea events per hour of sleep. Tracheal sounds were digitized and recorded as power spectra. An automated computer program detected transient falls (TS-dip) in the time series of moving average of the logarithmic power of tracheal sound. We defined the tracheal sound-respiratory disturbance index (TS-RDI) as the number of TS-dips per hour of examination. We also calculated the oxygen desaturation index (the number of SaO2 dips of at least 4% per hour of examination). The TS-RDI highly correlated with AHI (r = 0.93). The mean (+/- SD) difference between the TS-RDI and AHI was -8.4 +/- 10.4. The diagnostic sensitivity and specificity of the TS-RDI when the same cutoff value was used as for AHI were 93% and 67% for the AHI cutoff value of 5 and 79% and 95% for the AHI cutoff value of 15. The agreement between the TS-RDI and AHI was better than that between the oxygen desaturation index and AHI. CONCLUSIONS: The fully automated tracheal sound analysis demonstrated a relatively high performance in the diagnosis of sleep apnea-hypopnea syndrome. We think that this method is useful for the portable monitoring of sleep apnea-hypopnea syndrome

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Abstract: A parallel supercomputer model based on realistic tissue data is developed for sound propagation in the human thorax and the sound propagation behavior is analyzed under various conditions using artificial sound sources. The model uses the Visible Human male data set for a realistic representation of the human thorax. The results were analyzed in time and frequency domains. The analysis suggests that lower frequencies of around 100 Hz are more effectively transmitted through the thorax and that the spatial confinement of sound waves within the thorax results in a resonance effect at around 1500 Hz. The results confirm previous studies that show the size of the thorax plays a significant role in the type of sound generated at the chest wall

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Abstract: We analysed respiration sounds of individual asthmatic patients, in the scope of the development of a method for computerized recognition of the degree of airway obstruction. Respiration sounds were recorded during laboratory sessions of histamine-provoked airway obstruction. We applied an interpolation technique using supervised artificial neural networks to investigate the optimal frequency band required for studying tracheal asthmatic lung sounds. The optimal band was found to be 100-2300 Hz. The forced expiratory volume in 1 s (FEV1) and the respiratory resistance parameter Rrs(4) were used to describe the degree of airway obstruction that is associated with the lung sounds. By comparing the results obtained with the two parameters, we found that for parametrization of the associated degree of airway obstruction respiratory resistance measurements are preferable over forced expiratory volume measurements

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149. Polat, H. and I. Guler. 2004. A simple computer-based measurement and analysis system of pulmonary auscultation sounds. *J.Med.Syst.* 28:665-672.
Abstract: Listening to various lung sounds has proven to be an important diagnostic tool for detecting and monitoring certain types of lung diseases. In this study a computer-based system has been designed for easy measurement and analysis of lung sound

using the software package DasyLAB. The designed system presents the following features: it is able to digitally record the lung sounds which are captured with an electronic stethoscope plugged to a sound card on a portable computer, display the lung sound waveform for auscultation sites, record the lung sound into the ASCII format, acoustically reproduce the lung sound, edit and print the sound waveforms, display its time-expanded waveform, compute the Fast Fourier Transform (FFT), and display the power spectrum and spectrogram

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Abstract: Several clinical and ambulatory settings necessitate respiratory monitoring without a mouthpiece or facemask. Several studies have demonstrated the utility of breathing sound measurements performed on the chest or neck to detect airflow. However, there are limitations to skin surface measurements, including susceptibility to external noise and transducer motion. Thus, this two-part study investigated a novel location for breathing sound measurements: the external ear. The first study investigated characteristics of sound transmission from the oropharynx to the external ear in 19 adults (nine males). Broadband noise was directed into the oropharynx through a tube and mouthpiece and measured indirectly via an accelerometer affixed to the cheek. Resultant transmission to the external ear was measured with a microphone inserted into an earplug that provided acoustic isolation from ambient noise. Near-unity coherence estimates (> 0.9) between the sounds recorded at the external ear and the oropharynx were observed up to approximately 800 Hz, indicating a low-frequency region of preferred transmission. In the second study, each of 20 subjects (nine males) breathed through a pneumotachograph at targeted shallow (3.0 mL/s/kg) and tidal (7.5 mL/s/kg) flows normalized to body mass, and the resulting sounds were recorded at the external ear. Recordings during breath hold measured background noise. Shallow and tidal expiratory flows, respectively, produced signal-plus-noise-to-noise [(S + N)/N] ratios of 6.7 +/- 4.1 dB and 14.0 +/- 5.3 dB (mean +/- standard deviation) across all subjects between 150 and 300 Hz. Concurrent inspiration demonstrated (S + N)/N ratios of 6.6 +/- 3.9 dB and 14.9 +/- 6.3 dB. Thus, the external ear shows promise as an anatomic site to detect and monitor breathing in a relatively noninvasive and unobtrusive manner

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Abstract: Previous studies have suggested that acoustic analysis may be useful in distinguishing different types of snoring prior to possible corrective surgery. This study aimed to establish whether it could replace sleep nasendoscopy in a clinical setting. Thirty-five patients undergoing sleep nasendoscopy had their snoring recorded and analysed using commercially available equipment. It was found that centre frequency can be used to distinguish pure palatal from tongue base snoring, with a clear cut-off value of 90 Hz between the two. Multisegmental snoring cannot be identified on the basis of centre frequency alone. It may be distinguished from tongue base, but not palatal snoring by the nature of the frequency distribution plot (sensitivity 77%, specificity 81%). Blinded assessment of waveforms of individual snores gave poor accuracy (53%) and poor interobserver agreement (kappa = 0.10). Acoustic analysis may help screen for pure tongue base snoring. However, we feel that it is unlikely to replace sleep nasendoscopy

152. Shah, C. and M. H. Kollef. 2004. Endotracheal tube intraluminal volume loss among mechanically ventilated patients. *Crit Care Med* 32:120-125.
Abstract: OBJECTIVE: To measure endotracheal tube intraluminal volume loss among mechanically ventilated patients. DESIGN: Prospective observational study. SETTING: Medical intensive care unit (19 beds) of an urban university-affiliated teaching hospital. PATIENTS: A total of 101 patients with acute respiratory failure requiring >24 hrs of mechanical ventilation. INTERVENTIONS: None. MEASUREMENTS AND MAIN RESULTS: Acoustic reflectometry was employed to measure the intraluminal volume of 13-cm endotracheal tube segments. The endotracheal tube segment volumes were statistically smaller among endotracheal tubes used in patients compared with unused endotracheal tubes (5.4 +/- 0.7 vs. 6.0 +/- 0.6 mL, p <.001). The average percentage difference in endotracheal tube segment volumes, between the unused endotracheal tubes and the endotracheal tubes used in patients, was 9.8% (range, 0-45.5%). The percentage difference in the endotracheal tube segment volumes increased significantly with increasing duration of tracheal intubation (r2 =.766, p <.001). The minimum diameter of the endotracheal tube segments was also statistically smaller among endotracheal tubes used in patients compared with the unused endotracheal tubes (7.5 +/- 0.4 vs. 6.7 +/- 1.2 mm, p <.001). CONCLUSIONS: Endotracheal tube intraluminal volume loss is common among patients with acute respiratory failure requiring mechanical ventilation and increases with prolonged tracheal intubation

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Abstract: Detection of aspiration by bedside examination has frequently been found to be clinically inadequate when compared with videofluoroscopy (VF) as the gold standard. In Doncaster, UK, a new multidisciplinary approach to bedside assessment was devised using physiotherapists (PT) performing bronchial auscultation (BA) in combination with the speech and language

therapists' (SLT) clinical examination of dysphagia. In this study 105 patients referred for VF examination of dysphagia were first tested by the BA team. Comparison was made between the results of the VF team and the results of the BA team in classifying the patients as "aspirating" or at "risk of aspirating." A high degree of agreement was found for risk of aspiration (sensitivity 87%), although specificity was low (37%). BA was highly specific (88%) when confirming the absence of aspiration, but sensitivity to the presence of aspiration was 45%. From the 105 patients tested, the BA team would have failed to modify the diet in only one subject who was aspirating and would have unnecessarily modified the diet of 17 subjects. In conclusion, in the sample population of individuals with complex dysphagia, the BA team approach reliably detected patients identified by VF as at risk of aspiration. In the group of patients identified by VF as aspirating, the BA team proved unreliable in detecting the presence of aspiration, although it did reliably identify patients who were not aspirating. BA is a potentially useful clinical tool which requires further research

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Abstract: A relationship among air quality, respiratory health, and comfort in man and animal is widely shown. In general, a state of respiratory discomfort is prevailed by an increase in acoustic audible symptoms. The general concept of sound analysis as an objective contactless non-invasive biomarker for aerial pollution is studied on free-field cough sound of 12 Belgian Landrace piglets. A citric-acid-induced cough sound recognition algorithm with recognition rate of 95% is applied to cough sounds registered in the presence of distinct types of aerial pollutants: irritating gas (ammonia), respirable particles (dust), and temperature. The recognition performance for all aerial pollutants was >90% and maintained 94% on average. It is concluded that sound analysis allows an effective biomarker for all three types of aerial pollution. The generality of the biomarker is hypothesized to be due to the common mechanism involved in protective cough. As a consequence, it is suggested to use sound analysis as a biomarker for respiratory state in studies of exposure to air pollutants

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Abstract: We performed orotracheal intubation in 153 consecutive pediatric patients undergoing cardiac catheterization. Auscultation of bilateral breath sounds was confirmed. By fluoroscopy, the tip of the endotracheal tube (ETT) was seen in the right mainstem bronchus in 18 patients (11.8%) and in a low position, defined as within 1 cm above the carina, in 29 patients (19.0%). All of the 18 patients with right mainstem intubation were children <120 mo of age, and 7 were infants <12 mo of age (Fisher's exact test; P = 0.013). The age, weight, and ETT size for children who had endobronchial and low tracheal positions were significantly (P < 0.001) less than for those who had midtracheal positions. The failure to diagnose mainstem intubation by auscultation alone may be related to the use of the Murphy eye ETT, which reduces the reliability of chest auscultation in detecting endobronchial intubation. Suggested measures for preventing endobronchial intubation include maintaining increased awareness of the imperfection or lack of accuracy of the auscultatory method, assessing insertion depth by checking the length scale on the tube, and minimizing the patient's head and neck movement after intubation. When extreme flexion or extension of the neck is expected after ETT insertion, the resultant change in ETT final position must be anticipated and taken into consideration when deciding on the depth of ETT insertion. This approach resulted in a decrease in improper tube positioning from 20% when the study was initiated to 7.1% in the last 98 patients

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Abstract: OBJECTIVE: The efficacy of many of the noninvasive treatments for snoring has not been evaluated in controlled trials. This paper seeks to evaluate the efficacy of an oil-based spray in the treatment of snoring, in a double-blinded, placebo-controlled, crossover trial using objective acoustic analysis and subjective questionnaires. STUDY DESIGN AND SETTING: Participants were randomized to use both oil-based oral spray (treatment) and water-based oral spray (placebo) during a two-night in-home study period. Questionnaires were completed by participant and bed-partner in addition to audio-tape recordings which were analyzed for frequency, duration, and mean energy of snoring. RESULTS: Greatest snoring rate demonstrated 30% = benefit; 40% = no change; 30% = adverse effect (n = 20). Percent time snoring yielded: 30% benefit; 15% no change; 55% adverse effect (n = 20). Study data results for mean energy were (n = 12): benefit = 17%, no change = 33%, adverse effect = 50%. Bed-partner observations (n = 17) demonstrated 37% = benefit; 38% = no change; 25% = adverse effect. CONCLUSION/SIGNIFICANCE: Objective and subjective evaluation of the performance of the oil-based Snoreless spray in comparison to placebo demonstrated a lack of efficacy in snoring reduction

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Abstract: Auscultation-based diagnosis of pulmonary disorders relies heavily on the presence of adventitious sounds and on the altered transmission characteristics of the chest wall. The phase information of the respiratory cycle within which adventitious sounds occur is very helpful in diagnosing different diseases. In this study, respiratory sound data belonging to four pulmonary diseases, both restrictive and obstructive, along with healthy respiratory data are used in various classification experiments. The

sound data are separated into six subphases, namely, early, mid, late inspiration and expiration and classification experiments using a neural classifier are carried out for each subphase. The AR parameters acquired from segmented sound signals, prediction error and the ratio of expiration to inspiration durations are used to construct the feature set to the neural classifier. Classification experiments are carried out between healthy and pathological sound segments, between restrictive and obstructive sound segments and between two different disease sound segments. The results indicate that the classifier performance demonstrates subphase dependence for different diseases. These results may shed light in eliminating redundant feature spaces in building an expert system using lung sounds for pulmonary diagnosis

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Abstract: We study an invasion percolation process on Cayley trees and find that the dynamics of perimeter growth is strongly dependent on the nature of the invasion process, as well as on the underlying tree structure. We apply this process to model the inflation of the lung in the airway tree, where crackling sounds are generated when airways open. We define the perimeter as the interface between the closed and opened regions of the lung. In this context we find that the distribution of time intervals between consecutive openings is a power law with an exponent beta approximately 2. We generalize the binary structure of the lung to a Cayley tree with a coordination number Z between 2 and 4. For Z=4, beta remains close to 2, while for a chain, Z=2 and beta=1, exactly. We also find a mean field solution of the model

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Abstract: BACKGROUND AND OBJECTIVE: Advancing an uncut endotracheal tube into the right main bronchus produces unilateral breath sounds. We wanted to test the validity of using this method to distinguish oesophageal from tracheal intubation. METHODS: Forty-two patients were randomized into two groups. The first group was randomized to receive an endotracheal tube that was advanced into the right main bronchus. The second group of patients had their tracheas intubated as normal and then a second endotracheal tube was placed in the oesophagus. Blinded observers were then asked to decide by auscultation if the patients had unilateral breath sounds or not and if they were bronchial and therefore to decide if endotracheal intubation had occurred. RESULTS: Ninety-one per cent of patients (95% CI 0.71-0.99) intubated in the right main bronchus were correctly identified by unilateral breath sounds confirming the usefulness of this test. CONCLUSIONS: Advancing an endotracheal tube into the right main bronchus and auscultation of unilateral breath sounds is a useful way of confirming tracheal intubation

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Abstract: The utilisation of nocturnal wheeze monitoring and quantification for assessment of asthma activity was studied in symptomatic school-aged children before and during treatment. Twelve children 6-14 yrs of age with mild or moderate untreated asthma were studied at home three times: before, 48 h and 6 weeks into treatment with 5 mg montelukast daily. Lung sounds were recorded overnight by an automatic wheeze detection device (PulmoTrack). Per cent wheezing within each respiratory cycle was calculated every 30 s throughout the night and a Nocturnal Wheeze Index (NWI) was calculated for the total night. The results were compared with spirometric indices (forced expiratory volume in one second (FEV1), forced vital capacity), bronchial reactivity (provocative concentration causing a 20% fall in FEV1 by adenosine 5'-monophosphate (PC20)) and daily symptom scores, performed in parallel at each stage of the study. The pretreatment NWI was 814+/-898 (mean+/-SD), which declined to 318+/-199 2 days after onset, and to 137+/-101 after 6 weeks of treatment. The NWI in seven healthy children was 47+/-43. The FEV1, PC20 and symptom scores improved in parallel. Wheeze monitoring provides quantitative and noninvasive information about the extent of nocturnal wheezing in children, correlates well with conventional indices of asthma activity and can assist in assessing efficacy of treatment

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Abstract: Cough is common in childhood, resulting in significant morbidity and frequent medical consultation. Despite this, little is known about the frequency or development of cough, particularly in infants and young children. Recent progress in monitoring has enabled cough to be measured objectively both day and night. However, to date, objective measurement has only been used in adults and older children. The aim of this study was to see whether such methods could be extended to allow objective cough monitoring in infants. Thirty infants were recruited: 13 with coughing illnesses (group 1), and 17 normal, healthy babies (group 2) born to nonatopic, nonsmoking parents. Group 2 infants were studied when well, several times in the first year of life. Coughs were recorded using an adapted commercial cough monitor (Logan Research LR100) and simultaneous infrared video and sound recording. Thirty-eight recordings with simultaneous cough monitor and video data were analyzed: 9 from group 1, and 29 from group 2. Overall, the sensitivity of the monitor when compared to video was 81%, with a positive predictive value of 0.8. There was good agreement between the two methods for infants with infrequent cough (<5 coughs per hour). Agreement in infants with more frequent cough was not as good, because more coughs were consistently identified by the cough monitor. The portability and small

size of the cough monitor made it easy to use, although there were difficulties in keeping the leads attached in older, more mobile infants. In conclusion, objective assessment of cough is practical in infants, enabling the pattern of cough in illness and in health to be studied further

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163. Faber, C. E. and L. Grymer. 2003. Available techniques for objective assessment of upper airway narrowing in snoring and sleep apnea. *Sleep Breath.* 7:77-86.
Abstract: A number of techniques are available to determine the level of obstructive predominance in snoring and in the obstructive sleep apnea hypopnea syndrome (OSAHS): lateral cephalography, awake endoscopy, awake endoscopy with the Muller maneuver, endoscopy during sleep, endoscopy with nasal continuous positive airway pressure during sleep, fluoroscopy, CT scanning, MR scanning, manometry, and acoustic reflections. Data from different studies using various methods suggest that different patients have different patterns of narrowing or collapse of the pharynx. No reference standard exists for the determination of the predominant obstructive level during obstructive events, so further investigations are necessary to improve and validate existing methods and develop new techniques. These would improve our understanding of the pathophysiology of OSAHS and snoring and help to select the correct treatment option for different patients. This article lists criteria that must be used to assess the available techniques for diagnosis of obstruction level in snoring and OSAHS. The advantages and limitations of each diagnostic technique are summarized, with emphasis on the acoustic reflectometry technique

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Abstract: An acoustic backscatter technique was used to estimate in vivo whole-lung resonant frequencies in a bottlenose dolphin (Tursiops truncatus) and white whale (Delphinapterus leucas). Subjects were trained to submerge and position themselves near an underwater sound projector and a receiving hydrophone. Acoustic pressure measurements were made near the thorax while the subject was insonified with pure tones at frequencies from 16 to 100 Hz. Whole-lung resonant frequencies were estimated by comparing pressures measured near the subject's thorax to those measured from the same location without the subject present. Experimentally measured resonant frequencies for the white whale and dolphin lungs were 30 and 36 Hz, respectively. These values were significantly higher than those predicted using a free-spherical air bubble model. Experimentally measured damping ratios and quality factors at resonance were 0.20 and 2.5, respectively, for the white whale, and 0.16 and 3.1, respectively, for the dolphin

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Abstract: The feasibility and accuracy of an Internet-based system for teleauscultation was evaluated in 103 cardiac patients, who were auscultated by the same cardiologist with a conventional stethoscope and with an Internet-based method, using an electronic stethoscope and transmitting heart and lung sounds between computer work stations. In 92% of patients, the results of electronic and acoustic auscultation coincided, indicating that teleauscultation may be considered a reliable method for assessing cardiac patients and could, therefore, be adopted in the context of comprehensive telecare programs

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Abstract: REASONS FOR PERFORMING STUDY: It has long been recognised that the production of abnormal respiratory sounds by horses during exercise is frequently associated with upper airway obstructions. Respiratory acoustic measurements have shown promise in investigation of upper airway disorders in man and, more recently, in horses with experimentally-induced obstructions. OBJECTIVES: To evaluate sounds from exercising horses with naturally occurring dynamic obstructions of the upper respiratory tract and to compare these with those from normal horses in order to determine whether different obstructions produce characteristic spectral patterns. METHODS: The audio signal, airflow and videoendoscopic images were recorded simultaneously during an incremental exercise test on a high-speed treadmill. RESULTS: Spectral analysis of the audio signal showed marked differences between control and clinically afflicted horses. Dorsal displacement of the soft palate was characterised by a narrow low frequency (20-80 Hz) peak during expiration. Horses with dynamic laryngeal collapse produced inspiratory sounds characterised by a broad band high frequency spectral component in the range 1.1-2.7 kHz. CONCLUSIONS AND POTENTIAL RELEVANCE: Spectral analysis of respiratory sounds in horses has potential as a diagnostic technique for field use especially when facilities for high-speed treadmill assessment are not practicable

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Abstract: Auscultation is an important, non-invasive and simple measure in the diagnosis of lung diseases that can detect sometimes pathological processes prior to radiography. Attempts have already been made to automatically detect characteristic pathological sounds, but a knowledge of potential influencing factors is a must for correct interpretation. In this study we have investigated the effect of the subcutaneous fat layer on normal lung sounds. This is of importance to determine corrective factors for the automatic detection of bronchial breathing in pneumonia. The lung sounds of 125 healthy people (55f, 70m) were digitally recorded at four different positions of the thorax (3. ICR paravertebral, 7. ICR medioscapular, all left and right). Evaluation was done separately for gender. The subcutaneous fat layer was measured with a Holtain Skinfold Caliper at the identical four recording positions. For a quantitative evaluation of the sounds we calculated the relative power of frequency bands 330-600 Hz and 60-330 Hz and their ratio. The relation between these parameters and the subcutaneous fat layer was analyzed with the Pearson correlation. The results of this study show that the influence of subcutaneous fat layer is negligible and can be ignored in the automatic detection of lung sounds

168. Hadjileontiadis, L. J. 2003. Discrimination analysis of discontinuous breath sounds using higher-order crossings. *Med.Biol.Eng Comput.* 41:445-455.
Abstract: The paper evaluates the performance of an automatic discrimination analysis (DA) method used to discriminate efficiently the types of discontinuous breath sound (DBS), i.e. fine crackles (FCs), coarse crackles (CCs) and squawks (SQs); this may lead to more accurate characterisation of the pulmonary acoustical changes due to the related pathology. Based on higher-order crossings (HOCs), the proposed method, HOC-DA, captured the differences in the oscillatory patterns of FCs, CCs and SQs, which are only exposed when higher (> 1) crossings are employed. Prior to HOC-DA, wavelet-based de-noising of DBSs was employed to eliminate the effects of the vesicular sound (background noise) from their oscillatory pattern. The HOC-DA was applied to 157 discontinuous breath sounds corresponding to 16 cases included in three lung sound databases. Results showed that the HOC-DA efficiently separated FCs from CCs, SQs from CCs (both with an accuracy of 100%), and SQs from FCs (accuracy of 80%), with the optimum order ranging from 9 to 11. When compared with other classification tools, the HOC-DA resulted in high discrimination accuracy without involving high computational complexity. Owing to its simplicity, it could be implemented in a real-time context and be used in clinical medicine as a module of an integrated intelligent patient evaluation system

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Abstract: The analysis of breathing sounds measured over the extrathoracic trachea offers a noninvasive technique to monitor obstructions of the respiratory tract. Essential to development of this technique is a quantitative understanding of how such tracheal sounds are related to the underlying tract anatomy, airflow, and disease-induced obstructions. In this study, the first dynamic acoustic model of the respiratory tract was developed that takes into consideration such factors as turbulent sound sources and varying glottal aperture. Model predictions were compared to tracheal sounds measured on four healthy subjects at target flow rates of 0.5, 1.0, 1.5, and 2.0 L/s, and also during nontargeted breathing. Both the simulation and measurement spectra depicted increasing sound power with increasing flow, with smaller incremental increases at the higher flow rates. A sound power increase of approximately 30 dB between a flow rate of 0.5 and 2.0 L/s was observed in both the simulated and measured spectra. Variations of as much as 15 dB over the 300-600 Hz frequency band were noted in the sound power produced during targeted and nontargeted breathing maneuvers at the same flow rates. We propose that this variability was in part due to changes in glottal aperture area, which is known to vary during normal respiration and has been observed as a method of flow control. Model simulations incorporating a turbulent source at the glottis with respiratory cycle variations in glottal aperture from 0.64 cm2 to 1.4 cm2 explained approximately 10 dB of the measured variation. This study provides the first links between spatially distributed sound sources due to turbulent flow in the respiratory tract and noninvasive tracheal sounds measurements

170. Hashimoto, Y., A. Murata, M. Mikami, S. Nakamura, E. Yamanaka, and S. Kudoh. 2003. Influence of the rheological properties of airway mucus on cough sound generation. *Respirology.* 8:45-51.
Abstract: OBJECTIVES: There have been several reports regarding the role of airway mucus in cough sound generation, but the properties of the mucus that influence cough sound generation remain unclear. The aim of this study was to elucidate the influence of the rheological properties of airway mucus on cough sound generation. METHODOLOGY: The acoustic properties of voluntary cough sounds from 15 patients with chronic productive cough and nine controls with dry cough were analyzed by dividing the energy envelope of the sounds into three phases and computing the root mean square values and the duration of each phase as a proportion of the total cough duration. The rheological properties of the airway mucus (yield value, ciliary transportability and spinability) were also measured. Differences between productive and dry cough sounds, and correlations between the acoustic properties of cough sounds and the rheological properties of the airway mucus, were analyzed. RESULTS: The acoustic properties of productive and dry cough sounds differed significantly ($P < 0.05$). The acoustic properties of second phase cough sounds correlated significantly with the yield value and ciliary transportability of the airway mucus ($P < 0.05$). CONCLUSIONS: The rheological properties of the airway mucus influenced cough sound generation

171. Karnawat, B. S. 2003. "Air entry"--an adventitious entry in respiratory system examination. *Indian Pediatr.* 40:914-915.

172. Kawamura, T., T. Matsumoto, N. Tanaka, S. Kido, Z. Jiang, and N. Matsunaga. 2003. Crackle analysis for chest auscultation and comparison with high-resolution CT findings. *Radiat.Med.* 21:258-266.
Abstract: PURPOSE: The purpose of our study was to clarify the correlation between respiratory sounds and the high-resolution CT (HRCT) findings of lung diseases. MATERIALS AND METHODS: Respiratory sounds were recorded using a stethoscope in 41 patients with crackles. All had undergone inspiratory and expiratory CT. Subjects included 18 patients with interstitial pneumonia and 23 without interstitial pneumonia. Two parameters, two-cycle duration (2CD) and initial deflection width (IDW) of the "crackle," were induced by time-expanded waveform analysis. Two radiologists independently assessed 11 HRCT findings. An evaluation was carried out to determine whether there was a significant difference in the two parameters between the presence and absence of each HRCT finding. RESULTS: The two parameters of crackles were significantly shorter in the interstitial pneumonia group than the non-interstitial pneumonia group. Ground-glass opacity, honeycombing, lung volume reduction, traction bronchiectasis, centrilobular nodules, emphysematous change, and attenuation and volume change between inspiratory and expiratory CT were correlated with one or two parameters in all patients, whereas the other three findings were not. Among the interstitial pneumonia group, traction bronchiectasis, emphysematous change, and attenuation and volume change between inspiratory and expiratory CT were significantly correlated with one or two parameters. CONCLUSION: Abnormal respiratory sounds were correlated with some HRCT findings

173. Koehler, U., V. Gross, C. Reinke, T. Penzel, and C. Vogelmeier. 2003. [Acoustic follow-up of nocturnal bronchial obstruction therapy]. *Pneumologie* 57:198-201.
Abstract: Long acting beta 2-agonists belong to the basic therapy of COPD. Especially patients with nocturnal respiratory problems may benefit from this therapy. Long term recording of lung sounds is a new method for quantitative measurements of bronchial obstructions. In combination with polysomnography an evaluation of cardiorespiratory parameters and sleep structure is possible. A total of 10 patients (8 male and 2 female) with moderate COPD (FEV1 58 +/- 11 %) and signs of bronchial obstruction were investigated. The combination of acoustic long term recording and polysomnography was done for 2 or 3 nights without and under therapy (long acting beta 2-agonist, 50 microg Salmeterol). In all patients we could find nocturnal bronchial obstruction events. Nocturnal wheezing time was reduced during therapy to 33 +/- 17 % (1. therapy night, n. s.) compared to 49 +/- 30 % without therapy (control night) and to 17 +/- 17 % (2. therapy night, n = 6, p < 0.05) vs. 51 +/- 30 % (control night, n = 6). Sleep efficiency and REM sleep increased (n. s.) under therapy, deep sleep stages NREM III/IV were nearly the same. Acoustic long term monitoring confirms the reduction of nocturnal bronchial obstructions under therapy with beta 2-agonists. A better sleep quality may be expected from the improvement of the respiratory situation during sleep

174. Korpas, J., M. Vrabec, J. Sadlonova, D. Salat, and L. A. Debreczeni. 2003. Analysis of the cough sound frequency in adults and children with bronchial asthma. *Acta Physiol Hung.* 90:27-34.
Abstract: It is well known that the frequency distribution of cough sound varies in different pathological conditions. Its identification could have diagnostic value. In this study the cough sound frequency in adults (n=20, 51.7 +/- 11 yrs), children (n=21, 11.8 +/- 0.4 yrs) asthmatics and healthy volunteers (n=25, 21 yrs) was explored. All patients were suffering from bronchial asthma. They were on a stable therapeutic regime and in a quiet status. Voluntary cough sound was recorded by a microphone and a tape recorder an ddigitally processed. Overlapping technique and Fast Fourier Transform were used to estimate the sound spectra. The records were smoothed by the method of Pascal triangle. They demonstrate the mean values of cough sound spectra. The registered pseudo three-dimensional plots of cough sound frequency (1 K spectra as function in time) of adults showed that the intensity of frequencies increased from 100 to 900 Hz in 3-4 waves. These frequencies afterwards decreased and between 1 to 2 kHz a smaller elevation was present. The spectra of children resembled to the spectrum of adults but had a smoother course. The spectra of asthmatics had some specificity and differed from the spectrum of healthy volunteers

175. Mangione, S. and F. D. Duffy. 2003. The teaching of chest auscultation during primary care training: has anything changed in the 1990s? *Chest* 124:1430-1436.
Abstract: OBJECTIVE: To survey the teaching time and importance given to cardiopulmonary auscultation during internal medicine (IM) and family practice (FP) residencies, and to compare current practices to those of the early 1990s. DESIGN: A nationwide mail survey of IM and FP program directors (PDs). SETTING: All Accreditation Council for Graduate Medical Education-accredited IM and FP residencies. PARTICIPANTS: A total of 538 of 939 PDs (57.5%). Measurements and main results: In contrast to the early 1990s, when there had been no significant difference in teaching practices between IM and FP programs, more IM than FP residencies taught cardiopulmonary auscultation in 1999 (cardiac auscultation: IM residencies, 48%; FP residencies, 29.2% [p < 0.001]; pulmonary auscultation: IM residencies, 23.7%; FP residencies, 12.2% [p < 0.001]). Across the decade there also had been a significant increase in the percentage of IM programs offering structured education in chest auscultation (cardiac auscultation increase, 27.1 to 48% [p < 0.001]; pulmonary auscultation increase, 14.1 to 23.7% [p < 0.02]), but no significant changes for FP residencies. IM PDs gave more clinical importance to auscultation and expressed a greater desire for expanded teaching than did

their counterparts in FP programs. CONCLUSIONS: This study indicates a significant gain over the last decade in the percentage of IM residencies offering structured teaching of cardiopulmonary auscultation. This same gain did not occur for FP programs. Whether these differences in attitudes and teaching practices will translate into improved auscultatory proficiency of IM trainees will need to be determined

176. Merino, J. G. 2003. [Laennec and the creation of auscultation signs]. *Gac.Med.Mex.* 139:165-168.
Abstract: Toward the end of the 18th century, clinical diagnosis in medicine shifted its focus from reliance on symptoms, which translates to subjective experience of illness, to signs, objective manifestations of pathologic changes. Several techniques were developed to elicit signs in clinical practice, and Laennec used them routinely. He palpated and prodded his patients to get an idea of changes in internal organs. He also applied his ear directly to his patient's chest to hear their heartbeat. On one occassion, he was unable to use these techniques and had the happy occurrence of rolling up a notebook to hear his patient's chest. This led him to hear a great number of new sounds. Through detailed observations, he was able to describe, classify, and correlate these sounds with autopsy findings, thus creating a new semiology of chest diseases. In this essay explore how in which Laennec created his instrument and system of signs of chest diseases, and how he was able to transmit his inventions to his colleagues

177. Mlynski, R., S. Grutzenmacher, C. Lang, and G. Mlynski. 2003. Acoustic rhinometry and paranasal cavities: a systematic study in box models. *Laryngoscope* 113:290-294.
Abstract: OBJECTIVE/HYPOTHESIS: Acoustic rhinometry (AR) is a well-established diagnostic tool in rhinology. The aim of the study was to test the hypothesis that the paranasal sinuses are a main cause for inaccuracy of AR in the posterior part of the nose. STUDY DESIGN: Experimental study to evaluate the influence of simulated paranasal sinus volume and of the contralateral side of the nose on AR measurements in "box models." METHODS: Models were measured with paranasal sinus volume simulated between 0 and 25 mL and with the junction between the models and the paranasal sinuses varying in length and diameter. RESULTS: Moderate but distinct modification of the posterior area-distance curve was found within the models after changing size of the paranasal sinuses and its junction to the cavity. The apparent cross-sectional area (CSA) measured in the posterior cavum decreased with the volume of the paranasal sinuses. This effect was limited by the length and the diameter of the paranasal junction, as well as by the concha. No influence of the contralateral side on AR measurements was seen. CONCLUSIONS: Acoustic rhinometry reveals reproducible measurements up to 4 cm from the nostril that correspond with the actual model CSA. Simulated paranasal sinuses appear to partially contribute to the inaccuracy in the posterior part of the area-distance curve

178. Oud, M. 2003. Lung function interpolation by means of neural-network-supported analysis of respiration sounds. *Med Eng Phys* 25:309-316.
Abstract: Respiration sounds of individual asthmatic patients were analysed in the scope of the development of a method for computerised recognition of the degree of airways obstruction. Respiration sounds were recorded during laboratory sessions of allergen provoked airways obstruction, during several stages of advancing obstruction. The technique of artificial neural networks was applied for relating sound spectra and simultaneously measured lung function values (spirometry parameter FEV(1)). The ability of feedforward neural networks was tested to interpolate obstruction levels of FEV(1)-classes of which no members were included in the set used for training a network. In this way, a situation was simulated of an existing network recognising a new asthmatic attack under the same physiological conditions. It appeared to be possible to interpolate FEV(1) values, and it is concluded that a deterministic relationship exists between sound spectra and lung function parameter FEV(1). Variance optimisation appeared to be important in optimising the neural network configuration

179. Paciej, R., A. Vyshedskiy, J. Shane, and R. Murphy. 2003. Transpulmonary speed of sound input into the supraclavicular space. *J Appl Physiol* 94:604-611.
Abstract: The transpulmonary speed of sound input at the mouth has been shown to vary with lung volume. To avoid the disadvantages that exist in certain clinical situations in inputting sound at the mouth, we input sound in the supraclavicular space of 21 healthy volunteers to determine whether similar information on the relationship of sound speed to lung volume could be obtained. We measured the transit time at multiple microphones placed over the chest wall using a 16-channel lung sound analyzer (Stethographics). There was a tight distribution of transit times in this population of subjects. At functional residual capacity, it was 9 +/- 1 (SD) ms at the apical sites and 13 +/- 1 ms at the lung bases. The sound speed at total lung capacity was 24 +/- 2 m/s and was 22 +/- 2 m/s at residual volume ($P < 0.001$). In all subjects, the speed of sound was faster at higher lung volume. This improved method of studying the mechanism of sound transmission in the lung may help in the development of noninvasive tools for diagnosis and monitoring of lung diseases

180. Raphael, D. T. and H. Lee. 2003. Acoustic reflectometry detection of an endobronchial intubation in a patient with equal breath sounds. *J.Clin.Anesth.* 15:41-47.
Abstract: Acoustic reflectometry can be used to distinguish between a tracheal and an esophageal intubation based on an area-distance profile. In a patient undergoing laparoscopic surgery, acoustic reflectometry was used to detect a bronchoscopically

confirmed endobronchial intubation in the presence of equal bilateral breath sounds. An in vitro simulation suggests that in an endobronchial intubation, in the presence of a space leak between the tube cuff and the bronchus, an acoustic pressure disturbance can be transmitted to the opposite lung (causing equal breath sounds), without significant bulk airway flow (causing inadequate ventilation of the opposite lung)

181. Royston, T. J., Y. Yazicioglu, and F. Loth. 2003. Surface response of a viscoelastic medium to subsurface acoustic sources with application to medical diagnosis. *J Acoust.Soc Am* 113:1109-1121.
Abstract: The response at the surface of an isotropic viscoelastic medium to buried fundamental acoustic sources is studied theoretically, computationally and experimentally. Finite and infinitesimal monopole and dipole sources within the low audible frequency range (40-400 Hz) are considered. Analytical and numerical integral solutions that account for compression, shear and surface wave response to the buried sources are formulated and compared with numerical finite element simulations and experimental studies on finite dimension phantom models. It is found that at low audible frequencies, compression and shear wave propagation from point sources can both be significant, with shear wave effects becoming less significant as frequency increases. Additionally, it is shown that simple closed-form analytical approximations based on an infinite medium model agree well with numerically obtained "exact" half-space solutions for the frequency range and material of interest in this study. The focus here is on developing a better understanding of how biological soft tissue affects the transmission of vibro-acoustic energy from biological acoustic sources below the skin surface, whose typical spectral content is in the low audible frequency range. Examples include sound radiated from pulmonary, gastro-intestinal and cardiovascular system functions, such as breath sounds, bowel sounds and vascular bruits, respectively

182. Sanchez, I. and C. Vizcaya. 2003. Tracheal and lung sounds repeatability in normal adults. *Respir.Med.* 97:1257-1260.
Abstract: Tracheal and lung sounds measurements for clinical applications depends on their intrasubject repeatability. Our objectives were to characterize tracheal and lung sounds and to investigate the temporal variability in normal adults. Tracheal sounds were studied in 7 subjects and lung sounds in 10 adults. Acoustic measurements were done in five occasions over a month for tracheal sounds and on seven occasions over a year for lung sounds. Sounds were recorded using contact sensors on the suprasternal notch and on the posterior right lower lobe. Subjects breathed through a pneumotachograph at flows of 0.9-1.1 l/s. Signals were low-pass filtered, amplified and Fourier analysis was applied to sounds within a target flow range. We measured the frequencies below which 25% (F25), 50% (F median), 75% (F75) and 99% (SEF99) of the spectral power between 100 and 2000 Hz. There were no differences between the measurements obtained at different days comparing each subject (P = ns, ANOVA). Our results show that the spectral pattern of tracheal and lung sounds are stable with low intrasubject variability

183. Sera, T., S. Satoh, H. Horinouchi, K. Kobayashi, and K. Tanishita. 2003. Respiratory flow in a realistic tracheostenosis model. *J Biomech.Eng* 125:461-471.
Abstract: The possible mechanism of wheeze generation in tracheostenosis was identified by measuring inspiratory and expiratory flow in a "morphological and distensible" realistic tracheostenosis model. The shape of the model was based on CT (Computed Tomography) images of a patient that had tracheostenosis. A trachea consists of tracheal cartilage rings and smooth muscle. Spatial variation of wall distensibility was achieved in the model by varying the wall thickness based on the elastic modulus measured in pig airways. The spatial variation influenced the flow in the airway and the turbulence production rate decreased faster at smooth muscles. Using the model, we investigated the mechanism of wheeze generation by focusing on the turbulence intensity. The turbulence intensity in expiratory flow was about twice that in inspiratory flow, and larger vortices existed in post-stenosis in expiratory flow, and thus might contribute to wheeze generation

184. Singhi, S., A. K. Bhalla, A. Bhandari, and A. Narang. 2003. Counting respiratory rate in infants under 2 months: comparison between observation and auscultation. *Ann.Trop.Paediatr.* 23:135-138.
Abstract: The World Health Organization's global programme for the control of acute respiratory infections relies on counting respiratory rate (RR) by observing abdominal and chest movements in order to diagnose pneumonia. However, few studies on the reliability of the observation method have been published. We counted RR simultaneously by observation and auscultation in 100 healthy infants at 1, 2, 4, 6 and 8 weeks of age for 15, 30 and 60 sec, and compared RRs obtained by the two methods. In all the age groups studied, the co-efficients of variation for the RRs recorded by observation or auscultation were similar. The mean RR by observation was higher by 1-3 breaths/min than mean RR by auscultation ($p < 0.001$). The 95% confidence interval (+/-2 SD) for the difference between RR by the two methods ranged from +5 to -8 breaths/min for RR counted for 1 full minute. Our data support the assumption that observation is as reliable as auscultation for counting RR

185. Stevens, M. W., M. H. Gorelick, and T. Schultz. 2003. Interrater agreement in the clinical evaluation of acute pediatric asthma. *J.Asthma* 40:311-315.
Abstract: Prior studies of observer agreement of the clinical exam of children with asthma have focused on small numbers of specially trained observers, often in the setting of clinical trials. Our objective was to evaluate interobserver reliability in the physical

exam of acute pediatric wheezing and asthma among a large group of diverse examiners, in a setting of routine clinical practice, and without prior special training. The setting was a large urban children's hospital. Observers were attending pediatric emergency physicians and fellows; hospital respiratory therapists; and emergency department (ED) nurses. Patients were children receiving nebulized medications for wheezing in the ED or inpatient asthma unit. Pairs of observers simultaneously but independently rated work of breathing, wheeze, decreased air entry, prolonged expiration, breathlessness, respiratory rate, mental status, and global (or overall) severity using a structured exam template. A total score for each exam was also evaluated. A total of 230 pairs of observations were performed; mean patient age was 5.3 years. For all pairs, the weighted kappa statistics for the exam components ranged from 0.61 to 0.74 (moderate or substantial agreement). The global severity category and total score had weighted kappas of 0.80 and 0.82, respectively (excellent agreement). Agreement was generally somewhat lower for unlike (different profession) observer pairs than for like observer pairs, but remained acceptable. Agreement in two age groups (< or = 3 years old and > or = 4) was at least moderate for all exam components analyzed. Spearman rank correlations between individual exam components and the global assessments of patient severity were all greater than 0.5, indicating at least moderate to good correlations. We found substantial interobserver agreement among a broad range of examiners in the components of the clinical examination of acute wheezing in both younger and older children. This is contrary to the commonly held observation that the poor interobserver reliability of physical exam findings in asthma may limit their usefulness as asthma outcome measures. Support for use of a structured respiratory exam format or template in asthma guidelines was also shown

186. ves-Pereira, M., J. M. Reis Ferreira, M. J. Joanaz de, J. Motylewski, E. Kotlicka, and N. A. Castelo Branco. 2003. Noise and the respiratory system. *Rev Port.Pneumol.* 9:367-379.
Abstract: Noise-induced pulmonary pathology is still an issue that is regarded with much suspicion despite the significant body of evidence demonstrating that acoustic phenomena target the respiratory tract. The goal of this review paper is threefold: a) to describe acoustic phenomena as an agent of disease, and the inadequacies of current legislation regarding noise-induced, non-auditory pathology; b) to trace how the interest in noise-induced pulmonary pathology emerged within the scope of studies on vibroacoustic disease; and c) to bring to light other studies denouncing noise as an agent of disease that impinges on the respiratory tract. As concluding remarks, future perspectives in LFN-related research will be discussed. The need for animal models will be emphasized

187. Welsby, P. D., G. Parry, and D. Smith. 2003. The stethoscope: some preliminary investigations. *Postgrad.Med.J.* 79:695-698.
Abstract: Textbooks, clinicians, and medical teachers differ as to whether the stethoscope bell or diaphragm should be used for auscultating respiratory sounds at the chest wall. Logic and our results suggest that stethoscope diaphragms are more appropriate

188. Agrawal, S., P. Stone, K. McGuinness, J. Morris, and A. E. Camilleri. 2002. Sound frequency analysis and the site of snoring in natural and induced sleep. *Clin Otolaryngol.* 27:162-166.
Abstract: The aim of this study was to compare the snoring sounds induced during sleep nasendoscopy, and to compare them with those of natural sleep using sound frequency spectra. The snoring of 16 subjects was digitally recorded during natural and induced sleep, noting the site of vibration during sleep nasendoscopy. Patients with palatal snoring during sleep nasendoscopy had a median peak frequency at 137 Hz (118 snore samples). The peak frequency of tongue-base snoring was 1243 Hz (10 snore samples), and simultaneous palate and tongue was 190 Hz (six snore samples). The median power ratios were 7, 0.2 and 5 respectively. The centre frequencies were 371, 1094 and 404 Hz respectively. Epiglottic snores had a peak frequency of 490 Hz (five snore samples). Comparison of the induced (n = 118) and natural (n = 300) snore samples of the 12 palatal snorers showed a significant difference in both the power ratio and centre frequencies (P = 0.031 and P = 0.049). The peak frequency position was similar (P = 0.34). Our results indicate that induced snores contain a higher frequency component of sound, not evident during natural snoring. This is consistent with an element of tongue-base snoring. Although there is good correlation generally, sleep nasendoscopy may not accurately reflect natural snoring

189. Alencar, A. M., S. P. Arold, S. V. Buldyrev, A. Majumdar, D. Stamenovic, H. E. Stanley, and B. Suki. 2002. Physiology: Dynamic instabilities in the inflating lung. *Nature* %20;417:809-811.
Abstract: In lung diseases such as asthma, expiratory flow becomes limited, airways can collapse and the vital exchange of gases is compromised. Here we model the inflation of collapsed regions of the lung during inspiration in terms of avalanches propagating through a bifurcating network of airways, and find that the accompanying cascade of dynamic pressure instabilities -- avalanche 'shocks' -- manifests as negative elastic resistance of the lung. Our analysis of this apparent thermodynamic paradox provides a better understanding of aeration in the deep regions of the lung, which may find application in medical conditions in which gas exchange is impaired

190. Bergstresser, T., D. Ofengeim, A. Vyshedskiy, J. Shane, and R. Murphy. 2002. Sound transmission in the lung as a function of lung volume. *J Appl Physiol* 93:667-674.
Abstract: We were interested in how the transmission of sound through the lung was affected by varying air content in intact

humans as a method of monitoring tissue properties noninvasively. To study this, we developed a method of measuring transthoracic sound transit time accurately. We introduced a "coded" sound at the mouth and measured the transit time at multiple microphones placed over the chest wall by using a 16-channel lung sound analyzer (Stethographics). We used a microphone placed over the neck near the trachea as our reference and utilized cross-correlation analysis to calculate the transit times. The use of the coded sound, composed of a mix of frequencies from 130 to 150 Hz, greatly reduced the ambiguity of the cross-correlation function. The measured transit time varied from 1 ms at the central locations to 5 ms at the lung bases. Our results also indicated that transit time at all locations decreased with increasing lung volume. We found that these results can be described in terms of a model in which sound transmission through the lung is treated as a combination of free-space propagation through the trachea and a propagation through a two-phase system in the parenchyma

191. Blechschmidt-Trapp, R. A. and R. Werthschutzky. 2002. [Acoustic Tomography of a Lung Phantom]. *Biomed Tech.(Berl)* 47 Suppl 1 Pt 1:404-407.

192. Cable, C. S., N. G. Ducharme, R. P. Hackett, H. N. Erb, L. M. Mitchell, and L. V. Soderholm. 2002. Sound signature for identification and quantification of upper airway disease in horses. *Am J Vet.Res.* 63:1707-1713.
Abstract: OBJECTIVE: To investigate whether upper airway sounds of horses exercising with laryngeal hemiplegia and alar fold paralysis have distinct sound characteristics, compared with unaffected horses. ANIMALS: 6 mature horses. PROCEDURE: Upper airway sounds were recorded in horses exercising on a high-speed treadmill at maximum heart rate (HR(MAX)) under 3 treatment conditions (ie, normal upper airway function [control condition], and after induction of left laryngeal hemiplegia or bilateral alar fold paralysis) in a randomized crossover design. Fundamental frequency, spectrograms using Gabor transform, and intensity characteristics of acquired sounds (peak sound level [sound(peak] and highest frequency of at least -25 dB sound intensity [F(25max)]) were evaluated. RESULTS: Evaluation of the fundamental frequency of the time domain signal was not useful. Sensitivity and specificity (83 and 75%, respectively) of spectrograms were greatest at maximal exercise, but the exact abnormal condition was identified in evaluation of only 12 of 18 spectrograms. Increased accuracy was obtained using sound(peak) and F(25max) as discriminating variables. The use of sound(peak) discriminated between control and laryngeal hemiplegia conditions and F(25max) between laryngeal hemiplegia and alar fold paralysis conditions. This increased the specificity of sound analysis to 92% (sensitivity 83%) and accurately classified the abnormal state in 92% of affected horses. CONCLUSIONS AND CLINICAL RELEVANCE: Sound analysis might be a useful adjunct to the diagnosis and evaluation of treatment of horses with upper airway obstruction, but would appear to require close attention to exercise intensity. Multiple measurements of recorded sounds might be needed to obtain sufficient accuracy for clinical use

193. Carmichael, M. 2002. Sounds of sleep. *Newsweek.* 140:41.

194. de Frutos, M. C., E. Gonzalez Perez-Yarza, R. A. Aldasoro, J. I. Emparanza Knorr, B. M. Callen, and A. J. Mintegui. 2002. [Agreement between tracheal auscultation and pulmonary function in methacholine bronchial inhalation challenge in asthmatic children]. *An.Esp.Pediatr.* 56:304-309.
Abstract: BACKGROUND: PC wheezing (PCw) is defined as the concentration of methacholine at which wheeze is detected on auscultation of the trachea. PCw has been suggested as a measure of bronchial hyperresponsiveness in methacholine challenge testing (MCT). OBJECTIVE: The aim of this study was to determine the agreement between the concentration of methacholine that produces a 20 % decrease in forced expiratory volume in 1 second (FEV1) (PC20) and PCw in MCT in asthmatic children. PATIENTS AND METHODS: Eighteen asthmatic children with a mean age of 11.5 years (range: 6-16 years) were studied. Fifteen of the children were under treatment with inhaled glucocorticoids. MCT was performed according to the guidelines of the American Thoracic Society (1999) using a Hudson nebulizer calibrated to obtain a mean output of 0.14 ml/min. After each nebulization, two independent observers registered FEV1 and tracheal auscultation. FEV1 was determined by forced spirometry 30 and 90 seconds after the end of nebulization and PC20 was registered (exponential model). Respiratory rate and transcutaneous oxygen saturation were continuously monitored. Tracheal auscultation was performed at 0, 60 and 120 seconds after the end of nebulization. The end point was defined as the appearance of wheezing over the trachea. The values of PC20 and PCw, as well as the concentration of methacholine corresponding to a decrease in FEV1 equal to or higher than 20 %, were compared using Student's matched pairs-test and Wilcoxon's test. The degree of agreement between variables was compared by using Bland-Altman's test. RESULTS: MCT was positive in 17 of 18 patients. No differences were found between PC20 and PCw (p 0.15). Both variables showed agreement in 12 of 17. A clear association was found between both measures (log PCw, log PC20): R: 0.92; $p < 0.001$. The mean decrease in FEV1 on reaching PCw was 24.8 % (range: 10-41). No adverse effects were observed. CONCLUSION: The agreement between PC20 and PCw in MCT in asthmatic children is excellent. PCw could be helpful in determining bronchial hyperresponsiveness in young asthmatic children in whom spirometry is not feasible

195. Elphick, H. E., S. Ritson, and M. L. Everard. 2002. Differential response of wheezes and ruttles to anticholinergics. *Arch Dis Child* 86:280-281.

Abstract: Computerised breath sounds analysis was used to assess the response of infants with wheeze and ruttles to the drug ipratropium bromide. A mean decrease in breath sounds intensity occurred in infants with ruttles after five minutes (20.5 dB), but not until 20 minutes in those with wheeze (8.1 dB). This differential response may be related to different underlying pathophysiology

196. Faber, C. E., L. Grymer, O. Hilberg, and O. Norregaard. 2002. Flextube reflectometry and pressure-recordings for level diagnosis in obstructive sleep apnoea. *Rhinology* 40:203-210.
Abstract: The objective of this study was to compare sound reflections in a flexible tube (flextube reflectometry) with pressure-catheter recordings (ApneaGraph) for identifying the predominant obstructive level of the upper airway during sleep. Seventeen males with suspected obstructive sleep apnoea syndrome (OSAS) were included in the study. The mean (standard deviation = SD) number of flextube narrowings per hour recording was 50.2 (20.4) and the mean (SD) RDI (respiratory disturbance index = apnoeas and hypopnoeas per hour recording) determined by the ApneaGraph was 45.7 (20.2). The mean difference (SD) between the number of flextube narrowings per hour recording and the RDIs determined by the ApneaGraph was not statistically significantly different from 0. There was no statistically significant correlation between the percentage of retropalatal narrowing of the total narrowing (retropalatal and retrolingual narrowing) measured by flextube reflectometry and the percentage of retropalatal ("upper") obstructive apnoeas and hypopnoeas of the total number ("upper", "intermediate" and "lower") measured by ApneaGraph (Spearman's correlation coefficient r = 0.24, p = 0.36, N = 17). In conclusion diverging results were found in flextube reflectometry studies and pressure-recordings performed on different nights regarding the level distribution of obstructions during sleep. Possible explanations of this discrepancy are discussed

197. Fiz, J. A., R. Jane, A. Homs, J. Izquierdo, M. A. Garcia, and J. Morera. 2002. Detection of wheezing during maximal forced exhalation in patients with obstructed airways. *Chest* 122:186-191.
Abstract: STUDY OBJECTIVES: Wheezing is a common clinical finding in patients with asthma and COPD during episodes of severe airway obstruction, and can also be heard in normal subjects during forced expiratory maneuvers; however, the properties of wheezing are difficult to perceive and quantify during auscultation. We therefore developed and evaluated a new technique for recording and analyzing wheezing during forced expiratory maneuvers in a group of patients with obstructed airways (asthma, COPD) and a control group of healthy subjects. MATERIAL AND METHODS: Sixteen patients with asthma (9 men and 7 women), 6 patients with COPD (6 men), and 15 healthy subjects (7 men and 8 women) were enrolled. The patients had moderate-to-severe obstruction (FEV(1) of 40 to 53% predicted). A contact sensor on the trachea was used to record sound during forced expiratory maneuvers. Wheeze detection was carried out by a modified algorithm in a frequency-time space after applying the fast Fourier transform. RESULTS: More wheezes were recorded in patients with obstructed airways than in control subjects: asthma patients, 8.4 +/- 6.4 wheezes; COPD patients, 10.4 +/- 6.1 wheezes; and control subjects, 2.9 +/- 2.0 wheezes (mean +/- SD). The mean frequency of all detected wheezes was higher in control subjects than in patients with obstructed airways (asthma patients, 560.9 +/- 140.8 Hz; COPD patients, 669.4 +/- 250.1 Hz; and control subjects, 750.7 +/- 175.7 Hz). The total number of wheezes after terbutaline inhalation changed more in patients with obstructed airways than in control subjects. CONCLUSIONS: The new method that we describe for studying airway behavior during forced expiratory maneuvers is able to identify and analyze wheeze segments generated in patients with obstructed airways, as evidenced by the greater number of wheezes detected in the patient group, the main finding of this study. This method clearly and objectively identifies the presence of obstructive disease

198. Grimal, Q., A. Watzky, and S. Naili. 2002. A one-dimensional model for the propagation of transient pressure waves through the lung. *J Biomech.* 35:1081-1089.
Abstract: The propagation of pressure waves in the lung has been investigated by many authors concerned with respiratory physiology, ultrasound medical techniques or thoracic impact injuries. In most of the theoretical studies, the lung has been modeled as an isotropic and homogeneous medium, and by using Hooke's constitutive law (see e.g. Ganesan et al. Respir. Physiol. 110 (1997) 19; Jahed et al. J. Appl. Physiol. 66 (1989) 2675; Grimal et al. C.R. Acad. Sci., Paris 329 (IIb) (2001) 655-662), or more elaborated material laws (see, e.g. Bush and Challener (Proceedings of the International Research Council on Biokinetics Impacts (IRCOBI), Bergish-gladbach, 1988); Stuhmiller et al. J. Trauma 28 (1988) S132; Yang and Wang, Finite element modeling of the human thorax. Web page: http://wwwils.nlm.nih.gov/research/visible/vhpconf98/AUTHORS/YANG/YANG.HTM .). The hypothesis of homogeneous medium may be inappropriate for certain problems. Because of its foam-like structure, the behavior of the lung-even if the air and the soft tissue are assumed to behave like linearly elastic materials-is susceptible to be frequency dependent. In the present study, the lung is viewed as a one-dimensional stack of air and soft tissue layers; wave propagation in such a stack can be investigated in an equivalent mass-spring chain (El-Raheb (J. Acoust. Soc. Am. 94 (1993) 172; Int. J. Solids Struct. 34 (1997) 2969), where the masses and springs, respectively, represent the alveolar walls and alveolar gas. Results are presented in the time and frequency domains. The frequency dependence (cutoff frequency, variations in phase velocity) of the lung model is found to be highly dependent on the mean alveolar size. We found that short pulses induced by high velocity impacts (bullet stopped by a bulletproof jacket) can be highly distorted during the propagation. The pressure differential between two alveoli is discussed as a possible injury criterion

199. Gross, V., P. Fachinger, T. Penzel, U. Koehler, P. von Wichert, and C. Vogelmeier. 2002. Detection of bronchial breathing caused by pneumonia. *Biomed Tech.(Berl)* 47:146-150.
Abstract: The classic auscultation with stethoscope is the established clinical method for the detection of lung diseases. The interpretation of the sounds depends on the experience of the investigating physician. Therefore, a new computer-based method has been developed to classify breath sounds from digital lung sound recordings. Lung sounds of 11 patients with one-sided pneumonia and bronchial breathing were recorded on both the pneumonia side and on contralateral healthy side simultaneously using two microphones. The spectral power for the 300-600 Hz frequency band was computed for four respiratory cycles and normalized. For each breath, the ratio R between the time-segments (duration = 0.1 s) with the highest inspiratory and highest expiratory flow was calculated and averaged. We found significant differences in R between the pneumonia side (R = 1.4 +/- 1.3) and the healthy side (R = 0.5 +/- 0.5; p = 0.003 Wilcoxon-test) of lung. In 218 healthy volunteers we found R = 0.3 +/- 0.2 as a reference-value. The differences of ratio R (delta R) between the pneumonia side and the healthy side (delta R = 1.0 +/- 0.9) were significantly higher compared to follow-up studies after recovery (delta R = 0.0 +/- 0.1, p = 0.005 Wilcoxon-test). The computer based detection of bronchial breathing can be considered useful as part of a quantitative monitoring of patients at risk to develop pneumonia

200. Gross, V., C. Reinke, T. Penzel, H. F. Becker, and C. F. Vogelmeier. 2002. [Dependence of nocturnal bronchial obstruction on sleep position]. *Biomed.Tech.(Berl)* 47 Suppl 1 Pt 2:863-5.:863-865.
Abstract: Patients with bronchial obstructions often have problems to stay asleep at night. The interaction between sleep position and bronchial obstructions has not been investigated until now. A total of 20 patients was included in this study. All patients were recorded one night in our sleep laboratory with a parallel recording of lung sounds using a commercial Pulmotrack 1010 system. The bronchial obstructions were lower in lateral position than in supine position for both tracheal and chest sounds (p = 0,083 and p = 0,036; n.s.). This effect seemed to be especially high in patients with many obstruction episodes. From our results we can conclude that there is a small dependence of bronchial obstructions from sleep position. Further investigations are needed to verify this result

201. Hilberg, O. 2002. Objective measurement of nasal airway dimensions using acoustic rhinometry: methodological and clinical aspects. *Allergy* 57 Suppl 70:5-39.:5-39.
Abstract: INTRODUCTION: Nasal congestion is an important symptom in many diseases of the upper airways. Nasal congestion may also affect personal well-being and quality of life. Furthermore, as the nasal mucosa is the first part of the airways in contact with the environment, objective evaluation of nasal congestion or nasal patency is important. Systematic evaluation of nasal patency was described in the last part of the 19th century by Zwaardemaker. Measurement of the pressure drop over the nasal cavity at a passive dow has been described in 1903 by Courtade and is one of first descriptions rhinomanometry. The technique is still in use and computer technology has made the measurements much easier but the method has not yet been accepted for wide clinical use. METHODOLOGY: Acoustic methods have also been used for evaluation of nasal patency. A qualitative method was the hum-test by Spiess (1902), where external occlusion of the nonocciuded side of the nasal cavity is experienced as a change in the timbre of the sound during humming. Acoustic reflections have been used in geophysical investigations especially with regard to search for oil. The use of acoustic reflections from the airways gained special interest in 1960-70 for determining the geometry of the vocal tract shape with regard to speech reconstruction. A method described by A. Jackson (1977) was adopted and for the first time applied to the nasal cavity. The method for determining the cross-sectional area as function of distance in the airways by acoustic reflections is impulse or relatively simple. The incident sound pseudorandom noise in the audible frequency range is compared with the response - the reflections from the airways. Intuitively, if the size of the entrance to the airways is known, the size of the reflections may represent changes of the airway size and the time between reflections may give the distance between the changes, dependent on the speed of sound. In this way it is possible to determine the area as function of distance in the airways. The technique has some assumptions and the major effort has been to validate use in the nose and elucidate aspects with regard to sound loss in the airways and resolution. Therefore, the acoustic reflection technique - named acoustic rhinometry - was compared with other methods like MRI, CT, and rhinomanometry. Allergic and nonallergic subjects were also compared. RESULTS: Acoustic rhinometry showed reasonable correlation with CT in a cadaver and in 10 subjects in comparison with MRI for the first 6 cm of the nasal cavity. Models based on MRI scannings of subjects also showed good correlation for the first 6 cm of the nasal cavity. Posteriorly in the nasal cavity and the epipharynx, differences were found mainly due to 'sound loss' to the paranasal sinuses. Sound loss due to viscous loss or friction at increasing surface/area ratio (the complex geometry in the nose) and loss due to nonrigidity the nasal mucosa were also examined. Neither these factors affected the area-distance function significantly. Acoustic rhinometry seems to reflect the area-distance function in the nose reasonably accurately. In allergic subjects acoustic rhinometry has been used to evaluate hypersensitivity. More pronounced spontaneous variation in nasal mucosa congestion was found in patients suffering from hay fever compared to nonallergic subjects. Furthermore, a tendency to a more swollen mucosa in the allergic subjects compared to the normal state, and increased sensitivity to histamine was found. This and reduction in swelling of the mucosa in allergic subjects during nasal steroid treatment out of the pollen season indicate an ongoing inflammatory process or hypersensitivity in allergic subjects out ot the pollen season. During allergen challenge the change in nasal cavity dimension as well as inflammation may affect olfaction in hay fever patients. DISCUSSION: Acoustic rhinometry has not only been used to

examine hay fever patients but in many different aspects of rhinology. Since the introduction of the acoustic reflection technique in the nose more than papers using the technique have been published. Most of the papers find the technique valuable for evaluation of nasal patency. Fortunately, some critical papers have drawn attention to some practical aspects of the technique. Standard operating procedures, and calibration checks as well as training operators will enhance the accuracy and reproducibility of results. CONCLUSION AND PERSPECTIVES: A decade after its introduction acoustic rhinometry is a well-established method for evaluation of nasal patency, but further improvement can be obtained by continued validation and adjustments of the technique

202. Kamal, I. 2002. Lung volume dependence of pharyngeal cross-sectional area by acoustic pharyngometry. *Otolaryngol.Head Neck Surg.* 126:164-171.
Abstract: Pharyngeal size and the dynamic behavior of the pharynx may be important factors in the modulation of pharyngeal airflow. There are two measures of pharyngeal function: changes in pharyngeal area with lung volume and changes in pharyngeal area in response to externally applied positive pressure. Both measurements have been used for the assessment of pharyngeal function, and both reflect pharyngeal "floppiness." The aim of the present study was to examine the relationship between pharyngeal cross-sectional area, using acoustic reflection technique, and different lung volumes (tidal volume, inspiratory reserve volume, and expiratory reserve volume), to determine whether there are differences in mechanical properties of the pharynx of normal volunteers in response to changes in intrapharyngeal pressure. The acoustic technique was used to assess the pharyngeal cross-sectional area of 40 healthy volunteers (29 men and 11 women) at tidal volume, inspiratory reserve volume, and expiratory reserve volume. In men, the mean pharyngeal area at tidal volume was 3.191 cm2, the mean pharyngeal area at inspiratory reserve volume was 2.976 cm2, and the mean pharyngeal area at expiratory reserve volume was 2.975 cm2. In women, the corresponding pharyngeal area measurements were 2.832, 2.484, and 2.492 cm2. Statistical analysis of results showed that men have a larger pharyngeal cross-sectional area and the pharyngeal airways of men and women act in a similar manner in response to changes in intrapharyngeal pressure, with men having a greater change. Examination of the pharyngeal compliance by acoustic pharyngometry adds to the potential of this technique as a tool for the evaluation of the pharyngeal airway in terms of area and dynamic behavior assessment. This may be of relevance in promotion of the development of upper airway assessment in patients with obstructive sleep apnea

203. Karnath, B., A. W. Frye, and M. D. Holden. 2002. Incorporating simulators in a standardized patient exam. *Acad.Med* 77:754-755.
Abstract: OBJECTIVE: Using simulated patients during a clinical skills exam that involves many students has the advantage of standardizing the delivery of historical data. One major disadvantage is the inability to standardize the physical exam findings. We designed a simulated patient exam that incorporates simulated abnormal physical exam findings. DESCRIPTION: The simulated patient exam case was divided into three separate stations: (1) the simulated patient's history, (2) the simulated physical exam, and (3) the presentation station. Dyspnea was chosen as the chief complaint because of the broad differential of possible cardiac and pulmonary auscultatory findings. In the first station, students obtained historical data from the standardized simulated patient. Students were graded on their ability to ask appropriate historical questions. Trained observers were used to verify the numbers of historical cues obtained by the students. The second station consisted of simulated physical exam findings. Students first measured the blood pressure on a commercially available blood pressure simulator arm from the Medical Plastics Laboratory, Inc., Gatesville, TX. Students then auscultated an abnormal digital heart sound and pulmonary sound from a small auscultation transducer developed by Andries Acoustics, Spicewood, TX. Students also palpated a simulated pulse from a newly developed pulse transducer. Digital cardiopulmonary sounds and pulse data were recorded onto a CD-ROM disc and transmitted to the small transducers via a CD-ROM disc player. Students used their own stethoscopes to auscultate cardiopulmonary sounds from the small transducers. The students were graded in the second station on their ability to accurately measure a blood pressure, identify abnormal cardiopulmonary digital sounds, and finally describe a peripheral pulse. In the third station, students presented the historical data and physical exam findings to a faculty member, and then provided a differential diagnosis list based on their key findings from the other two stations. A total of 171 students (n = 171) completed the simulated patient exam. Each student completed the exam in 45 minutes. DISCUSSION: In our simulated patient exam, students were evaluated not only on their data-gathering skills for key historical findings but also on the ability to correctly identify key physical exam findings such as abnormal cardiopulmonary sounds. Key physical exam findings were then integrated into the clinical decision-making process, which was presented in the faculty presentation station. Simulated patients with abnormal cardiopulmonary findings can be used for testing purposes. However, cardiac auscultatory abnormalities such as the ventricular S3 gallop are difficult to find and usually occur in a decompensated state such as heart failure. Other physical exam findings such as pulmonary crackles and wheezes also occur in decompensated conditions. Therefore, the use of simulators during a simulated patient exam offers the possibility of introducing several abnormal physical exam findings without having an unstable patient present in an exam setting. Further, the use of simulated physical exam findings allows for complete standardization of a clinical-simulated patient exam

204. Karnath, B., W. Thornton, and A. W. Frye. 2002. Teaching and testing physical examination skills without the use of patients. *Acad.Med* 77:753.
Abstract: OBJECTIVE: To design a cardiopulmonary physical exam curriculum that does not involve the use of patients. Bedside teaching is becoming a lost art, and the use of alternative methods of instruction such as simulation has become increasingly

important. Simulators have been shown to enhance physical examination skills of students and physicians in training.(1) DESCRIPTION: In 1995, a program was started to improve cardiopulmonary physical diagnosis and the teaching of auscultation at the University of Texas Medical Branch at Galveston (UTMB). The teaching manikin "Harvey" played a vital role in the development of the new curriculum. In 1997, UTMB adopted an organ-based approach to the basic science curriculum. The cardiopulmonary module in the basic science curriculum was a ten-week course taught in the second year of medical school. The physical diagnosis section of that course involved six instructional hours; four of the six hours were dedicated to cardiac auscultation and two hours to pulmonary auscultation. Only simulators and CD-ROMs were used for instruction. The 184 second-year medical students at UTMB were formed into small groups for instruction and practice. Although "Harvey" was an effective teaching tool, other simulators had to be developed for testing students' skills after instruction. It would be very difficult to administer a skills OSCE for 184 students without the development of several smaller transportable simulators. A commercially available blood pressure simulator from the Medical Plastics Laboratory, Inc., Gatesville, TX, was used to test the accuracy of students' blood pressure readings. Small auscultation transducers combined with a palpable pulse simulator, developed by one of the authors (WT) in collaboration with Andries Acoustics, Spicewood, TX, were used to efficiently test students' proficiency in cardiopulmonary auscultation. Digital simulated cardiopulmonary sounds were recorded onto a standard CD-ROM mini-disc and transmitted to the small transducers. Students used their own stethoscopes for auscultation. The targeted skills were efficiently tested in one hour of testing time per student. DISCUSSION: This cardiopulmonary instructional module was well received by the second-year medical students. In the skills OSCE, 80% of the students accurately measured systolic and diastolic blood pressure to within 5 mm Hg. Cardiopulmonary auscultation proficiency results showed average recognition of 60% for cardiac abnormalities and 88% for pulmonary sounds. Developing auscultation transducers with pulse simulation capability ensured that students could identify systole. Therefore, heart murmurs and sounds could be timed with the cardiac cycle. We found the results from the skills OSCE encouraging. Most students demonstrated reasonable competency in the skills taught, and the new transportable simulators performed well. The six-hour instructional module was meant to prepare students for their bedside teaching during the third year of medical school. The significant cost of the "Harvey" simulator may be a barrier to its widespread use for teaching. Therefore, continued development of smaller transportable simulators for teaching and testing purposes is important

205. Kiyokawa, H. and H. Pasterkamp. 2002. Volume-dependent variations of regional lung sound, amplitude, and phase. *J.Appl.Physiol* 93:1030-1038.
Abstract: Acoustic imaging of the respiratory system demonstrates regional changes of lung sounds that correspond to pulmonary ventilation. We investigated volume-dependent variations of lung sound phase and amplitude between two closely spaced sensors in five adults. Lung sounds were recorded at the posterior right upper, right lower, and left lower lobes during targeted breathing (1.2 +/- 0.2 l/s; volume = 20-50 and 50-80% of vital capacity) and passive sound transmission (< or =0.2 l/s; volumes as above). Average sound amplitudes were obtained after band-pass filtering to 75-150, 150-300, and 300-600 Hz. Cross correlation established the phase relation of sound between sensors. Volume-dependent variations in phase (< or =1.5 ms) and amplitude (< or =11 dB) were observed at the lower lobes in the 150- to 300-Hz band. During inspiration, increasing delay and amplitude of sound at the caudal relative to the cranial sensor were also observed during passive transmission in several subjects. This previously unrecognized behavior of lung sounds over short distances might reflect spatial variations of airways and diaphragms during breathing

206. Koehler, U., V. Gross, C. Reinke, T. Penzel, and C. F. Vogelmeier. 2002. [Acoustic analysis of nocturnal bronchial obstruction]. *Pneumologie* 56:19-24.
Abstract: Patients with obstructive pulmonary disease also have respiratory problems in sleep. The continuous acoustic lung sound detection together with a cardiorespiratory polysomnography allows a synchronous registration of bronchial obstruction as well as vigilance and respiratory parameters in sleep.A total of 20 patients (9 male and 11 female) with known obstructive airway disease and evident diurnal bronchial obstruction were investigated. We did a monitoring in all patients with a nocturnal continuous acoustic lung sound detection together with a cardiorespiratory polysomnography. The mean age was 55 +/- 12 years (range 23 to 74).In all patients acoustic nocturnal bronchial obstructions could be registered. The wheezing-time (time portion of wheezing while sleeping) was 32.1 +/- 27.4 % (mean +/- SD). We could not proof reliable a rhythm of bronchial obstructions. Only 3 patients had increased bronchial obstructions between 3 and 5 AM. The sleep structure was disturbed in 16 of 20 patients with reduced deep sleep, REM sleep and prolonged sleep latency.Knowing about nocturnal bronchial obstructions helps to adapt the antiobstructive therapy. One can expect that an improvement of the respiratory situation also improves sleep quality

207. Koh, Y. Y., Y. Park, J. H. Jeong, C. K. Kim, and J. T. Kim. 2002. Relationship of wheezing to airflow obstruction in asthmatic children and a history of cough-variant asthma. *J Asthma* 39:307-314.
Abstract: The aim of this study was to examine the relationship of wheezing to airflow obstruction during acute episodes of asthma in patients who had CVA (Cough variant asthma). Two groups of asthmatic children, one group with a past history of CVA (n = 13) and the other group without such a history (n = 14), were followed longitudinally for 12 months. During that time, they were evaluated for the presence of wheezing and the severity of airflow obstruction during acute episodes of asthma. Significant airflow obstruction occurred free of wheezing more frequently and the presence of clinical wheezing was associated with more severe

airflow limitation, in asthmatic patients with a past history of CVA than in those without such a history. We conclude that asthmatic patients who have experienced CVA develop the wheezing symptom at a higher level of airflow obstruction

208. Koss, M. C., Y. Yu, J. A. Hey, and R. L. McLeod. 2002. Acoustic rhinometry in the dog: a novel large animal model for studies of nasal congestion. *Am.J.Rhinol.* 16:49-55.
Abstract: The aim of this project was to develop and pharmacologically characterize an experimental dog model of nasal congestion in which nasal patency is measured using acoustic rhinometry. Solubilized compound 48/80 (0.3-3.0%) was administered intranasally to thiopental anesthetized beagle dogs to elicit nasal congestion via localized mast cell degranulation. Compound 48/80-induced effects on parameters of nasal patency were studied in vehicle-treated animals, as well as in the same animals pretreated 2 hours earlier with oral d-pseudoephedrine or chlorpheniramine. Local mast cell degranulation caused a close-related decrease in nasal cavity volume and minimal cross-sectional area (Amin) together with a highly variable increase in nasal secretions. Maximal responses were seen at 90-120 minutes after 48/80 administration. Oral administration of the adrenergic agonist, d-pseudoephedrine (3.0 mg/kg), significantly antagonized all of the nasal effects of compound 48/80 (3.0%). In contrast, oral administration of the histamine H1 receptor antagonist chlorpheniramine (10 mg/kg) appeared to reduce the increased nasal secretions but was without effect on the compound 48/ 80-induced nasal congestion (i.e., volume and Amin). These results show the effectiveness of using acoustic rhinometry in this anesthetized dog model. The observations that compound 48/80-induced nasal congestion was prevented by d-pseudoephedrine pretreatment, but not by chlorpheniramine, suggest that this noninvasive model system may provide an effective tool with which to study the actions of decongestant drugs in preclinical investigations

209. Kraman, S. S., G. R. Wodicka, H. Kiyokawa, and H. Pasterkamp. 2002. Are minidisc recorders adequate for the study of respiratory sounds? *Biomed.Instrum.Technol.* 36:177-182.
Abstract: Digital audio tape (DAT) recorders have become the de facto gold standard recording devices for lung sounds. Sound recorded on DAT is compact-disk (CD) quality with adequate sensitivity from below 20 Hz to above 20 KHz. However, DAT recorders have drawbacks. Although small, they are relatively heavy, the recording mechanism is complex and delicate, and finding one desired track out of many is inconvenient. A more recent development in portable recording devices is the minidisc (MD) recorder. These recorders are widely available, inexpensive, small and light, rugged, mechanically simple, and record digital data in tracks that may be named and accessed directly. Minidiscs hold as much recorded sound as a compact disk but in about 1/5 of the recordable area. The data compression is achieved by use of a technique known as adaptive transform acoustic coding for minidisc (ATRAC). This coding technique makes decisions about what components of the sound would not be heard by a human listener and discards the digital information that represents these sounds. Most of this compression takes place on sounds above 5.5 KHz. As the intended use of these recorders is the storage and reproduction of music, it is unknown whether ATRAC will discard or distort significant portions of typical lung sound signals. We determined the suitability of MD recorders for respiratory sound research by comparing a variety of normal and pathologic lung sounds that were digitized directly into a computer and also after recording by a DAT recorder and 2 different MD recorders (Sharp and Sony). We found that the frequency spectra and waveforms of respiratory sounds were not distorted in any important way by recording on the two MD recorders tested

210. Krieter, B., H. Matz, E. Konecny, and H. Gehring. 2002. [Continuous bilateral auscultation as perioperative monitoring of ventilation: comparison of 2 systems for registering respiratory sounds]. *Biomed.Tech.(Berl)* 47 Suppl 1 Pt 2:561-3.:561-563.

211. Mansy, H. A., T. J. Royston, R. A. Balk, and R. H. Sandler. 2002. Pneumothorax detection using pulmonary acoustic transmission measurements. *Med Biol Eng Comput* 40:520-525.
Abstract: Pneumothorax is a common clinical condition that can be life threatening. The current standard of diagnosis includes radiographic procedures that can be costly and may not always be readily available or reliable. The objective of this study was to investigate the hypothesis that pneumothorax causes detectable pathognomonic changes in pulmonary acoustic transmission. An animal model was developed whereby 15 mongrel dogs were anaesthetised, intubated and mechanically ventilated. A thoracoscopic trocar was placed into the pleural space for the introduction of air and confirmation of a approximately 30% pneumothorax by direct visualisation. Broadband acoustic signals were introduced into the endotracheal tube, while transmitted waves were measured at the chest surface. Pneumothorax was found consistently to lower the pulmonary acoustic transmission in the 200-1200 Hz frequency band, whereas smaller transmission changes occurred at lower frequencies ($p < 0.0001$, sign test). The ratio of acoustic energy between low-(< 220 Hz) and high-(550-770 Hz) frequency bands was significantly different in the control and pneumothorax states ($p < 0.0001$, sign test). This implies that pneumothoraces can be reliably detected using pulmonary acoustic transmission measurements in the current animal model. Further studies are needed to investigate the feasibility of using this technique in humans

212. Mansy, H. A., T. J. Royston, R. A. Balk, and R. H. Sandler. 2002. Pneumothorax detection using computerised analysis of breath sounds. *Med.Biol.Eng Comput.* 40:526-532.
Abstract: The primary objective of the study was to investigate the effects of pneumothorax (PTX) on breath sounds and to

evaluate their use for PTX diagnosis. The underlying hypothesis is that there are diagnostic breath sound changes with PTX. An animal model was created in which breath sounds of eight mongrel dogs were acquired and analysed for both normal and PTX states. The results suggested that pneumothorax was associated with a reduction in sound amplitude, a preferential decrease in high-frequency acoustic components and a reduction in sound amplitude variation during the respiration cycle ($p<0.01$ for each, using the Wilcoxson signed-rank test). Although the use of diminished sound amplitude for PTX diagnosis assumes availability of baseline measurements, this appears unnecessary for high-frequency reduction or sound amplitude changes over the respiratory cycle. Further studies are warranted to test the clinical feasibility of the method in humans

213. McGinn, J. D. and R. L. Plant. 2002. Acoustic analysis of upper airway obstruction in the excised human larynx. *Ann.Otol.Rhinol.Laryngol.* 111:738-744.
Abstract: Upper airway obstruction is an emergency that requires quick and decisive intervention. Stridor is the sound created by airflow through a partially obstructed airway, and has been described to vary with the site and degree of obstruction. This study sought to determine the sound characteristics of stridor in the excised human larynx. Five fresh cadaver human larynges were harvested and subjected to obstructions at supraglottic, glottic, and subglottic subsites. Subglottic pressure, airflow, and audio signal were recorded. Data were analyzed on the basis of laryngeal obstruction subsite and the degree of laryngeal resistance. Visual inspection demonstrated certain trends in peak spectral energy depending on the site and, more significantly, the amount of obstruction. Statistical analysis of spectral waveforms showed better correlation with the amount of obstruction than with the site of obstruction. In summary, the frequency distribution of stridor produced in an excised human larynx was influenced by the amount of laryngeal resistance, but not by the site of airway obstruction

214. Moerman, M., M. De Meyer, and D. Pevernagie. 2002. Acoustic analysis of snoring: review of literature. *Acta Otorhinolaryngol.Belg.* 56:113-115.
Abstract: Acoustic analysis of snoring could make patient assessment more accurate, treatment planning more efficient and could provide objective documentation reliable for comparison. However, spectral characteristics are irregular and difficult to analyse. The authors give an overview of the available literature and the various applied methods. These methods differ in purpose and are subject to restrictions. Until now, acoustic analysis of snoring remains controversial. For linking the results of the acoustic analysis with anatomical levels or degree of obstruction, further study is needed to develop a reliable parameter

215. Monahan, K. J., E. K. Larkin, C. L. Rosen, G. Graham, and S. Redline. 2002. Utility of noninvasive pharyngometry in epidemiologic studies of childhood sleep-disordered breathing. *Am J Respir Crit Care Med* 165:1499-1503.
Abstract: Measurement of pharyngeal dimensions may contribute to the characterization of anatomic risk factors for sleep-disordered breathing (SDB) in children. Acoustic pharyngometry, a noninvasive method, has been used successfully in adults, but application in children has been limited. We sought to evaluate the feasibility and utility of this technique in children, including assessment of the variation of pharyngeal measurements with height, sex, ethnicity, prematurity, and indices of SDB. Subjects were drawn from a large, community-based cohort of children of age 8-11 years. Demographic, morphologic, and sleep-related information were collected via standard questionnaires, direct measurement, and home cardiorespiratory monitoring during sleep. Pharyngeal dimensions were assessed in 203 children using acoustic pharyngometry performed with an optimized mouthpiece. In this sample, the coefficient of variation of minimum pharyngeal cross-sectional area (CSA) and mean CSA were similar to those in adults (8.0 and 11.1%, respectively). The minimum CSA, but not mean CSA, was significantly reduced in preterm children, habitual snorers, and children with SDB relative to unaffected children. Thus, minimum CSA is a useful measure for evaluating SDB risk factors in preadolescent children

216. Mori, M. 2002. [Contribution of Japanese researchers to progress in the field of pulmonary medicine in the last 100 years: Respiratory sound]. *Nippon Naika Gakkai Zasshi* 91:1728-1729.

217. O'Brien, W. D., Jr., J. M. Kramer, T. G. Waldrop, L. A. Frizzell, R. J. Miller, J. P. Blue, and J. F. Zachary. 2002. Ultrasound-induced lung hemorrhage: role of acoustic boundary conditions at the pleural surface. *J Acoust.Soc.Am* 111:1102-1109.
Abstract: In a previous study [J. Acoust. Soc. Am. 108, 1290 (2000)] the acoustic impedance difference between intercostal tissue and lung was evaluated as a possible explanation for the enhanced lung damage with increased hydrostatic pressure, but the hydrostatic-pressure-dependent impedance difference alone could not explain the enhanced occurrence of hemorrhage. In that study, it was hypothesized that the animal's breathing pattern might be altered as a function of hydrostatic pressure, which in turn might affect the volume of air inspired and expired. The acoustic impedance difference between intercostal tissue and lung would be affected with altered lung inflation, thus altering the acoustic boundary conditions. In this study, 12 rats were exposed to 3 volumes of lung inflation (inflated: approximately tidal volume; half-deflated: half-tidal volume; deflated: lung volume at functional residual capacity), 6 rats at 8.6-MPa in situ peak rarefactional pressure (MI of 3.1) and 6 rats at 16-MPa in situ peak rarefactional pressure (MI of 5.8). Respiration was chemically inhibited and a ventilator was used to control lung volume and respiratory frequency. Superthreshold ultrasound exposures of the lungs were used (3.1-MHz, 1000-Hz PRF, 1.3-micros pulse duration, 10-s

exposure duration) to produce lesions. Deflated lungs were more easily damaged than half-deflated lungs, and half-deflated lungs were more easily damaged than inflated lungs. In fact, there were no lesions observed in inflated lungs in any of the rats. The acoustic impedance difference between intercostal tissue and lung is much less for the deflated lung condition, suggesting that the extent of lung damage is related to the amount of acoustic energy that is propagated across the pleural surface boundary

218. Powell, C. V., P. McNamara, A. Solis, and N. J. Shaw. 2002. A parent completed questionnaire to describe the patterns of wheezing and other respiratory symptoms in infants and preschool children. *Arch.Dis.Child* 87:376-379.
Abstract: AIM: To develop a standardised and validated respiratory symptom questionnaire for use in epidemiological or follow up studies in infants and preschool children. METHODOLOGY: After initial design and development, the questionnaire was administered to two cohorts of subjects, one recruited from a respiratory clinic and the other from a postnatal ward. The two cohorts then repeated the questionnaire, two weeks apart. The qualities of the questionnaire were assessed. RESULTS: Response rate to the initial questionnaire was 100% for the clinic based cohort and 64% for postnatally recruited families (total number of subjects 114). Questions showed good to moderate short term reliability (weighted kappa scores 0.47-0.7; average correct classification rates 0.74-0.91). Four domain concept scores showed excellent internal consistency (Cronbach alpha scores 0.87-0.95). Using principal component factor analysis, four new domains were devised showing acceptable construct validity and internal consistency. Criterion validity was assessed using a respiratory physician based diagnosis of asthma (RPBDA) as the gold standard for comparison. All eight scales in the questionnaire could significantly distinguish between infants with RPBDA and well or mildly symptomatic subjects. CONCLUSION: We have developed a practical, acceptable questionnaire with eight concept domains for use in infants and preschool children. The questionnaire has strong construct validity and internal consistency with good short term reliability of questions. More detailed study of criterion validity and the responsiveness of the questionnaire is required using a larger population and including children with the different phenotypes of wheezy illness

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Abstract: We measured tracheal flow from tracheal sounds to estimate tidal volume, minute ventilation (VI), respiratory frequency, mean inspiratory flow (VT/TI), and duty cycle (TI/Ttot). In 11 normal subjects, 3 patients with unstable airway obstruction, and 3 stable asthmatic patients, we measured tracheal sounds and flow twice: first to derive flow-sound relationships and second to obtain flow-volume relationships from the sound signal. The flow-volume relationship was compared with pneumotach-derived volume. When subjects were seated, facing forward and with neck rotation, flexion, and standing, flow-volume relationship was within 15% of pneumotach-derived volume. Error increased with neck extension and while supine. We then measured ventilation without mouthpiece or nose clip from tracheal sounds during quiet breathing for up to 30 min. Normal results +/- SD revealed tidal volume = 0.37 +/- 0.065 liter, respiratory frequency = 19.3 +/- 3.5 breaths/min, VI = 6.9 +/- 1.2 l/min, VT/TI = 0.31 +/- 0.06 l/s, and TI/Ttot = 0.37 +/- 0.04. Unstable airway obstruction had large VI due to increased VT/TI. With the exception of TI/Ttot, variations in ventilatory parameters were closer to log normal than normal distributions and tended to be greater in patients. We conclude that phonospirometry measures ventilation reasonably accurately without mouthpiece, nose clip, or rigid postural constraints

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Abstract: To evaluate the utility of monitoring the sound-filtering characteristics of the respiratory system in the assessment of acute lung injury (ALI), we injected a multifrequency broadband sound signal into the airway of five anesthetized, intubated pigs, while recording transmitted sound over the trachea and on the chest wall. Oleic acid injections effected a severe lung injury predominantly in the dependent lung regions, increasing venous admixture from 6 +/- 1 to 54 +/- 8% ($P < 0.05$) and reducing dynamic respiratory system compliance from 19 +/- 0 to 12 +/- 2 ml/cmH(2)O ($P < 0.05$). A two- to fivefold increase in sound transfer function amplitude was seen in the dependent ($P < 0.05$) and lateral ($P < 0.05$) lung regions; no change occurred in the nondependent areas. High within-subject correlations were found between the changes in dependent lung sound transmission and venous admixture (r = 0.82 +/- 0.07; range 0.74-0.90) and dynamic compliance (r = -0.87 +/- 0.05; -0.80 to -0.93). Our results indicate that the acoustic changes associated with oleic acid-induced lung injury allow monitoring of its severity and distribution

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Abstract: Case reports of a short trachea with early branching of the main bronchi are uncommon. The case is presented of a 64 year old woman with upper airway obstruction due to this anatomical abnormality which caused breathlessness and wheezing that was misdiagnosed (and treated) as bronchial asthma for many years

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Abstract: Patients with bronchial asthma often have respiratory problems in sleep. The effects of bronchial obstructions while

sleeping have been analysed in some studies. For an exact assessment the sleep itself must not be disturbed by the method. The continuous acoustic lung sound detection is such a method. It helps to assess the circadian rhythm during antiobstructive therapy which may lead to a better sleep quality and daytime fitness

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Abstract: A theoretical and experimental study was undertaken to examine the feasibility of using audible-frequency vibro-acoustic waves for diagnosis of pneumothorax, a collapsed lung. The hypothesis was that the acoustic response of the chest to external excitation would change with this condition. In experimental canine studies, external acoustic energy was introduced into the trachea via an endotracheal tube. For the control (nonpneumothorax) state, it is hypothesized that sound waves primarily travel through the airways, couple to the lung parenchyma, and then are transmitted directly to the chest wall. In contradistinction, when a pneumothorax is present the intervening air presents an added barrier to efficient acoustic energy transfer. Theoretical models of sound transmission through the pulmonary system and chest region to the chest wall surface are developed to more clearly understand the mechanisms of intensity loss when a pneumothorax is present, relative to a baseline case. These models predict significant decreases in acoustic transmission strength when a pneumothorax is present, in qualitative agreement with experimental measurements. Development of the models, their extension via finite element analysis, and comparisons with experimental canine studies are reviewed

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Abstract: BACKGROUND: There is some information about wheeze characteristics in infants, however it is not clear whether the different wheeze patterns relates to prognosis and evolution during the first two years of life. OBJECTIVES: To characterize wheezing and spectral pattern of lung sounds in infants with acute bronchiolitis (AB) and in infants with recurrent wheeze (RW) as well as to compare these parameters with the clinical evolution 2 years after admission. METHODS: Seventy six AB infants (48 boys), aged 5.5 +/- 0.7 months (mean +/- SD), 62 RSV (+) and 32 RW infants (20 boys), aged 11.4 +/- 2 months were studied during the first week of admission at the hospital. Patients were studied during spontaneous sleep, breathing with a face mask connected to a pneumotachograph at flows of 0.1 +/- 0.02 L/s. Sounds were registered at baseline and 20 minutes after salbutamol using 2 contact sensors placed at both lower lobes levels. Signals were low-pass filtered, amplified and a Fourier analysis was applied to sounds within a target flow range. Spectral analysis was done between 100 and 1000 HZ. RESULTS: In 40/76 (53%) AB vs 30/34 (88%) RW sinusoidal wheezing ($p < 0.01$; chi 2) were observed and a positive bronchodilator response was obtained in 37/76 (49%) AB vs 32/34 (94%) RW ($p < 0.01$; chi 2). Patients with sinusoidal wheezing (s-w) had more wheezing episodes in follow-up, 26/40 vs 8/36 in complex wheezing (c-w), ($p < 0.01$: chi 2) and 30/34 in RW ($p < 0.01$; chi 2). IgE values at 18 months were higher in s-w compared to c-w (63 +/- 7 vs 24 +/- 5 Iu/mL ($p < 0.01$) and 96 +/- 11 Iu/mL in RW ($p < 0.01$). CONCLUSIONS: a) Wheezing characteristics in acute bronchiolitis vs recurrent wheezing are different; b) Bronchodilator response relates to wheeze characteristics and c) Higher IgE and more recurrent wheezing episodes are seen in acute bronchiolitis with sinusoidal wheezing. These findings suggest that lung sounds analysis is useful in assessing wheezy patients and have a value to identify infants on risk of developing asthma

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Abstract: BACKGROUND: Exposure to high intensity, low frequency noise can cause whole-body vibration. Such exposures to airborne vibration can reach the limits of human tolerance and have been associated with physiological and pathological disorders. The objective of this study was to characterize human body vibration response during exposures to operational airborne vibration. METHODS: Triaxial body accelerations were collected at multiple anatomical sites with the subject located at selected crew positions during ground-based engine runup tests on several military tactical aircraft. The acceleration time histories were processed in one-third octave frequency bands and compared with the one-third octave band noise data. RESULTS: The most significant finding was the occurrence of a resonance peak in the fore-and-aft (X) chest acceleration in the frequency bands between 63 and 100 Hz. Both the chest acceleration and associated noise level increased as the subject moved aft of the exhaust outlet, coinciding with the report of increasing chest vibration. A relatively linear relationship was found between the overall chest accelerations and noise levels between 5 and 250 Hz. An approach to developing combined noise and vibration exposure criteria was proposed. CONCLUSIONS: The resonance observed in the upper torso strongly suggested that airborne vibration in the 60 to 100 Hz frequency band may be an important contributing factor in the generation of subjective symptoms and possibly physiological and pathological disorders. Additional field and laboratory studies are required to validate the relationship between the biodynamic responses, noise levels, and physiological and pathological consequences

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Abstract: The internal noise spectrum in miniature electret microphones of the type used in the manufacture of hearing aids is measured. An analogous circuit model of the microphone is empirically fit to the measured data and used to determine the important sources of noise within the microphone. The dominant noise source is found to depend on the frequency. Below 40 Hz and above 9 kHz, the dominant source is electrical noise from the amplifier circuit needed to buffer the electrical signal from the microphone diaphragm. Between approximately 40 Hz and 1 kHz, the dominant source is thermal noise originating in the acoustic flow resistance of the small hole pierced in the diaphragm to equalize barometric pressure. Between approximately 1 kHz and 9 kHz, the noise originates in the acoustic flow resistances of sound entering the microphone and propagating to the diaphragm. To further reduce the microphone internal noise in the audio band requires attacking these sources. A prototype microphone having reduced acoustical noise is measured and discussed

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Abstract: The presented research positively evaluates the vocality of the cough sound by estimating the global cough fundamental frequency or pitch. The fundamental frequency was determined by autocorrelation analysis on both the original time-signal and the linear predicted time-signal. The experimental cough database was registered in the free acoustical field on respectively three pathological and nine healthy non-smoking human subjects and on two pathological and two healthy Belgian Landrace piglets. For both species differences between pitch values for cough-sounds originating from subjects suffering from a respiratory infection and healthy subjects are put forward. The retrieved pitch-difference between respectively healthy and infected subjects indicates the existence of acoustically different cough-classes in accordance with a different cause or physical condition of the respiratory system

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Abstract: Cough or cough epochs may be an important and persistent symptom in many respiratory diseases requiring both a continuous and objective observation. The research presented in this paper is aimed at assessing a blind data-based classification between 'spontaneous' and 'voluntary' human cough on individual sound samples. Cough sounds were registered in the free acoustic field on 3 pathological and 9 healthy non-smoking subjects, all aged between 20 and 30. Each sound is represented by the normalized power spectral density (PSD). Different transformations of the cough PSD-vector are chosen as input features to the classification algorithm. An experimental error rate comparison between different neural and fuzzy classification networks is performed. All evaluated algorithms used the Euclidean metric. This resulted in a correct class-discrimination between 'spontaneous' and 'voluntary' cough for 96% of the cough database

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Abstract: Sleep-disordered breathing (SDB) affects more than 4% of the adult population with an even higher prevalence within high-risk groups. Nasal continuous positive air pressure, although considered the current gold standard treatment for SDB, demonstrates poor patient compliance. Alternative therapies, such as palatal surgeries and airway orthotics, lack validated candidacy selection protocols, resulting in varying success rates. Although much has been published over the last several years regarding the effect of these therapies on the upper airway, no publication has presented an accounting of the use of acoustic reflection (AR) to evaluate airway characteristics pre- and post-treatment with these alternative therapies. This article will review AR and our current knowledge base of the pathological airway characteristics that can be assessed through AR. It will include the advantages, limitations, and potential clinical usefulness of this diagnostic modality in the treatment of patients with SDB

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Abstract: We developed a lung sound auscultation simulator "Mr. Lung" in 2001. To improve the auscultation skills of lung sounds, we utilized this new device in our educational training facility. From June 2001 to March 2002, we used "Mr. Lung" for our small group training in which one hundred of the fifth year medical students were divided into small groups from which one group was taught every other week. The class consisted of ninety-minute training periods for auscultation of lung sounds. At first, we explained the classification of lung sounds, and then auscultation tests were performed. Namely, students listened to three cases of abnormal or adventitious lung sounds on "Mr. Lung" through their stethoscopes. Next they answered questions corresponding to the portion and quality of the sounds. Then, we explained the correct answers and how to differentiate lung sounds on "Mr. Lung". Additionally, at the beginning and the end of the lecture, five degrees of self-assessment for the auscultation of the lung sounds were performed. The ratio of correct answers for lung sounds were 36.9% for differences between bilateral lung sounds, 52.5% for coarse crackles, 34.1% for fine crackles, 69.2% for wheezes, 62.1% for rhonchi and 22.2% for stridor. Self-assessment scores

were significantly higher after the class than before. The ratio of correct lung sound answers was surprisingly low among medical students. We believe repetitive auscultation of the simulator to be extremely helpful for medical education

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Abstract: AIMS: To examine parents' accounts of how they recognise and judge respiratory symptoms in children, and to investigate their interpretations of respiratory survey questions about wheeze, shortness of breath, and cough. METHODS: Qualitative study using semistructured interviews. Data were analysed using the constant comparative method. Nineteen parents of children aged under 6 years were recruited from a cohort of parents who had responded to an earlier respiratory symptom survey and from one general practice. RESULTS: Parents judged respiratory symptoms using a range of cues, including changes in the sound of breathing and changes in appearance and behaviour. Experiential resources and contextual factors played an important role in parents' judgements. Interpretations of questions about respiratory symptoms were varied, particularly in relation to the terms "attacks of wheeze" and "shortness of breath". Parents' descriptions of wheeze differed from descriptions of the sound of wheeze used in some survey questionnaires. Parents drew fine distinctions between different "types" of cough and identified a distinct "asthma" cough. CONCLUSIONS: Attention needs to be given to the complexity of reporting respiratory symptoms in children and to the importance of contextual factors in parents' judgements. We suggest that questions which require parents to report on children's internal feelings or states be avoided. Consideration should be given to providing parents with explicit direction on what cues to attend to or ignore in reporting symptoms, and to clarifying some questions that are currently used in clinical practice and in surveys

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Abstract: Sound generation by confined stationary jets is of interest to the study of voice and speech production, among other applications. The generation of sound by low Mach number, confined, stationary circular jets was investigated. Experiments were performed using a quiet flow supply, muffler-terminated rigid uniform tubes, and acrylic orifice plates. A spectral decomposition method based on a linear source-filter model was used to decompose radiated nondimensional sound pressure spectra measured for various gas mixtures and mean flow velocities into the product of (1) a source spectral distribution function; (2) a function accounting for near field effects and radiation efficiency; and (3) an acoustic frequency response function. The acoustic frequency response function agreed, as expected, with the transfer function between the radiated acoustic pressure at one fixed location and the strength of an equivalent velocity source located at the orifice. The radiation efficiency function indicated a radiation efficiency of the order (kD)2 over the planar wave frequency range and (kD)4 at higher frequencies, where k is the wavenumber and D is the tube cross sectional dimension. This is consistent with theoretical predictions for the planar wave radiation efficiency of quadrupole sources in uniform rigid anechoic tubes. The effects of the Reynolds number, Re, on the source spectral distribution function were found to be insignificant over the range 2000<Re<20000. The source spectral distribution function approximately obeyed a St(-3) power law for Strouhal number values St<0.9, and a St-5 power law for St>2.5. The influence of a reflective open tube termination on the source function spectral distribution was found to be insignificant, confirming the absence of a feedback mechanism

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Abstract: In snorers, the physiologic decrease of postural muscle tone during sleep results in increased collapsibility of the upper airway. Measurement of nasal pressure changes with prongs is increasingly used to monitor flow kinetics through a collapsing upper airway. This report presents a mathematical model to predict nasal flow profile from three critical components that control upper airway patency during sleep. The model includes the respiratory pump drive, the stiffness of the pharyngeal soft tissues, and the dynamic support of the muscles surrounding the upper airway. Depending on these three components, the proposed model is able to reproduce the characteristic changes in flow profile that are clinically observed in snorers and non-snorers during sleep

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Abstract: We analyze a sequence of short transient sound waves, called "crackles," which are associated with explosive openings of airways during lung inflation. The distribution of time intervals between consecutive crackles Delta(t) shows two regimes of power law behavior. We develop an avalanche model which fits the data over five decades of Delta(t). We find that the regime for large Delta(t) is related to the dynamics of distinct avalanches in a Cayley tree, and the regime for small Delta(t) is determined by the dynamics of crackle propagation within a single avalanche. We also obtain a mean-field solution of the model which provides information about lung inflation

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Abstract: The sounds generated by breathing in asthma are widely accepted as an indicator of disease activity. We have investigated the use of a mobile phone and electronic signal transfer by e-mail and voice mail to study tracheal breath sounds in individuals with normal lung function and patients with chronic or exercise-induced asthma. Spectrograms from patients with active asthma and impaired lung function were significantly different from people without asthma ($p<0.0001$). Our results suggest that mobile phone recordings clearly discriminate tracheal breath sounds in asthma and could be a non-invasive method of monitoring airway diseases

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Abstract: AIMS: To investigate how parents report children's respiratory sounds on video compared to a clinical "gold standard". METHODS: Five clinicians agreed on 10 video clips of children with audible breathing. These responses were the "gold standard". The clips were shown to parents of children: (a) with asthma/wheeze; (b) with other respiratory complaints; (c) without respiratory complaints. Parents were asked what they called the sounds, where they originated, and whether their own child made similar sounds. RESULTS: A total of 190 parents took part. The "correct" labelling of wheeze was 59% (95% confidence interval 52 to 66%) and 47% (95% confidence interval 40 to 54%) for other sounds (stridor, snoring, stertor). Parents were better at locating both sounds than labelling. There were no differences between subject groups. There were more false positive responses to labelling and locating other sounds than for wheeze (27% v 8% and 33% v 10%). CONCLUSION: Parents locate sounds better than describing them. At least 30% of all parents use other words for wheeze and 30% labelled other sounds as "wheeze". This could have important clinical implications

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Abstract: OBJECTIVE: To record respiratory sounds in exercising horses and determine whether spectrum analysis could be use to identify sounds specific for laryngeal hemiplegia (LH) and dorsal displacement of the soft palate (DDSP). ANIMALS: 5 Standardbred horses. PROCEDURE: Respiratory sounds were recorded and pharyngeal pressure and stride frequency were measured while horses exercised at speeds corresponding to maximum heart rate, before and after induction of LH and DDSP. RESULTS: When airway function was normal, expiratory sounds predominated and lasted throughout exhalation. After induction of LH, expiratory sounds were unaffected; however, all horses produced inspiratory sounds characterized by 3 frequency bands centered at approximately 0.3, 1.6, and 3.8 kHz. After induction of DDSP, inspiratory sounds were unaffected, but a broad-frequency expiratory sound, characterized by rapid periodicity (rattling) was heard throughout expiration. This sound was not consistently detected in all horses. CONCLUSIONS AND CLINICAL RELEVANCE: The technique used to record respiratory sounds was well tolerated by the horses, easy, and inexpensive. Spectrum analysis of respiratory sounds from exercising horses after experimental induction of LH or DDSP revealed unique sound patterns. If other conditions causing airway obstruction are also associated with unique sound patterns, spectrum analysis of respiratory sounds may prove to be useful in the diagnosis of airway abnormalities in horses

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Abstract: Sound signals of respiratory airflow represent summations of acoustic waves of various frequencies, which basically depend on the characteristics of the flow and on those of the surrounding tissue. This study was designed to examine the capability of time-frequency distribution (TFD) of respiratory signals in order to differentiate between unobstructed and obstructed upper airways. In order to investigate the TFD characteristics of defined upper airway geometry we conducted a controlled basic study in a laboratory system with an in vitro isolated airway model, which was either unobstructed or had concentric obstructions of various degrees at different locations along the tube. Pressure fluctuations were acquired with a microphone proximal to the airway opening. A short-term Fourier transform was used to study the TFDs of these signals. The results of the in vitro study showed that the energy of the higher frequencies increased for relatively small incremental changes in: i) reduction of the lumen cross-section, ii) decrease of distance from measurement site to obstruction, and iii) increase of breathing effort. Further development of this method may lead to noninvasive clinical techniques for early diagnosis of upper airway obstructions

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Abstract: BACKGROUND: Over the last decade there has been an apparent increase in childhood wheeze. We speculated that much of the reported increase may be attributed to the term wheeze being adopted by parents to describe a variety of other forms of noisy breathing. AIMS: To investigate terminology used by parents to describe their children's breath sounds. METHODS: An interview was carried out with the parents of 92 infants with noisy breathing, beginning with an open question and then directed towards a more detailed description. Finally, the parents were asked to choose from a wheeze, ruttle, and stridor on imitation by the investigator and video clips of children. RESULTS: Wheeze was the most commonly chosen word on initial questioning (59%). Only 36% were still using this term at the end of the interview, representing a decrease of one third, whereas the use of the word ruttles doubled. CONCLUSIONS: Our results reflect the degree of inaccuracy involved in the use of the term wheeze in clinical practice, which may be leading to over diagnosis. Imprecise use of this term has potentially important implications for therapy and clinical trials

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Abstract: The aim of this study was to examine an acoustic reflection method using a flexible tube for identifying the obstructive site of the upper airway in snorers and patients with obstructive sleep apnoea (OSA). As a preliminary study it was performed n models and subjects in the awake state. Flextube narrowing was produced in a model of the nose and pharynx and three blinded observers assessed the obstructive level. The correlation between pharyngeal narrowing assessed by endoscopy and by acoustic measurement during Muller manoeuvres was also examined in 10 OSA patients and 11 healthy non-snoring, adults. Three blinded observers dentified the level of 176 of 180 random cases of flextube narrowing in a polycarbonate model correctly The level of narrowing was always correctly evaluated within 1.9 mm. Pharyngeal area decrease was measured by the flextube method during the Muller manoeuvre but it was not closely related to the findings by endoscopy. In conclusion the flextube reflectometry method was able to demonstrate narrowng in a model of the nose and pharynx in a precise way. Narrowing was also observed during Muller manoeuvres. Flextube reflectometry may be a promising method to detect upper airway narrowing but further evaluation during sleep is required

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Abstract: Wheezing in infants is common and increasing in prevalence. Infants are particularly prone to wheezing due to developmental differences in airway mechanics compared to adults. These effects are enhanced in the presence of airway inflammation. Wheezing in infants is related to flow limitation which is a function of airway calibre and airway wall compliance. This review discusses the factors contributing to flow limitation and hence, wheezing. It tries to make the link between risk factors influencing airway structure, and thus function, with particular emphasis on the special physiological peculiarities of infants and lung growth. While in adults inflammation and remodelling alone may explain structural and functional changes in wheezing disorders, this reviews proposes a model emphasising that in infants inflammation, remodelling and airway development have to be considered as a continuously interacting system

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Abstract: The field of respiratory flow and transport has experienced significant research activity over the past several years. Important contributions to the knowledge base come from pulmonary and critical care medicine, surgery, physiology, environmental health sciences, biophysics, and engineering. Several disciplines within engineering have strong and historical ties to respiration including mechanical, chemical, civil/environmental, aerospace and, of course, biomedical engineering. This review draws from a wide variety of scientific literature that reflects the diverse constituency and audience that respiratory science has developed. The subject areas covered include nasal flow and transport, airway gas flow, alternative modes of ventilation, nonrespiratory gas transport, aerosol transport, airway stability, mucus transport, pulmonary acoustics, surfactant dynamics and delivery, and pleural liquid flow. Within each area are a number of subtopics whose exploration can provide the opportunity of both depth and breadth for the interested reader

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Abstract: Most clinicians learned the art and science of auscultation using an acoustic stethoscope. While many models of electronic stethoscopes have been marketed over the years, none of them seem to do a very good job of emulating the most common forms of acoustic stethoscopes available. This paper is an appeal to biomedical circuit designers to learn more about the acoustics of commonly used stethoscopes and to develop an appropriate group of circuits which would emulate them much like music synthesizers can emulate almost any musical instrument. The implications are for creative designers to move toward a rational and acceptable design for both personal physician use and for telemedicine

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Abstract: Low-frequency forced oscillation (LFOT) and raised volume rapid thoracic compression (RVRTC) techniques were used to measure airways and respiratory tissue mechanics and forced expiratory volumes in 24 asymptomatic infants with recurrent wheeze. Total respiratory impedance spectra (Zrs) (0.5 to 20 Hz) were obtained (n = 22) and a model containing airway (resistance [Raw] and inertance [Iaw]) and constant-phase tissue (tissue damping [G] and tissue elastance [H]) compartments fitted to Zrs. Forced expiratory volumes (FEV(0.5)) were determined (n = 16). Standardized variants (Z scores) were calculated for comparison to a healthy population (Hall et al., Am J Respir Crit Care Med 2000;162:1397-1402). Wheezy infants had elevated H (Z scores: 0.61 +/- 0.20; p = 0.007) but not Raw (0.14 +/- 0.25; p > 0.2), G (0.41 +/- 0.21; p = 0.066), or FEV(0.5) (-0.25 +/- 0.25; p > 0.2) compared with healthy infants. Infants younger than 1 yr of age were not significantly different from normals, whereas lung function from infants older than 1 yr had deviated from normal infants, with Z scores of 0.58 +/- 0.2 (p = 0.018), 0.79 +/- 0.31 (p = 0.032), 1.06 +/- 0.25 (p = 0.002), and -0.94 +/- 0.22 (p = 0.007) for Raw, G, H, and FEV(0.5) respectively. We conclude that asymptomatic infants with recurrent wheeze have altered lung function. The abnormalities were more pronounced in respiratory tissue mechanics than in airway mechanics or forced volumes, highlighting the value of techniques capable of partitioning lung function into airway and respiratory tissue components

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Abstract: With the emerging use of tracheal sound analysis to detect and monitor respiratory tract changes such as those found in asthma and obstructive sleep apnea, there is a need to link the attributes of these easily measured sounds first to the underlying anatomy, and then to specific pathophysiology. To begin this process, we have developed a model of the acoustic properties of the entire respiratory tract (supraglottal plus subglottal airways) over the frequency range of tracheal sound measurements, 100 to 3000 Hz. The respiratory tract is represented by a transmission line acoustical analogy with varying cross sectional area, yielding walls, and dichotomous branching in the subglottal component. The model predicts the location in frequency of the natural acoustic resonances of components or the entire tract. Individually, the supra and subglottal portions of the model predict well the distinct locations of the spectral peaks (formants) from speech sounds such as /a/ as measured at the mouth and the trachea, respectively, in healthy subjects. When combining the supraglottic and subglottic portions to form a complete tract model, the predicted peak locations compare favorably with those of tracheal sounds measured during normal breathing. This modeling effort provides the first insights into the complex relationships between the spectral peaks of tracheal sounds and the underlying anatomy of the respiratory tract

251. Hetherington, T. E. 2001. Laser vibrometric studies of sound-induced motion of the body walls and lungs of salamanders and lizards: implications for lung-based hearing. *J Comp Physiol [A]* 187:499-507.
Abstract: A laser Doppler vibrometer was used to measure the acoustic responses of different body surfaces of several species of salamanders and lizards. The lateral body wall over the lung displayed sound-induced motion up to 30 dB greater than the lateral head surface from 300-1,000 Hz in salamanders and from 200-2,500 Hz in lizards. The lateral body wall of lungless plethodontid salamanders showed no such enhanced motion to sound. The lateral body wall of lizards was more responsive than their tympanum to sound frequencies below about 1,250-2,000 Hz. The frequency of the peak response of lizard body walls matched the resonant frequency of a Helmholtz resonator with the volume and dimensions of their lungs. In contrast, the frequency of peak response of salamander body walls was well below the resonant frequencies calculated for both Helmholtz resonators and closed tubes with the dimensions and volumes of their lungs. Nonetheless, filling the lungs with saline dramatically reduced the responsiveness of the lateral body walls of both the lunged salamanders and the lizards. As previously demonstrated in anuran amphibians, the lateral body wall and lungs of salamanders and lizards may function in sound reception, especially at relatively low frequencies

252. Holmes, W. F., J. T. Macfarlane, R. M. Macfarlane, and R. Hubbard. 2001. Symptoms, signs, and prescribing for acute lower respiratory tract illness. *Br.J Gen.Pract* 51:177-181.
Abstract: BACKGROUND: Most patients who consult with acute lower respiratory symptoms receive antibiotics, usually without evidence of significant infection. The physical signs at presentation of acute lower respiratory tract illness and the rate at which symptoms resolve and normal activities recover is not well documented. AIM: To examine in patients with lower respiratory tract infection (LRTi), their physical signs at presentation, their relationship to antibiotic prescribing, and symptom resolution and resumption of normal activities. DESIGN OF STUDY: Analysis of data collected prospectively during presentation of acute LRTi in primary care and from patient symptom diary cards. SETTING: Forty GPs who were members of an informal Community Respiratory Infection Interest Group recruited 391 patients to the study. METHOD: Information was collected on pulse, oral temperature, respiratory rate, abnormalities on auscultation, and details of any antibiotic prescription. Patients completed symptom diary cards for the following 10 days. RESULTS: Of the 391 patients who consulted 71% received antibiotics. A minority had abnormal physical signs: 17% had a pulse greater than 90 bpm, 15% a respiratory rate greater than 20 breaths per minute, 4% had a temperature greater than 38 degrees C, and 25% had an abnormality on auscultation. Antibiotic prescribing was more

common in the presence of abnormal chest signs (odds ratio = 8.71, 95% confidence interval = 3.69-20.61) or discoloured sputum (OR = 2.67, 95% CI = 1.57-4.56). Ten days after consultation, 58% of patients were still coughing and 29% had not returned to normal activities. CONCLUSION: Abnormal physical signs at presentation do not explain the high rates of antibiotic prescribing nor do they predict persisting cough and functional impairment at 10 days. Reconsultation for the same symptoms within a month is common and is strongly related to persisting cough, but not abnormalities at presentation

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Abstract: BACKGROUND: In elderly asthmatics, underdiagnosis is one of the important features. The main reason for underdiagnosis is thought to be a low frequency in complaining of symptoms due to the reduction of intellectual recognition and physical activity. Among the various symptoms, wheezing is the principal clue in diagnosing bronchial asthma, and decreased complaints for wheezing are also noted in elderly asthmatics. The objective of this study is to determine if less complaints of wheezing in elderly asthmatic is due to decrease in the development of wheezing. METHODS: 61 young (20-39 years old), 68 middle-aged (40-59 years old) and 65 elderly (older than 60 years old) stable asthmatic subjects were studied (each group shall be called, hereafter, Young Group, Middle-aged Group and Old Group, respectively). During the methacholine induced airway narrowing, lung auscultation and questionnaire survey about presence and perception of wheezing were conducted in 194 asthmatics. RESULTS: One hundred and sixty-nine patients (87%) developed wheezing during the methacholine induced airway obstruction. The frequency of wheezing during the methacholine challenge was found to be comparable among the groups. The methacholine concentration, % fall in FEV1, and FEV1 levels of the initial detection of wheezing were not different among the groups. Among the patients who developed wheezing, 47 patients (77%), 42 patients (61.8%) and 26 patients (40%) complained of wheezing in Young, Middle and Old Group, respectively. CONCLUSION: In conclusion, the decreased perception of wheezing is a main factor for the low frequency of complaints of wheezing in elderly asthmatics

254. Kamal, I. 2001. Normal standard curve for acoustic pharyngometry. *Otolaryngol.Head Neck Surg.* 124:323-330.
Abstract: Pharyngeal size, compliance, and the dynamic behavior of the upper airway are important factors in the production of obstructive sleep apnea. Assessment of the upper airway for possible site(s) of obstruction is one of the keys to a successful management of the condition. Acoustic pharyngometry has the potential for localizing such sites, however, standardizing the operating technique and producing a standard normal curve is a prerequisite before exploring the potential of this equipment. A total number of 350 normal volunteers (271 males and 79 females) were examined by acoustic pharyngometry and a coefficient of variance of 5% to 7% was obtained from each of them. Mean and standard deviation of pharyngeal area at each point of X-axis (distance) was obtained and analyzed statistically to produce a general standard curve. Using special techniques during examination, the oropharyngeal junction and glottis were located, and thus a mapped acoustic pharyngogram was produced. Mean pharyngeal area was 3.194 cm(2) in males (SD 0.311) and 2.814 cm(2) in females (SD 0.331). Mean glottic area was 1.06 cm(2) in males (SD 0.119) and 0.936 cm(2) in females (SD 0.108). A minimal pharyngeal area is probably needed as a "golden standard" to evaluate patients with obstructive sleep apnea

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Abstract: A remote auscultation support system was developed that compresses and records in real time the patient's breath sound and heart sound, obtained using a stethoscope, and sends this data to an attending doctor at a hospital via network. For real-time recording of the breath sound and heart sound, special-purpose, high-quality sound coding technology was developed and incorporated in the system, This sound coding technology enables the amount of data to be reduced to about 1/18 with virtually no deterioration of the properties of the auscultation sound, high-speed transmission of this data using network, and remote diagnosis of the auscultation sound by a medical specialist. The auscultation locations of each patient, together with the doctor, stethoscoper, and patient database are input into the system in advance at the hospital. At the patient's home or sanatorium, the auscultation sound is recorded according to a human body display that shows auscultation locations, and then sent to the hospital. To ensure patient confidentiality when the auscultation data is transmitted via network, the system scrambles the auscultation data and allows only the attending doctor to play and diagnose the auscultation sound. These features not only support an understanding of the condition of patients being treated at home, but they also enable the construction of an auscultation database for electronic charts that allows auscultation results to be shared within the hospital. When this remote auscultation support system was manufactured and its performance was assessed, virtually the same waveform was obtained for the recorded and played breath sound as for the original breath sound. Results showed that even at a sampling frequency of 11 kHz, remote diagnosis by a medical specialist was in fact possible. Furthermore, if auscultation data of 10 seconds per location for 10 locations is sent, the amount of data sent is only about 120 Kbytes. Since this amount of data converts to only about 25 pages of electronic mail text, even via the existing mobile network the auscultation sounds of many patients can be sent efficiently

256. Kiyokawa, H., M. Greenberg, K. Shirota, and H. Pasterkamp. 2001. Auditory detection of simulated crackles in breath sounds. *Chest* 119:1886-1892.
Abstract: BACKGROUND: Computerized analysis of breath sounds has relied on human auditory perception as the reference standard for identifying crackles. In this study, we tested the human audibility of crackles by superimposing artificial clicks on recorded breath sounds and having physicians listen to the recordings to see if they could identify the crackles. OBJECTIVES: To establish the audibility of simulated crackles introduced in breath sounds of different intensity, to study the effects of crackle characteristics on their audibility, and to investigate crackle detection within and between observers. METHODS: Fine, medium, and coarse crackles with large and small amplitude were synthesized by computer software. Waveform parameters were based on published characteristics of lung sound crackles. The amplitude for small crackles was defined as just above the threshold of audibility for simulated crackles inserted in sound recorded during breath hold. Simulated crackles were then superimposed on breath sounds recorded at 0 L/s (breath hold), 1 L/s, and 2 L/s airflow. Five physicians listened during playback on two separate occasions to determine if crackles could be heard and to calculate the interobserver and intraobserver variations. RESULTS: Failed detection of crackles was significantly more common in the following conditions: (1) background breath sounds had higher intensity (2 L/s airflow) compared to lower intensity (1 L/s), (2) crackle type was coarse or medium compared to fine, and (3) crackle amplitude was small compared to large. Both intraobserver and interobserver agreements were high (kappa > 0.6). RELEVANCE: The validation of automated techniques for crackle detection in lung sound analysis should not rely on auscultation as the only reference. Detection of crackles is facilitated when patients take slow, deep breaths that generate little breath sounds

257. Kompis, M., H. Pasterkamp, and G. R. Wodicka. 2001. Acoustic imaging of the human chest. *Chest* 120:1309-1321.
Abstract: STUDY OBJECTIVES: A novel method for acoustic imaging of the human respiratory system is proposed and evaluated. DESIGN: The proposed imaging system uses simultaneous multisensor recordings of thoracic sounds from the chest wall, and digital, computer-based postprocessing. Computer simulations and recordings from a life-size gelatin model of the human thorax are used to evaluate the system in vitro. Spatial representations of thoracic sounds from 8-microphone and 16-microphone recordings from five subjects (four healthy male adults and one child with lung consolidation) are used to evaluate the system in vivo. RESULTS: Results of the in vitro studies show that sound sources can be imaged to within 2 cm, and that the proposed algorithm is reasonably robust with respect to changes in the assumed sound speed within the imaged volume. The images from recordings from the healthy volunteers show distinct patterns for inspiratory breath sounds, expiratory breath sounds, and heart sounds that are consistent with the assumed origin of the respective sounds. Specifically, the images support the concept that inspiratory sounds are produced predominantly in the periphery of the lung while expiratory sounds are generated more centrally. Acoustic images from the subject with lung consolidation differ substantially from the images of the healthy subjects, and localize the abnormality. CONCLUSIONS: Acoustic imaging offers new perspectives to explore the acoustic properties of the respiratory system and thereby reveal structural and functional properties for diagnostic purposes

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Abstract: Sonography has inherent limitations for thoracic imaging because sound waves are reflected by bone and air space (such as in lung parenchyma). However, sonography is less expensive and more convenient than computed tomography (CT) or magnetic resonance imaging (MRI); it provides immediate information with real-time imaging; and it can provide information not available from a standard radiograph. This review describes the utility and limitations of sonography and compares sonography to radiography, CT, and MRI with regard to diagnosing pleural, pulmonary, and aortic diseases, including pneumothorax, pleural effusions and masses, hemothorax, empyema, consolidated lung, pneumonia, pulmonary abscess, pulmonary embolism, mediastinal masses, aortic dissection, aortic intramural hematoma, and penetrating aortic ulcers

259. Larivee, Y., Z. Leon, M. Salas-Prato, E. Ganeva, and M. Desrosiers. 2001. Evaluation of the nasal response to histamine provocation with acoustic rhinometry. *J.Otolaryngol.* 30:319-323.
Abstract: The objectives of this study were to evaluate the reproducibility of the nasal response to histamine with the acoustic rhinometer and to compare the responses in normal and rhinitic subjects. Our study comprised 10 normal and 10 rhinitic subjects. Each subject had six sessions of provocation: three with histamine phosphate at a concentration of 4 mg/mL and three with saline phosphate provocation. Basal measurements of the nasal volumes were taken initially and then at 5-minute intervals for 90 minutes. All rhinometric measurements were made bilaterally and in triplicate. The variation between the triplicate measurements (2% +/- 0.1% [95% CI]) and the variation between the basal measurements (7.3% +/- 3.1% [95% CI]) were very low in both normal and rhinitic subjects. The comparison of the average congestive response of the normal subjects revealed that they responded steadily for at least 90 minutes to histamine and saline but that the response to histamine was significantly more important. There was also a low variability in the congestive response between the subjects. The comparison of the average congestive response of the rhinitic subjects revealed that their responses were more dynamic, not steady, compared with those of the normal subjects. The response was statistically significant only in the first few intervals. The comparison of the average congestive response to saline suggests that rhinitic subjects present a more important response than normal subjects. The comparison of the average congestive response to histamine between rhinitic and normal subjects was not statistically different but was different in the shape of the response pattern. Acoustic rhinometry is a highly reproducible method for measuring nasal volume in our provocation

protocol. Histamine nasal provocation leads to a pattern of congestive response that is different in normal and rhinitic subjects. Histamine nasal provocation seems to be useful in addition to the study of nasal hyperreactivity and, as such, could permit differentiation between rhinitic and nonrhinitic subjects

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Abstract: PURPOSE: Cardiac auscultation is suffering from a declining interest caused by competing diagnostic technology and, possibly, inadequate teaching and testing of physicians-in- training. Because access to technology, traditional teaching practices, and methods of trainees' assessment vary among different countries, we speculated that trainees' proficiency in auscultation might also vary. SUBJECTS AND METHODS: We tested the cardiac auscultatory skills of 314 internal medicine residents (189 from the United States, 89 from Canada, and 36 from England) from 14 programs. Ail participants were asked to listen by stethophones to 12 prerecorded cardiac events and to answer a multiple-choice questionnaire. They also completed a survey concerning attitudes toward cardiac auscultation and auscultatory teaching received during training. RESULTS: Mean (+/- SD) identification scores for the 12 cardiac events ranged from 0% to 58% for American trainees (mean 22% +/- 12%), 0% to 58% for Canadians (mean 26% +/- 13%), and 0% to 42% for British trainees (mean 20% +/- 12%. Canadians' cumulative scores were slightly but significantly greater than those of American (P = 0.02) and British house officers (P = 0.05). British house officers improved the most during the 3 years of training (P <0.05). Canadian and British trainees had received more auscultatory teaching during medical school and residency; they had also used audiotapes more frequently (all P <0.001). CONCLUSIONS: Auscultatory proficiency was poor in all three countries. Although there were slight differences among countries, the most striking finding was the consistent inaccuracy of all trainees. This suggests that variables other than teaching and testing affect proficiency. (C)2001 by Excerpta Medica, Inc

261. Mansy, H. A., T. J. Royston, and R. H. Sandler. 2001. Acoustic characteristics of air cavities at low audible frequencies with application to pneumoperitoneum detection. *Med Biol.Eng Comput.* 39:159-167.
Abstract: Air accumulations within living organisms are sometimes pathologic. An example is free air within the abdomen from perforation of the intestines (a condition called pneumoperitoneum). The objectives of the described research were to define the acoustic signatures of abdominal air cavities at low frequencies and to investigate the feasibility of using these signatures for pneumoperitoneum diagnosis. The central hypothesis was that low-frequency vibro-acoustic property changes are detectable using broad-band acoustic excitation applied at the abdominal surface. Band-limited white noise (0-3200 Hz) was introduced at the abdominal surface of sedated dogs and response was measured by a surface vibro-acoustic sensor. The transfer function and coherence were estimated from these measurements. The presence of pneumoperitoneum caused increased resonances and anti-resonances ($p < 0.01$). Measures of the latter parameters were proposed and evaluated to quantitatively measure their magnitude. Resonant spectral peaks of more than 3 dB were consistent with pneumoperitoneum ($p < 0.01$), and both resonance and anti-resonance increased with condition severity ($p < 0.03$). The data also suggest a possible reduction in the resonant and anti-resonant frequencies with decreasing air cavity volumes ($p = 0.14$) as supported by theoretical predictions. Finally, anti-resonance was also found to be associated with a drop in coherence. These findings suggest that the proposed technique may be useful in the diagnosis of pneumoperitoneum

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Abstract: Auscultation of the lungs has been a central element in clinical examination since the early part of the nineteenth century. However, the role of the stethoscope in our diagnostic work-up has more and more been challenged by newer diagnostic equipment. Research carried out over the last 30 years has given us new knowledge about the physical basis of lung sounds and the meaning of the sounds. Electronic stethoscopes and computer-based analysis of digital lung sounds are now available. Lungs auscultation findings should be interpreted with caution and be related to the case history and other clinical findings

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264. Ognibene, N. E., M. A. Merrick, and C. D. Ingersoll. 2001. Intra- and intersession reliability of acoustic rhinometry in measuring nasal cross-sectional area. *Ear Nose Throat J* 80:536, 539-536, 540.
Abstract: We evaluated the intrasession and intersession reliability of acoustic rhinometry in measuring nasal cross-sectional areas in 10 subjects. Subjects were measured under three conditions: with a Breathe Right nasal strip in place, with a sham strip in place, and with no strip in place. Two sets of three measurements were taken 1 week apart. The intrasession reliability both with and without the Breathe Right strip was very good (intraclass correlation coefficient [ICC] [2,1]: 0.97 and 0.98, respectively). The intersession reliability with and without the Breathe Right strip was not nearly as good (ICC [2,1]: 0.62 and 0.67). The Breathe Right strip increased the mean nasal cross-sectional area by 0.10 cm2 (17.4%). We conclude that acoustic rhinometry is a reliable way to measure nasal cross-sectional area during a single session of multiple tests, but it is not as reliable across sessions. We also determined that the Breathe Right nasal strip significantly increases nasal cross-sectional area

265. Pavesi, L., S. Subburaj, and K. Porter-Shaw. 2001. Application and validation of a computerized cough acquisition system for objective monitoring of acute cough: a meta-analysis. *Chest* 120:1121-1128.
Abstract: STUDY OBJECTIVE: The purpose of the meta-analysis was to understand the antitussive effect of treatment with dextromethorphan hydrobromide, 30 mg, vs placebo over a 3-h treatment period in patients with cough due to uncomplicated upper respiratory tract infection (URTI), and to show that the computerized system for acquisition and analysis of cough sound was consistent and reproducible across the individual studies. STUDY DESIGN: The six studies used for the meta-analysis were randomized, double-blind, parallel-group, single-dose, placebo-controlled studies with a 3-h postdose cough evaluation period. SETTING: One study was conducted in Durban, South Africa, and five studies were conducted in Bombay, India. Four studies took place in clinics, and two studies were in-home studies. PATIENTS: Seven hundred ten adult patients with cough due to uncomplicated URTI who were otherwise healthy and who satisfied the inclusion/exclusion criteria for the meta-analysis. Measurements and results: For each patient, a standard baseline was calculated pretreatment, then a 3-h continuous cough recording was made after treatment was initiated. Five efficacy variables were measured in 30-min intervals: cough bouts, cough components, cough effort, cough intensity, and cough latency. The meta-analysis showed consistent results across most of the studies for each of the efficacy variables. It demonstrated significantly greater overall reductions in cough bouts, cough components, and cough effort, and an increase in cough latency for patients treated with dextromethorphan hydrobromide, 30 mg, vs those treated with placebo. CONCLUSION: The results of a meta-analysis of the six clinical studies show that the antitussive effect of a single dose of dextromethorphan hydrobromide, 30 mg, has been established. The consistent nature of the results shows that the computerized cough acquisition and analysis system is a valid and reproducible methodology for evaluating cough associated with URTI

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Abstract: The variation of acoustic attenuation with lung density was determined in experimental studies on seven healthy human volunteers, using a change of lung volume as a means of varying lung density. White noise between 50 and 680 Hz was introduced into the mouth and the transmitted signals were recorded with four microphones on the posterior chest wall (left/right, top/base) at 24, 40, 60 and 80% of total lung capacity. The change in lung volume had a frequency-dependent effect on acoustic attenuation in all subjects. A frequency between 177 and 243 Hz was identified, where altering the lung volume between 24 and 80% of total lung capacity induced a change in attenuation of only 1.0 (+/-0.5) to 2.7 (+/-1.8) dB, while at a frequency of 364-436 Hz marked variations in attenuation 8.9 (+/-2.0) to 21.5 (+/-4.8) dB occurred with similar lung volume changes

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Abstract: Chin lift, jaw thrust and these manoeuvres combined with continuous positive airway pressure (CPAP) can be used to improve the patency of the upper airway during general anaesthesia. We used video endoscopy and measurement of stridor to compare the efficacy of these manoeuvres in 24 children (3-10 yr) with adenotonsillar hyperplasia. A bronchofibrescope was passed via the nose while the children were breathing spontaneously, to identify (i) the shortest transverse distance between the tonsils during inspiration and during expiration and (ii) the distance from the tip of the epiglottis to the posterior pharyngeal wall. Chin lift or jaw thrust lifted the epiglottis and, when combined with CPAP (10 cm H2O), there was a significant lateral displacement of the tonsils. Both chin lift plus CPAP and jaw thrust plus CPAP reduced stridor significantly compared with the unsupported condition. In conclusion, in spontaneously breathing children with large tonsils, chin lift plus CPAP is recommended, whereas jaw thrust plus CPAP is no better and may cause post-operative discomfort

268. Saarinen, A., H. Rihkanen, L. P. Malmberg, L. Pekkanen, and A. R. Sovijarvi. 2001. Disturbances in airflow dynamics and tracheal sounds during forced and quiet breathing in subjects with unilateral vocal fold paralysis. *Clin.Physiol* 21:712-717.
Abstract: Variable extra thoracic obstruction has been found in spirometric studies in subjects with unilateral vocal fold paralysis. The aim of the study was to further evaluate airflow dynamics in these subjects with body plethysmography and tracheal sound analysis. Ten patients with unilateral vocal fold paralysis without a history of chronic pulmonary diseases and 10 healthy control subjects were studied. Flow-volume spirometry, body plethysmography and tracheal sound analysis were performed within 1 day. The study shows that peak inspiratory flow (PIF) and specific airway conductance (SG(aw)) expressed as percentage of Finnish reference values were significantly lower and airway resistance (R(aw)) was higher among the patients than among the controls (P=0.004, P=0.026 and P=0.004, respectively). The patients had higher sound amplitude of both inspiratory and expiratory tracheal sounds than the controls [root mean square (RMS) values of the power spectra were 31.5 and 25 dB, P=0.006 in inspiration and 31.5 and 26 dB, P=0.013 in expiration, respectively]. Quartile frequencies (F25 and F50) and RMS of expiratory tracheal sounds had significant negative correlation with PIF (P=0.02, P<0.001, P=0.02, respectively) and forced inspiratory volume in 1 s (FIV(1)) (P=0.01, P<0.001, P=0.01, respectively). There was also an association between F50 and peak expiratory flow (PEF) (P=0.02). According to the present study, both quiet breathing and forced inspiration are disturbed in subjects with unilateral vocal fold paralysis. A close relationship between tracheal sounds and respiratory function tests exists

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Abstract: The aim of this study was to investigate the changes in tracheal sounds and airflow dynamics in patients who underwent surgical medialization of a unilaterally paralysed vocal fold. Ten adults with unilateral vocal fold paralysis but no history of pulmonary diseases were Included. Vocal medialization was performed by an injection of autologous fascia into the paralysed vocal fold. Recording of tracheal sounds, flow-volume spirometry and body plethysmography were carried out before and 4-14 months after the operation. The mean number of inspiratory wheezes per respiratory cycle increased from 0.02 (range 0- 0.10) to 0.42 (range 0-0.86) and the mean number of expiratory wheezes per respiratory cycle from 0.03 (range 0-0.20) to 0.36 (range 0-0.89). The increment was statistically significant (P=0.03 and P=0.04, respectively). The mean expiratory sound amplitude, in terms of root mean square (RMS), increased From 31.5 dB (range 24.0-38.0) to 34.9 dB (range 25-42) (P = 0.03) and the average peak inspiratory flow (PIF) decreased from 4.63 1 s(-1) (range 2.84-7.51) to 4.03 1 s(-1) (range 2.27-6.68) (P = 0.01). The results indicate that when the paralysed vocal fold is brought into midline by a surgical procedure, the prevalence of inspiratory and expiratory wheezes increases and sound intensity rises. According to this preliminary data tracheal sound analysis gives additional information for the assessment of the subtle changes in the larynx

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Abstract: BACKGROUND: There are changes in inspiratory breath sound intensity in patients with airway obstruction. Airway narrowing may change sound spectral characteristics. AIM: To define the characteristics of lung sounds at standardized air flow during methacholine challenge and to compare acoustic changes with transcutaneous oxygen tension (PtcO2) during induced airway narrowing. PATIENTS AND METHODS: Forty asthmatic children (20 male) aged 5.2 +/- 1 years and 40 normal children (18 male), aged 5.6 +/- 1 years were studied. All patients were free of respiratory tract infections one month before the study. A methacholine challenge from 0.06 to 8 mg/ml was performed; the test was ended when a fall in PtcO2 of > 20% from baseline was observed or if the final concentration was reached. Subjects breathed through a pneumotachograph aiming at flows of 0.4 to 0.6 l/s. Respiratory sounds were recorded using contact sensors at the suprasternal notch and at the posterior right lower lobe. From average spectra, power at low (100-200 Hz = P1) and high frequencies (400-2000 = P2) was calculated. Frequencies below which 50% (F50) and 99% (SEF90) of the spectral power between 100 and 2000 Hz was contained, were also calculated. RESULTS: In asthmatics, the metacholine concentration at which a 20% fall in PtcO2 was observed, was lower than in normal children ($p < 0.05$). There was an increase in P1 ($p < 0.01$) and a reduction in P2 ($p < 0.01$) during inspiration, in subjects that experienced a 20% reduction in PtcO2. Also, there was an increase in F50 and SEF99 during inspiration in lung sounds, but not over the trachea. CONCLUSIONS: Lung sounds analysis can be useful for the assessment of airway reactivity in asthmatic children

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Abstract: BACKGROUND: Dysphagia and subsequent aspiration are serious complications of acute stroke that may be related to an impaired cough reflex. It was hypothesized that aspirating stroke patients would have impaired objective measures of voluntary cough as compared with both nonstroke control subjects and nonaspirating stroke patients. METHODS: Swallowing was evaluated by standard radiologic or endoscopic methods, and stroke patients were grouped by aspiration severity (severe, n = 11; mild, n = 17; no aspiration, n = 15). Airflow patterns and sound pressure level (SPL) of voluntary cough were measured in stroke patients and in a group of normal control subjects (n = 18). Initial stroke severity was determined retrospectively with the Canadian Neurological Scale. RESULTS: All cough measures were altered in stroke patients as a group relative to nonstroke control subjects. Univariate analysis showed that peak flow of the inspiration phase (770.6 +/- 80.6 versus 1,120.1 +/- 148.4 mL/s), SPL (90.0 +/- 3.1 versus 100.2 +/- 1.6 dB), peak flow of the expulsive phase (875.1 +/- 122.7 versus 1,884.1 +/- 221.6 mL/s), expulsive phase rise time (0.34 +/- 0.1 versus 0.09 +/- 0.01 s), and cough volume acceleration (5.5 +/- 1.3 versus 27.8 +/- 3.9 mL/s/s) were significantly impaired in severe aspirators as compared with nonaspirators. Aspirating patients had more severe strokes than nonaspirators (mean Canadian Neurological Scale score 7.7 +/- 0.7 versus 9.8 +/- 0.3). Multivariate logistic regression found only expulsive phase rise time values during cough correlated with aspiration status. CONCLUSION: Objective analysis of cough may provide a noninvasive way to identify the aspiration risk of stroke patients

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Abstract: Background: The aim of the study was to examine the use of oesophageal and precordial stethoscopes for monitoring in current paediatric anaesthetic practice in the UK and Ireland. Methods: A postal survey of members of the Association of Paediatric Anaesthetist of Great Britain and Ireland was undertaken. Results: One hundred and forty-five questionnaires were returned with a response rate of 67.4%. Some 35.2% of anaesthetists never use an oesophageal or precordial stethoscope and the majority of the remaining 64.8% use one in less than one-third of their practice. Conclusions: Use of the stethoscope as a continuous monitor has decreased and most anaesthetists feel it has been superseded by other monitoring. However, almost one-third of anaesthetists recorded critical incidents they had been involved with where an oesophageal or precordial stethoscope detected the incident early. Complications of these monitoring devices were rare and the main factors limiting their use was the presence of better monitoring, such as pulse oximetry and capnography, and lack of availability

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Abstract: Nasal resistance (NR) depends on the geometrical features and tortuosity of the nasal airway and on the air flow. Knowing the longitudinal distribution of cross-sectional areas (CSAs) in the nasal cavity (which can be obtained using acoustic rhinometry) and the laminar nasal resistance (obtainable by processing the rhinomanometric results), it is possible to calculate, utilizing a mathematical model elaborated on the basis of fluid dynamics, the differential nasal resistance (NRdiff) and the cumulative nasal resistance (NRcum), thus localizing the position at which the highest resistance is concentrated and the related longitudinal distribution. Using a mathematical model, we integrated the sigmoid curves DeltaP/Q of rhinomanometry with the cross-sectional areas obtained using acoustic rhinometry, thus obtaining the normal distribution of differential and cumulative nasal resistances. Afterwards, we empirically reduced the cross-sectional areas corresponding to the head, body, tail and the whole inferior turbinate, recalculating the differential and cumulative nasal resistance distribution curves. The results show that reduction of up to 50% of cross-sectional areas does not substantially affect the resistivity role of the nasal valve, while greater reductions move the highest resistivity point to an area at the junction of the body and the head of the inferior turbinate. The study of the differential nasal resistance trend curves as a function of the reduction of cross-sectional areas shows that the resistance variation of the body and the whole inferior turbinate prevail with reductions of up to 40%, while the variation of cross-sectional areas of the body bordering the inferior turbinate head is predominant with higher reductions. The cross-sectional areas of the nasal airway cavity with highest resistivity are mainly located in an anterior position, where the differential nasal resistances are higher, but there are substantial variations produced by reducing the cross-sectional area of the posterior nasal airway. A similar model can produce provisional values for the results obtainable with functional nasal surgery

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Abstract: This study was designed to validate a new home portable respiratory recording device (PRRD) to identify sleep apnoea and hypopnoea in a group of subjects (n=116), from a sample of the general population. Full night polysomnography (PSG) was used as the gold standard and simultaneously performed with PRRD. PRRD measurements included oronasal airflow (thermistry), chest wall impedance, oxygen saturation, snoring and body position. The sensors were unique for each recording system. Data obtained was blindly reviewed and analysed. A high level of agreement between both methods apnoea/hypopnoea index by PSG and the respiratory disturbance index (RDI) by PRRD was observed. Accuracy of the PRRD was evaluated in terms of sensitivity and specificity for different RDI-PRRD cut-off points with respect to AHI-PSG >10 and AHI- PSG >30. A logistic regression model

was performed to estimate the chance per unit of RDI of apnoeas. A received operating characteristic (ROC) curve was drawn to obtain the sensitivity/specificity profile for each observed RDI value obtained. From the ROC curve the authors identified the better cut-off points, which represent a balanced sensitivity/specificity. Through a classification table defined by the cut-off point, the post-odds to exhibit the disease was calculated. For a full PSG cut-off point of 10 a PRRD of six showed a balanced sensitivity of 95% and a specificity of 92%. For a full PSG cut-off point of 30 a PRRD of 16 shows a balanced sensitivity/specificity (100% and 97%, respectively). Post odds of apnoea were calculated for each cut-off point. In conclusion, these data suggest that the portable respiratory recording device is an effective device to identify apnoeas and hypopnoeas in a general population and is therefore a suitable device to be used in epidemiological studies

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Abstract: A new method for the extraction of features from stationary stochastic processes has been applied to a medical detection problem. It illustrates a practical application of automatic time series modeling, Firstly, the model type and the model order for two time series prototype models are selected. The prototypes represent the lung noises of a single healthy subject, before and after the application of methacholine, Using the model error ME as a measure for the difference between time series models, new data can be divided into classes that belong to the prototype models for this person. The prototype models are obtained from a few expiration cycles under known conditions. This is sufficient to detect the presence of methacholine in new data of the same subject if he is able to maintain stationary conditions by following accurately the prescribed breathing pattern, It is not necessary to use the same model type and the same model order for the prototypes and for new data. Automatically and individually selected models for prototypes and data give a good detection of methacholine

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Abstract: BACKGROUND: Reported wheeze is the cornerstone of asthma diagnosis. AIMS: To determine what parents understand by wheeze. METHODS: Two studies were undertaken: (1) Parents of clinic attendees with reported wheeze (n=160) were asked by questionnaire what they understood by "wheeze" and how they knew their child was wheezy. Responses were compared to definitions of wheeze in 12 epidemiology studies and their response options. (2) The extent of agreement of parents' reports (n=139) of acute wheezing in their children and clinicians' findings of "wheeze" and "asthma" was examined. RESULTS: (1) "Sound" and "difficulty in breathing" were perceived central to "wheeze". "What you hear" was not selected by 23% (95% confidence interval (CI) 16-30%). "Whistling" was mentioned by 11% (CI 6-15%) but featured in 11 of 12 epidemiology questionnaires. (2) There was les than 50% agreement between parents' and clinicians' reports of wheeze and asthma. CONCLUSIONS: Conceptual understandings of "wheeze" for parents of children with reported wheeze are different from epidemiology definitions. Parents' reports of acute wheeze and clinicians' findings also differ

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Abstract: Epidemiological studies indicate that the prevalence of "wheeze" is very high in early childhood. However, it is clear that parents and clinicians frequently use the term "wheeze" for a range of audible respiratory noises. The commonest audible sounds originating from the lower airways in infancy are ruttles, which differ from classical wheeze in that the sound is much lower in pitch, with a continuous rattling quality and lacking any musical features. The aim of this study was to clearly differentiate wheeze and ruttles objectively using acoustic analysis. Lung sounds were recorded in 15 infants, seven with wheeze and eight with ruttles, using a small sensitive piezoelectric accelerometer, and information relating to the respiratory cycle was obtained using inductive plethysmography. The acoustic signals were analysed using a fast fourier transformation technique (Respiratory Acoustics Laboratory Environment programme). The acoustic properties of the two noises were shown to be quite distinct, the classical wheeze being characterized by a sinusoidal waveform with one or more distinct peaks in the power spectrum display; the ruttle is represented by an irregular nonsinusoidal waveform with diffuse peaks in the power spectrum and with increased sound intensity at a frequency of <600 Hz. It is important for clinicians and epidemiologists to recognize that there are distinct types of audible respiratory noise in early life with characteristic acoustic properties

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Abstract: Airway diameter and airway wall mechanics (compliance) are important determinants of flow limitation and wheezing. We have previously used the high-speed interrupter technique (HIT) to measure input impedance (Zin) in infants at frequencies up to 900 Hz, including antiresonance phenomena, which are known to be related to wave propagation velocity, and have shown that the frequency at which the first antiresonance occurs (f(ar,1)) is a function of airway wall compliance. We aimed to determine whether f(ar,1) (and thus airway wall compliance) was different in infants with a history of wheezing disorders. We compared 23 asymptomatic infants (aged 36 to 81 wk) with a history of wheezing with an age-matched group of 19 healthy control infants. We found that f(ar,1) was significantly lower in infants with wheezing disorders than in the control group ($p < 0.005$), implying differences in airway wall compliance, even when they were clinically asymptomatic. Developmental differences in airway wall mechanics may be important in the pathogenesis of wheezing disorders or, alternatively, alterations in airway wall mechanics might be a consequence of postinflammatory remodeling

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Abstract: OBJECTIVE: The aim of this study is to determine the level of clinical auscultation skills in pediatric residents at Duke University Medical Center. METHODS: Forty-seven residents from pediatrics and joint medicine/pediatrics training programs at Duke University Medical Center were enrolled in this study. They were asked to examine the cardiovascular patient simulator, Harvey, and report their findings. Five common conditions seen in the pediatric population were presented: ventricular septal defect, atrial septal defect, pulmonary valve stenosis, combined aortic valve stenosis and insufficiency, and innocent systolic ejection murmur. The responses were scored by the number of features and diagnoses accurately reported. Five pediatric cardiologists and cardiologists in training were also asked to participate in a manner similar to the trainees. RESULTS: The mean score of features identified for the resident group was 11.4 +/- 2.6 of a possible 19. The diagnostic accuracy was 33%. There was no significant difference between residents by year of training or by type of residency program, although there was a trend toward improved performance with more training. The difference in performance between the pediatric cardiology group and the residents group was striking. The condition that was most frequently misdiagnosed was the innocent systolic ejection murmur. CONCLUSIONS: The clinical auscultation skills of pediatric residents in this study were suboptimal. There was a trend toward improvement as training progressed, although not statistically significant. These skills are likely to improve further with increased exposure to patients with cardiovascular disease especially in the ambulatory care setting

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Abstract: Auscultation is one of the most important noninvasive and feasible methods for the detection of lung diseases. Systematic changes in breathing sounds with increasing age are of diagnostic importance. To investigate these changes, we recorded lung sounds taken from four locations in the posterior thorax of 162 subjects, together with airflow. The data were analyzed according to age, sex, and smoking habit. In order to describe the power spectrum of the lung sounds, we calculated mean and median frequency, frequency with the highest power, and a ratio (Q) of relative power of the two frequency bands of 330 to 600 Hz and 60 to 330 Hz. Linear regression analysis was used as a measurement of age-dependence of these variables. Significant differences in Q were found in men versus women ($p < 0.05$), but not in smokers versus nonsmokers. Within the

groups, a small but significant correlation existed between Q and age (r(2) </= 0.1, p < 0.05). For both men and women, a slight increase of the relative power in the frequency band of 330 to 600 Hz was recorded with increasing age. However, on the basis of large individual variations, these small changes (DeltaQ approximately 5%, SD(Q) >/= +/- 5%) have no clinical significance and need not to be considered in the automatic detection of lung diseases by analyzing lung sounds

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Abstract: OBJECTIVE: To identify parameters that indicate retained secretions and the need for tracheal suctioning (TS) in patients receiving mechanical ventilation (MV). DESIGN: Prospective observational study. SETTING: A 14-bed medical ICU in a 946-bed university hospital. PATIENTS: Sixty- six consecutive patients receiving MV. INTERVENTIONS: Two successive tracheal suctions, TS1 and TS2, performed at a 2-h interval as usual patient care. Retained secretions were considered significant if the volume of secretions removed by TS2 was > 0.5 mL. Measurements and results: Variations between TS1 and TS2 of pulse oximetric saturation (SpO(2)), peak inspiratory pressure (Ppeak), tidal volume (VT), and Ramsay score were compared between patients with TS2 </= 0.5 mL (group 1; n = 27) and patients with TS2 > 0.5 mL (group 2; n = 39). The presence of a sawtooth pattern on flow-volume loop displayed on the monitor screen of the ventilator and of respiratory sounds heard over the trachea before TS2 were compared between the two groups. Variations of Ppeak, VT, SpO(2), and Ramsay score between TS1 and TS2 did not differ between the two groups. However, group 2 had a sawtooth pattern (82% vs 29.6%; p = 0.0001) and respiratory sounds (66.6% vs 25.9%; p = 0. 001) more frequently than group 1 before TS2. For the sawtooth pattern, the likelihood ratio (LR) of a positive test was 2.70 and the LR of a negative test was 0.25, while for respiratory sounds it was 2.50 and 0.45, respectively. When the presence of a sawtooth pattern and of respiratory sounds was combined, the LR of a positive test rose to 14.7 and the LR of a negative test was 0.42. CONCLUSIONS: A sawtooth pattern and/or respiratory sounds over the trachea are good indicators of retained secretions in patients receiving MV and may indicate the need for TS. Conversely, the absence of a sawtooth pattern may rule out retained secretions

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Abstract: Sleep nasendoscopy can be used to identify the site of snoring but questions remain about how well a short assessment during drug-induced sleep reflects the natural condition. To investigate the uniformity of snoring during natural sleep we studied five patients (three men, two women) referred by their GPs for treatment of their snoring. A digital audio tape recorder captured the free-field snore sound at different times of night in hospital. Acoustic Crest Factor values were calculated on the 15 recordings made, having previously demonstrated that high crest factor values distinguish palatal from non-palatal snoring at sleep nasendoscopy. Some recordings showed reproducibility, but others showed substantial changes between recordings an hour apart. We infer that the snoring mechanism may change in some individuals during the night, with or without a change of snore site. We conclude a single recording, as in sleep nasendoscopy, may not be representative

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Abstract: The conventional acoustic reflection technique in which acoustic waves are launched through the mouth cannot be applied during sleep, nor can it be applied to the nasopharynx, which is the major site of occlusion in patients with obstructive sleep apnea syndrome. We propose a new technique of nasal acoustic reflection to measure pharyngeal cross- sectional areas including the nasopharynx. The acoustic waves are introduced simultaneously to both nostrils during spontaneous nasal breathing. A new algorithm takes into account the nasal septum with asymmetric nasal cavities on both sides and assumes prior knowledge of the cross-sectional area of the nasal cavities and the position of the nasal septum. This method was tested on an airway model with a septum and on healthy human subjects. The conventional technique gave inaccurate measurements for pharyngeal cross-sectional areas for an airway model with asymmetric branching, whereas the new technique measured them almost perfectly. The oro- and hypopharyngeal cross- sectional area measurements acquired by the new method were not different from those obtained by the conventional method in normal subjects. This new method can be used as a monitor of upper airway dimensions in nocturnal polysomnography

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Abstract: In neonates intubated with an uncuffed endotracheal tube (ETT), positional changes of the head may induce obstruction (side position- related ETT obstruction [SPRO]) due to abutment of the beveled distal ETT orifice against the tracheal wall. We

studied whether the acoustic reflection (ACR) method, a 4-s measurement that maps cross-sectional area as a function of the distance along the ETT and the airways, could detect SPRO. Eleven preterm newborns intubated with 2.5-mm ETTs and clinically suspected of having SPRO were studied with the head oriented to the left and to the right. In all patients there was a marked decrease in the ACR-measured area beyond the distal tip of the ETT in the presence of obstruction (decrease = 38 +/- 22% [mean +/- SD] of the ETT inside area), while the ACR-measured area increased markedly in the absence of obstruction (increase = 49 +/- 17%). For six of the 11 infants, we also recorded the maximal flow produced by a set mechanical inflation pressure. This maximal flow decreased in the presence of obstruction (decrease = 47 +/- 18%), and was constantly associated with a decrease in ACR-measured area beyond the ETT. In conclusion, ACR measurement is an efficient method for diagnosing positional ETT obstruction in intubated newborns

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Abstract: This study investigated the influence of airway secretion viscosity on the characteristics of crackle sounds produced using a mechanically ventilated porcine lung model. Aqueous ultrasonic methylene blue stained gel solutions of viscosity 100, 150 and 200 P were prepared and instilled into 15 isolated, mechanically ventilated, porcine lungs immersed in water. Sound signals recorded by a hydrophone before and after instillation of gel were subjected to both fast Fourier transform and wave-form analysis. At the completion of sound recording, the main bronchi were dissected and the location of the stained gel was photographically recorded. Wave-form analysis demonstrated that expiratory phase crackle incidence and amplitude were both significantly higher than inspiratory phase data. This study demonstrates that crackle duration and amplitude are inversely related to gel viscosity and that electronic lung sound analysis can provide indirect evidence of sputum viscosity

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Abstract: Gas flows of 2, 3, and 4 L/min were directed through a sputum-like gel with viscosities of 100, 150, and 200 P and placed in a tube similar in diameter to a human segmental bronchus (4 mm), which was immersed in a bath of water. The sound produced by gas flow through the gel was recorded with a hydrophone. Sound data were subjected to time-expanded waveforms and fast Fourier transform (FFT) analysis. This study demonstrated that the number of crackles generated was directly related to the flow rate and inversely related to gel viscosity. The initial deflection width (IDW), two-cycle duration (2 CD), and peak-to-peak amplitude of crackles were significantly affected by the gas flow rate but not the viscosity of the gel. A lower gas flow rate generated crackles with longer IDW and 2 CD, but higher gas flow rates generated crackles with higher amplitude. Peak sound intensity measured from FFT increased as flow rate increased but decreased as the viscosity of the gel increased. At low gas flows, no gel-induced crackle sound was generated within the data capture window when the most viscous gel was examined. A digital video image of gas flow through the gel was captured, and this confirmed the absence of bubbles or slug formation at low flows through 200 P gel during the 3 seconds of data acquisition. This study describes some characteristics of crackles generated from different combinations of gas flow and gel viscosity and suggests that "coarse crackles" results from the explosion of gas bubbles in pulmonary secretions. Health care practitioners should consider the combined effect of rate of inspiratory gas flow and sputum viscosity during auscultation of patients' lungs

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Abstract: Our previous studies have demonstrated that tussiphonogram is suitable not only for the detection of pathological condition in the respiratory tract but also for treatment effectiveness assessment. The purpose of this study was to evaluate the possibilities of tussiphonography in detection of already little pathological changes in the airways and lungs. Therefore the changes of voluntary cough sound indexes were compared with pulmonary function tests in selected group of asthmatics before and after a pulsatile electromagnetic therapy in which the effect of therapy on pulmonary function tests was minimal. After magnetotherapy in 18 patients with increased expiratory forced lung capacity by 7.3% and increased peak inspiratory flow by 31.7% in average the voluntary cough sound intensity decreased by 37.8%, the sound duration shortened by 11% and the sound pattern showed the tendency to normalization. The improvement of mentioned cough indexes was absent in 17 patients who were treated by magnetotherapy too, but at the same time suffered from respiratory viral infection and in 22 patients treated only with climatotherapy and antiasthmatics. Changes of flow-volume loops in patients were not in the close relation to other followed indices. The correlation analysis showed a functional connection in relative differences of cough sound indices and some pulmonary function tests. The results confirmed the suitability of tussiphonography to indicate even mild pathological changes in respiratory tract. (Fig. 4, Ref. 21.)

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Abstract: This study measured transit time (TT) and attenuation of sound transmitted through six pairs of excised pig lungs.

Single-frequency sounds (50-600 Hz) were applied to the tracheal lumen, and the transmitted signals were monitored on the tracheal and lung surface using microphones. The effect of varying intrapulmonary pressure (Pip) between 5 and 25 cmH(2)O on TT and sound attenuation was studied using both air and helium (He) to inflate the lungs. From 50 to approximately 200 Hz, TT decreased from 4.5 ms at 50 Hz to 1 ms at 200 Hz (at 25 cmH(2)O). Between approximately 200 and 600 Hz, TT was relatively constant (1.1 ms at upper and 1.5 ms at lower sites). Gas density had very little effect on TT (air-to-He ratio of approximately 1.2 at upper sites and approximately 1 at lower sites at 25 cmH(2)O). Pip had marked effects (depending on gas and site) on TT between 50 and 200 Hz but no effect at higher frequencies. Attenuation was frequency dependent between 50 and 600 Hz, varying between -10 and -35 dB with air and -2 and -28 dB with He. Pip also had strong influence on attenuation, with a maximum sensitivity of 1.14 (air) and 0.64 dB/cmH(2)O (He) at 200 Hz. At 25 cmH(2)O and 200 Hz, attenuation with air was about three times higher than with He. This suggests that sound transmission through lungs may not be dominated by parenchyma but by the airways. The linear relationship between increasing Pip and increasing attenuation, which was found to be between 50 and approximately 100 Hz, was inverted above approximately 100 Hz. We suggest that this change is due to the transition of the parenchymal model from open to closed cell. These results indicate that acoustic propagation characteristics are a function of the density of the transmission media and, hence, may be used to locate collapsed lung tissue noninvasively

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Abstract: Measurement of lung function during tidal breathing may be performed regardless of the age and respiratory state of the patient. This is particularly advantageous in young children in whom forced respiratory manoeuvres cannot be performed, but has also been found useful in adults with various chest diseases. The most frequently reported tidal breathing parameters are mathematical expressions of the shape of the tidal flow/volume (TFV) loop or tidal flow/time traces, as the ratio of the time or volume taken to reach peak expiratory flow to total expiratory time or volume (tPTEF/tE or VPTEF/VE, respectively). However, new parameters have been suggested, focusing on the shape of the latter portion of the curve. Standardization of measurements is important, and more studies are required to settle some of the issues regarding, for instance, how many curves to evaluate, which parameter to report and how to perform challenge or reversibility tests. Intra-individual variation should be kept to a minimum, preferably performing measurements under the same conditions on each occasion. The issue of whether to sedate is a subject of debate. However, with experience, reproducible TFV measurements may be obtained in most subjects in the awake state, regardless of age, provided the setting is friendly and calm. TFV measurements have provided important information in research as well as clinical settings. Reduced tPTEF/tE has been demonstrated in newborn term and premature babies born to smoking mothers, and is a risk factor for recurrent wheeze within the first 3 yrs of life. Also, tPTEF/tE is clearly reduced in subjects with acute bronchial obstruction (BO) (such as occur in bronchiolitis), but also in asymptomatic children with BO for other reasons, such as asthma. Significant response to histamine and methacholine as well as to bronchodilator has been demonstrated in preschool children, adults and animals (horses, dogs and cats). The present paper discusses various practical issues concerning and possible uses of tidal flow/volume measurements. In conclusion, tidal flow/volume measurements may be important supplementary tools in the investigation of respiratory disease in both research and clinical work in subjects who for any reason cannot cooperate with more conventional lung function measurements

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Abstract: OBJECTIVE: The aim in this study was to analyze the efficiency and reliability of acoustic rhinometry (AR) readings in recognition of nasal septal deviation. METHOD: We compared 24 patients' AR readings with their sinus CT scans. The patient data were analyzed by comparison with normative data, area, and percentage differences between the two sides. Additionally, the data further analyzed by receiver operating characteristic curve and Spearman correlation of CT and AR in determining nasal septal deviation. RESULTS: The sensitivity of AR in detecting anterior septal deviations was found to be 54%, with a specificity of 70%. A very highly significant correlation (P < or = 0.001) was found between minimal cross-sectional area (CSA) 1 values and CT results. DISCUSSION: In the interpretation of AR readings, comparison of each CSA value should be included, in addition to use of the total absolute CSA values. CONCLUSION: According to our findings the diagnosis of nasal septal deviation can be supported by AR readings

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Abstract: This study was carried out to assess nasal response to different doses of methacholine and to evaluate the diagnostic possibilities of this test. Thirty-seven patients with allergic rhinitis induced by pollen (out of season), 16 with nonallergic rhinitis, and 25 normal subjects were evaluated. After provocation with saline, increasing doses of methacholine, ranging from 0.5 to 16 mg/mL,

were applied. Nasal obstruction was assessed by acoustic rhinometry 10 minutes after each dose, the minimum cross-sectional area and the nasal volume in both fossae were obtained. Ipratropium bromide was applied after the last dose of methacholine to evaluate reversibility. After methacholine challenge with 0.5, 1, 2, and 4 mg/mL there was a statistically significant decrease ($p < 0.05$) in nasal area and volume in a dose-dependent manner in patients with allergic and nonallergic rhinitis in comparison with controls. A ROC (receiver-operating characteristic) analysis showed that a decrease in nasal volume > or = 20% at methacholine concentration of 2 mg/mL is able to predict the presence of rhinitis (positive predicted value 93%, negative predicted value 79%) in 75% of subjects. The clinical relevance of this finding suggests that patients with symptomatic nonallergic rhinitis or even asymptomatic patients with allergic rhinitis out of pollen season present a nasal hyperreactivity to methacholine, and that a decrease of nasal volume > 20% by acoustic rhinometry after challenge with methacholine at 2 mg/mL is able to discriminate these patients from normal subjects. This method seems to be a suitable tool in the diagnosis of rhinitis

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Abstract: Pathological discontinuous adventitious sounds (DAS) are strongly related with the pulmonary dysfunction. Its clinical use for the interpretation of respiratory malfunction depends on their efficient and objective separation from vesicular sounds (VS). In this paper, an automated approach to the isolation of DAS from VS, based on their nonstationarity, is presented. The proposed scheme uses two fuzzy inference systems (FISs), operating in parallel, to perform the task of adaptive separation, resulting in the orthogonal least squares-based fuzzy filter (OLS-FF). By applying the OLS-FF to fine/coarse crackles and squawks, selected from three lung sound databases, the coherent structure of DAS is revealed and they are efficiently separated from VS. The important time domain DAS features, related to diagnostic information, are preserved and their true location and structural morphology are automatically identified. When compared to previous works, the OLS-FF performs quite similarly, but with significantly lower computational load, resulting in a faster real-time clinical screening of DAS

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Abstract: UPPER respiratory tract airflow in horses can increase from 240 litres/minute at rest to 4500 litres/minute during maximal exercise. At the same time, the respiratory rate may increase to 148 breaths/minute. In normal horses, the nostrils, pharynx and larynx dilate during exercise to accommodate this increased airflow and relatively little respiratory noise is produced. Abnormalities of the upper respiratory tract that restrict airflow during fast exercise cause turbulence and often result in poor exercise tolerance and the production of abnormal respiratory sounds. It is important that clinicians are able to identify abnormal exercise-related respiratory noises, differentiate them from the normal sounds produced by exercising horses and assess their significance with regard to the exercise capacity and use of the horse

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Abstract: With the aim of establishing the perceived role, value and application of auscultation in general veterinary practice, survey forms were posted to 217 veterinarians in Melbourne. Of these, 97 (45%) returned completed surveys. The questions were divided into three categories which attempted to establish: 1. The perceived use and value of the stethoscope or auscultation, 2. The application and degree of standardisation of common auscultatory criteria and 3. Self-assessed confidence in auscultatory ability. Responses indicated the stethoscope is highly utilised and valued most in the preliminary stages of cardiac and to a lesser extent respiratory diagnoses. The perceived values of specific auscultatory criteria directly related to their use. There was a wide variation in the interpretation of common auscultatory terms limiting the value afforded by documentation and restricting the ability to communicate auscultatory findings. Perceived confidence in auscultatory ability was most often described as either "Adequate. Skills sufficient for detection of murmurs and obvious gallops" or "A skill I would like to improve". Major criticisms of modem auscultation included interference, lack of exposure or familiarity with phenomena and the inability to review and interpret auscultatory findings. Major benefits Veterinarians demonstrated a keen interest to improve their auscultatory abilities, suggesting further education and access to heart sound libraries as possible solutions

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Abstract: A simple, non-invasive acoustical method is developed to detect respiratory phases in relationship to swallows without the direct measurement of airflow. In 21 healthy subjects (4-51 years) breath sounds are recorded at the trachea and at five different recording locations at the chest wall, with simultaneous recording of airflow by a pneumotachograph. The chest signal with the greatest inspiratory- expiratory power difference ('best location') is either in the mid- clavicular line in the second interspace on the left or third interspace on the right. Using the 'best location' on the chest wall and the tracheal signal, a phase detection algorithm is developed and achieves 100% accuracy in the estimation of respiratory phases without using the measured airflow signal. Thus, acoustically monitoring breaths and swallows holds promise as a non-invasive and reliable assessment tool in the study of swallowing dysfunction

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Abstract: Although lung sounds provide important information about the respiratory system, the analysis of lung sounds has not been widely used in clinical practice because of the complicated procedure involved. However, personal computer technology has made impressive strides in recent years. Today, practically all personal computer models on the market are equipped with the capacity for audio signal input and output. We developed a new computer system for lung sounds acquisition and analysis. The system hardware comprises only a personal computer and a microphone, and the software was developed for a widely used operating system (Windows 95). Our system can record, save, and replay lung sounds and analyze their time and frequency domains. To verify the accuracy of sound acquisition, we examined the frequency characteristics of the system as installed and utilized on 4 different machines. The characteristics were essentially flat throughout the 200- 2,000 Hz spectrum within which almost all lung sounds were contained. We feel our system can serve as a simple and useful tool for lung sound analysis

317. Olia, P. M., P. Sestini, and M. Vagliasindi. 2000. Acoustic parameters of voluntary cough in healthy non-smoking subjects. *Respirology.* 5:271-275.
Abstract: OBJECTIVE: The aim of this study was to explore cough in healthy subjects. METHODOLOGY: We studied 234 coughs generated by 24 (12 males) healthy non-smokers (forced expiratory volume in 1 s (FEV1) 103+/-8% of predicted), who had no significant differences in FEV1 and age between males and females. For each subject, several bouts of voluntary coughing were recorded using a personal computer with an A/D converter (sampling rate 10 kHz, 8 bit resolution) and the first and second coughs of each bout were analysed using short-time Fast Fourier Transformation. For each cough we studied the three phases that are produced. In particular, we studied the duration of the three parts, loudest frequency in the first part, lowest and highest frequencies, number of continuous frequencies and lowest and highest continuous frequencies in the second part, and the loudest frequency of the third part if present. RESULTS: We found significant differences between males and females in length of the first part (41.4+/-14 vs 44.7+/-10.4 msec, P = 0.04), loudest frequency of the first part (362+/-145 vs 449+/-145 Hz), lowest frequencies (282+/-100 vs 348+/-135 Hz) and highest continuous frequencies (3877+/-571 vs 4147+/-362 Hz; P < 0.001) of the second part. An interesting finding was that healthy males and females had the same number of continuous frequencies. Different frequencies are probably a consequence of anatomical differences in airway geometry involved in the cough. CONCLUSION: In cough frequency spectrum studies the differences between the two sexes should be taken into account to reduce the variability of the results

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Abstract: This paper concerns the analysis of adventitious sounds produced by individual asthmatic patients, and relates the sounds to the degree of airways obstruction at the moment of sound recording. In this study, airways obstruction is represented by a parameter commonly used in clinical tests, the forced expiratory volume in one second. A nonrestrictive approach using spectral information in detail is followed, resulting in a fairly high resolution of respiration sounds with respect to airways obstruction. The beneficial effect of a power raising transformation is presented, together with an illumination of the background of this effect

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Abstract: We describe the development of a clinical model of nasal congestion using a fixed dose histamine challenge in normals. The objective was to use histamine to induce a similar degree of nasal congestion as a natural common cold (from unpublished data of 250 cold sufferers) and thus establish a rapid screening system for decongestant drug effects. Sixtynine normal subjects were challenged with histamine diphosphate (300 micrograms/nostril) on 2 visits. Thirtytwo subjects were identified showing reproducible baseline values (< 15%CV (coefficient of variation)) and adequate nasal congestion (minimum 20%) without excessive sneezing. Reproducibility was evaluated in them post challenge using acoustic rhinometry and rhinomanometry. Twentythree subjects showed a variation < 25%CV of nasal volume over multiple visits in a 5 month period. The average reduction in nasal volume and airflow 15 minutes post challenge was 32% and 41% respectively. Acoustic rhinometry values were less variable than rhinomanometry values. Negligible differences (< 2%) in histamine response over visits and similar correlation between measured values at first, second and last visits indicate that 2 visits are adequate to evaluate response reproducibility in a selected population. We conclude that it is feasible to develop a robust clinical model of nasal congestion using histamine

320. Perlman, A. L., S. L. Ettema, and J. Barkmeier. 2000. Respiratory and acoustic signals associated with bolus passage during swallowing. *Dysphagia* 15:89-94.
Abstract: In order to advance our understanding of the relation between respiration and deglutition, simultaneous videofluoroscopy and respirodeglutometry was performed. Fifteen normal, healthy, young adults (20-29 years of age) were connected to a respirodeglutometer and positioned for simultaneous videofluoroscopic assessment in the lateral plane. Subjects performed three swallows each of a 5-ml and a 10-ml bolus of liquid barium and a 5-ml bolus of paste barium, for a total of nine swallows per subject. Location of the bolus head as identified with videofluoroscopy was associated with eight respirodeglutometric variables. In

addition, temporal relations for seven respirodeglutometric variables were calculated as a function of bolus volume and viscosity. Significant temporal differences were found for five of the variables by volume. No significant temporal differences were noted by viscosity. Expiration occurred before 79% and after 96% of the swallows. The number of inspirations preceding a swallow suggested a possible effect resulting from the need to hold a bolus in the mouth before receiving instructions to swallow during videofluoroscopic assessment. This effect may be important during patient evaluation. For a significant number of swallows, respiratory flow ceased before the velum was fully elevated

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Abstract: The aim of the study was to compare the lung sounds in patients with asbestos related pulmonary disorders with findings in high-resolution computed tomography (HRCT), and with lung function variables, in order to find out associations of acoustic changes with radiological fibrosis, emphysema or with pulmonary gas transfer functions. Sixty-four patients with asbestos-related pleural disease, with or without pulmonary disease, were studied. Lung sound recording and analysis was carried out with a computerized lung sound analyser, and HRCT of the chest, as well as forced spirometry and diffusing capacity measurement were performed. The fibrosis score correlated positively with the quartile frequencies of the power spectrum of lung sounds in inspiration (f50) and expiration (f50) and crackle count in inspiration, as well as negatively with diffusing capacity. When the patients with crackling sounds and significant fibrosis were excluded (n=18), emphysema correlated negatively with expiratory quartile frequencies of the power spectrum, with f25 and f50. Furthermore, diffusing capacity correlated with inspiratory f25 and forced expiratory volume in one second with inspiratory f50 when crackles and fibrosis were excluded. Changes in lung sounds were significantly associated with radiologically verified abnormalities and gas transfer of pulmonary tissue. High sound frequencies were associated with fibrotic changes of the lung while low sound frequencies with pulmonary emphysema. Acoustic analysis gives complementary clinical information for evaluation of asbestos-related pulmonary disorders

322. Raphael, D. T. 2000. Acoustic reflectometry profiles of endotracheal and esophageal intubation. *Anesthesiology* 92:1293-1299.
Abstract: BACKGROUND: Acoustic reflectometry can be used to create a "one- dimensional image" of a cavity, such as the airway and lung, with the image displayed as an area-length curve. This pilot study was undertaken to determine whether acoustic reflectometry could be used to distinguish between an endotracheal and an esophageal intubation. METHODS: Ten adult patients underwent general endotracheal anesthesia and neuromuscular blockade. The reflectometer wavetube was attached to an endotracheal tube, and a reflectometric profile was obtained of the endotracheal tube and the airway and lung cavity. After confirmation of tracheal intubation, a second endotracheal tube was placed in the esophagus. After four breaths were administered, a reflectometric profile of the endotracheal tube-esophagus cavity was obtained. RESULTS: The acoustic reflectometric profiles for tracheal and esophageal intubation profiles were distinctive and characteristic. For an endotracheal tube-airway cavity, the profile shows a constant cross- sectional area throughout the length of the endotracheal tube, followed by a rapid rise in the area past the carina. For an esophageal intubation, the profile shows constant cross-sectional area throughout the length of the endotracheal tube, followed by a sudden decrease in the cross-sectional area to zero. CONCLUSIONS: In this pilot study, acoustic reflectometry within seconds, and without resort to capnography, was able to generate characteristic and distinctive area- length profiles for both endotracheal and esophageal intubation. Acoustic reflectometry may have a role in the emergency imaging of the airway, and in the immediate detection of esophageal intubations, particularly in cases of cardiopulmonary arrest in which the usual techniques for confirmation of breathing tube placement fail

323. Saarinen, A., H. Rihkanen, S. Lehikoinen-Soderlund, and A. R. Sovijarvi. 2000. Airway flow dynamics and voice acoustics after autologous fascia augmentation of paralyzed vocal fold. *Ann.Otol.Rhinol.Laryngol.* 109:563-567.
Abstract: The aim of this study was to assess the effect of vocal fold medialization, accomplished by injection of autologous fascia, on airflow dynamics and voice acoustics. Ten patients with unilateral vocal fold paralysis were included. Flow-volume spirometry, body plethysmography, and acoustic analysis of voice were performed within 1 week before injection of autologous fascia and 4 to 14 months after operation. Medialization of the paralyzed vocal fold decreased the mean peak inspiratory flow (PIF) from 4.63 L to 4.10 L ($p = .012$). The acoustic characteristics of the voice improved: the values of jitter, shimmer, and mean noise-to-harmonics ratio decreased significantly ($p = .006$, $p = .017$, and $p = .047$, respectively), and the mean maximal phonation time almost doubled ($p = .002$). Changes in PIF and shimmer showed a negative correlation ($r = -.857$, $p = .007$). In conclusion, injection of autologous fascia improves voice acoustics, but induces a slight abnormal limitation on PIF. The results also suggest that improvement in voice acoustics is most prominent in subjects with the least deterioration in inspiratory airflow

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325. Springer, C., S. Godfrey, E. Picard, K. Uwyyed, M. Rotschild, S. Hananya, N. Noviski, and A. Avital. 2000. Efficacy and safety of methacholine bronchial challenge performed by auscultation in young asthmatic children. *Am.J.Respir.Crit Care Med.* 162:857-860.

Abstract: The measurement of bronchial reactivity is an important aid in the diagnosis of asthma, but the technique using spirometry is not feasible in young children. The aim of the present study was to determine the efficacy and safety of a modification of the chest auscultation method in the assessment of bronchial reactivity to inhaled methacholine in young asthmatic children. One hundred forty-six young children with asthma (mean age, 4.3 yr) underwent bronchial challenges with nebulized methacholine using the auscultation method (PCW). The end point was defined as the appearance of wheezing, oxygen desaturation, or tachypnea. For comparison, 30 children and young adults with asthma underwent bronchial provocation with methacholine using spirometry (PC(20)). A positive response using the auscultation method was observed in 95.9% of the younger children, and wheezes alone or in combination with other signs appeared in 80.8% of them. The mean desaturation at the end point was 4.6% (PCW) and 5.0% (PC(20)), with a similar pattern in the two groups. Cough was not helpful in determining the end point. We conclude that the modified auscultation method is effective and safe, with wheeze appearing at the end point in the large majority of the children

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327. Straus, S. E., F. A. McAlister, D. L. Sackett, and J. J. Deeks. 2000. The accuracy of patient history, wheezing, and laryngeal measurements in diagnosing obstructive airway disease. CARE-COAD1 Group. Clinical Assessment of the Reliability of the Examination-Chronic Obstructive Airways Disease [published erratum appears in JAMA 2000 Jul 12;284(2):181]. *JAMA* 283:1853-1857.
Abstract: CONTEXT: The accuracy of the clinical examination in detecting obstructive airway disease (OAD) is largely unknown because of a paucity of methodologically rigorous studies. OBJECTIVE: To determine the accuracy of patient history, wheezing, laryngeal height, and laryngeal descent in the diagnosis of OAD. DESIGN: Comparison study conducted from November 3, 1998, to December 4, 1998, evaluating 4 clinical examination elements for diagnosis of OAD vs the gold standard of forced expiratory volume in 1 second (FEV1) and FEV1-forced vital capacity (FVC) ratio less than the fifth percentile (adjusted for patient height, age, and sex). SETTING: Twenty-five sites, including primary care and referral practices, in 14 countries. PARTICIPANTS: A total of 309 consecutive patients were recruited (mean age, 56 years; 43% female), 76 (25%) with known chronic OAD, 114 (37%) with suspected chronic OAD, and 119 (39%) with neither known nor suspected OAD. MAIN OUTCOME MEASURES: Sensitivity, specificity, and likelihood ratios (LRs) for each of the 4 elements of the clinical examination compared with the gold standard. RESULTS: Mean FEV1 and FVC values were 2.1 L/s and 2.9 L; 52% had an FEV1 and FEV1-FVC ratio less than the fifth percentile. The LR for wheezing was 2.7 (95% confidence interval [CI], 1.7-4.2) and was not statistically significant in the multivariate model. The LR for laryngeal descent ranged from 0.9 (95% CI, 0.5-1.4) to 1.2 (95% CI, 0.4-3.4), depending on the cut point chosen, and did not enter the multivariate model. Only 4 of the history or physical examination elements we tested were significantly associated with the diagnosis of OAD on multivariate analysis: smoking for more than 40 pack-years (LR, 8.3), self-reported history of chronic OAD (LR, 7.3), maximum laryngeal height of 4 cm [corrected] or less (LR, 2.8), and age at least 45 years (LR, 1.3). Patients having all 4 findings had an LR of 220 (ruling in OAD); those with none had an LR of 0.13 (ruling out OAD). The area under the receiver operating characteristic curve for the model incorporating these 4 factors was 0.86. CONCLUSIONS: Further research is needed to validate our model, but in the meantime, our data suggest that less emphasis should be placed on the presence of individual symptoms or signs (such as wheezing or laryngeal descent) in the diagnosis of OAD

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Abstract: Aims of the study were 1) to compare Hudgel's hyperbolic with Rohrer's polynomial model in describing the pressure-flow relationship, 2) to use this pressure-flow relationship to describe these resistances and to evaluate the effects of sleep stages on pharyngeal resistances, and 3) to compare these resistances to the pressure-to-flow ratio (DeltaP/V). We studied 12 patients: three with upper airway resistance syndrome (UARS), four with obstructive sleep hypopnea syndrome (OSHS), three with obstructive sleep apnea syndrome (OSAS), and two with simple snoring (SS). Transpharyngeal pressures were calculated between choanae and epiglottis. Flow was measured by use of a pneumotachometer. The pressure-flow relationship was established by using nonlinear regression and was appreciated by the Pearson's square (r(2)). Mean resistance at peak pressure (Rmax) was calculated according to the hyperbolic model during stable respiration. In 78% of the cases, the value of r(2) was greater when the hyperbolic model was used. We demonstrated that Rmax was in excellent agreement with P/V. UARS patients exhibited higher awake mean Rmax than normal subjects and other subgroups and a larger increase from wakefulness to slow-wave sleep than subjects with OSAS, OSHS, and SS. Analysis of breath-by- breath changes in Rmax was also a sensitive method to detect episodes of high resistance during sleep

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Abstract: The aim of the present study was a validation of acoustic rhinometry (AR) by computed tomography (CT). Six healthy

subjects were examined by CT and AR. The CT data were processed in a computer program (AutoCAD), and a virtual three-dimensional model of each nasal cavity was constructed. This model permitted an individual prediction of the center line of the sound wave propagation through the air volume of the nasal cavity with the cross-sectional areas oriented perpendicularly to this line. The area-distance curves derived from AR and CT were compared. Linear regression analysis revealed a reasonable agreement of AR and CT in the anterior nose below a mean of 6 cm distance from the nostrils [r = 0.839, P < 0.01, m = 1.123, b = -0.113 (AR = m x CT + b)]. The measuring accuracy using CT as gold standard revealed a mean error at the nasal valve of <0.01 cm(2) (4.52%) and at the nasal isthmus of 0.02 cm(2) (1. 87%). Beyond 6 cm, the correlation decreased (r = 0.419), and overestimation of the true area occurred (>100%). In conclusion, the measurements were reasonably accurate for diagnostic use up to the turbinate head region. Certain factors induce an overestimation of the true areas beyond this region. However, these factors are constant and reproducible in a single subject, and intraindividual comparative measurements are possible beyond the turbinate head region

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Abstract: A stethoscope or listening tube with a custom earmold is routinely used to evaluate the acoustic output of a hearing aid. The diameter and length of the tubes of these listening devices cause changes in the acoustic output relative to the in situ condition. To compare these effects across commonly used listening devices, three stethoscopes and three listening tubes were evaluated with two different hearing aids when six different complex stimuli were used as input signals. In general, the listening devices resulted in a decrease (up to 20 dB) below l kHz, an increase (up to 20 dB) between 1 kHz and 2 kHz, and a decrease (up to 30 dB) above 2 kHz relative to the in situ output. These changes should be considered when making decisions regarding hearing aid status on the basis of listening checks via stethoscopes or listening tubes

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Abstract: OBJECTIVE: Develop and test methods for representing and classifying breath sounds in an intensive care setting. METHODS: Breath sounds were recorded over the bronchial regions of the chest. The breath sounds were represented by their averaged power spectral density, summed into feature vectors across the frequency spectrum from 0 to 800 Hertz. The sounds were segmented by individual breath and each breath was divided into inspiratory and expiratory segments. Sounds were classified as normal or abnormal. Different back-propagation neural network configurations were evaluated. The number of input features, hidden units, and hidden layers were varied. RESULTS: 2127 individual breath sounds from the ICU patients and 321 breaths from training tapes were obtained. Best overall classification rate for the ICU breath sounds was 73% with 62% sensitivity and 85% specificity. Best overall classification rate for the training tapes was 91% with 87% sensitivity and 95% specificity. CONCLUSIONS: Long term monitoring of lung sounds is not feasible unless several barriers can be overcome. Several choices in signal representation and neural network design greatly improved the classification rates of breath sounds. The analysis of transmitted sounds from the trachea to the lung is suggested as an area for future study

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Abstract: The aim of this paper is to investigate methods of standardizing lung sound analysis, with a view to supplementing traditional spirometric air flow measurements to help in the diagnosis of asthma and to provide a measure of the effectiveness of treatment. Lung sounds were measured in nine patients with asthma and five control subjects, alongside air flow measurements of forced expiratory volume (FEV1) and forced vital capacity (FVC). The patients were administered the bronchodilator, salbutamol, to assess how effective these measurement techniques were for quantifying its effect. The results agree with previous studies, that analysis of lung sounds is a potentially useful tool for indicating air flow changes. The results, however, also demonstrate that the emerging standard of 'F50' or 'median frequency' should be treated with great caution because of its high sensitivity to the measurement frequency range. F50 is very unlikely to provide a reliable single indicator of lung condition

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Abstract: During slow inflation of lung lobes, we measure a sequence of short explosive transient sound waves called "crackles," each consisting of an initial spike followed by ringing. The crackle time series is irregular and intermittent, with the number of

spikes of size s following a power law, n(s)proportional to s(- alpha), with alpha = 2.77 +/- 0.05. We develop a model of crackle wave generation and propagation in a tree structure that combines the avalanchelike opening of airway segments with the wave propagation of crackles in a tree structure. The agreement between experiments and simulations suggests that (i) the irregularities are a consequence of structural heterogeneity in the lung, (ii) the intermittent behavior is due to the avalanchelike opening, and (iii) the scaling is a result of successive attenuations acting on the sound spikes as they propagate through a cascade of bifurcations along the airway tree. [S1063-651X(99)13810-8]

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Abstract: Forced expiratory wheezes (FEW) are common and the pathogenesis of this phenomenon might involve fluttering of the airways, but this theory has not been confirmed in patients. We report a case of a patient with FEW and a normal FEV1 that showed a bronchoscopically confirmed collapse of the trachea and main stem bronchi during forced expiration. Superimposed to the flow-volume curve was an oscillating pattern with a frequency that corresponded well with the wheeze generated during forced expiration. The oscillating pattern in the flow-volume curve and the collapse of the major airways supports the theory of wheezes generated by fluttering airways during forced expiration. Although FEW may be found also in healthy subjects, flow limitation is essential for the generation of FEW. The inclusion of a forced expiratory maneuver in the clinical examination might therefore be helpful in guiding the diagnosis towards airways obstruction

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Abstract: In the past, the relationship between pulmonary hysteresis and a model of the recruitment-derecruitment of lung units has been explored (Cheng, W., DeLong, D.S., Franz, G.N., Petsonk, E.L., Frazer, D.G., 1995, Resp. Physiol. 102, 205-215). The recruitment process is characterized by a sequence of events which represents discrete configurational changes in lung structure. It is assumed that energy released during the opening of lung units is associated with the formation of discontinuous lung sounds. The goal of this study was to record tracheal sounds for lungs inflated from different end-expiratory pressures and to relate the sound power to the normalized hysteresis of individual pressure-volume (PL-VL) loops. PL-VL curves and lung sounds were recorded for control lungs and lungs rinsed with Tween 20 in order to estimate the role of alveolar surfactant on the recruitment-derecruitment process. Results indicate that there may be two populations of lung units, one which is altered by Tween 20 and another which is not. The population not affected by Tween 20 appears to be responsible for producing discrete lung sounds and may represent the opening of larger conducting airways. The second population, possibly within the respiratory zone, is affected by alterations in surface tension and contributes to pulmonary hysteresis, but, apparently, does not contribute significantly to lung sound power measured at the trachea

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Abstract: Adenoid hypertrophy is known as the most common cause of nasal obstruction in children; thus, adenoidectomy with, or without, tonsillectomy is one of the most commonly performed surgical procedures in the paediatric population. Although many methods have been suggested, few studies have reported on how to assess adenoid size, pre- operatively. Acoustic rhinometry is an objective technique as well as a non-invasive method, which can be easily used in young children. This study confirmed that acoustic rhinometry is a non-invasive and objective technique for assessing the geometry of the nasal cavity and nasopharynx. Forty children were evaluated using symptomology, two different radiological measurements and acoustic rhinometry; the results were compared with endoscopic findings. Clinical symptoms and A/N ratio measured with Fujioka's method significantly correlated with the endoscopic assessment findings ($r = 0.769$ and 0.604 respectively). Significant increases in the cross-sectional area and volume of the nasopharynx were observed at the adenoid notch after adenoidectomy ($p < 0.005$ and $p < 0.005$, respectively). Acoustic rhinometry showed a high degree of correlation of which adenoid occupied the nasopharyngeal airway under endoscopic examination ($r = 0.771$). Thus, the study concluded that acoustic rhinometry can be as good an objective method for measuring adenoid sizes as endoscopy and can be used as one of the pre-operative examination tools for adenoidectomy

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Abstract: Acoustic rhinometry (AR) evaluates the cross-sectional areas and volume of the nasal cavity through acoustic reflections. Successive valleys displayed on an AR graph are believed to correspond to anatomic landmarks. To assess the anatomic accuracy of AR, we performed AR and endoscopic measurements with a rigid endoscope in 85 normal human subjects after topical decongestion. Endoscopic measurements were recorded for distances between the midcolumella and the nasal valve, the anterior end of the inferior turbinate, the anterior end of the middle turbinate, the midportion of the middle turbinate, and the posterior nasopharynx. The first AR valley most closely corresponded with endoscopic measurements of the nasal valve. The second valley had a mean value that corresponded with the anterior end of the inferior turbinate. The third valley matched best with

the values of the anterior end of the middle turbinate. Nasopharyngeal measurements by each modality yielded a good agreement. AR appears to correspond to nasal anatomic landmarks but not in an exact point-to-point manner

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Abstract: Semiautomatic segmentation methods using High Resolution Computed Tomography (HRCT) or Magnetic Resonance Imaging give accurate and reproducible volumetric measurements in various intracranial diseases. In this prospective study, for the first time in literature, with the help of a new semiautomatic segmentation technique and coronal HRCT, we correlated the volumes and cross-sectional areas of the nasal cavity with those obtained by clinical acoustic rhinometry in 14 patients with chronic sinusitis. The measurements obtained by both techniques showed statistically significant correlations between volumes in the anterior and middle parts, but statistically poor correlations between the volumes in the posterior part of the nasal cavity. Coronal HRCT and our new microcomputer applicable semiautomatic segmentation software proved compatible with daily clinical practice. Based on the promising results of our study, we recommend the use of this technique in the validation studies of acoustic rhinometry and in complicated cases as a complementary examination in the evaluation of nasal cavity

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Abstract: The differentiation of palatal from non-palatal snoring is very important for ENT surgeons trying to determine whether palatal surgery would be curative. At present sleep nasendoscopy is the accepted method. Palatal vibration produces marked modulation of sound loudness at low frequency (below approximately 100 Hz). We calculate a crest factor for the sound waveform (ratio of peak to root mean square (rms) value in any given epoch), as a measure of the degree of modulation. Free-field snore sounds were recorded from 11 supine adult patients under intravenous sedation (midazolam), using a digital tape recorder. Recordings were transferred to a PC (sampling frequency 11 kHz), and analysed using code written by us. Direct visual confirmation of the site of snoring was gained from simultaneous sleep nasendoscopy, taken as the gold standard. In six patients the dominant site was the soft palate. The non-palatal group (five patients) comprised one epiglottic, two hypopharyngeal and two tongue base snorers. The crest factor was found to be significantly higher for palatal snorers ($p < 0.01$, Student- t or Mann-Whitney tests). Furthermore, palatal could be distinguished from non-palatal snorers on the basis of crest factor alone in all 11 cases, making this a promising non-invasive diagnostic technique

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343. Huang, L. and J. E. Williams. 1999. Neuromechanical interaction in human snoring and upper airway obstruction. *J.Appl.Physiol* 86:1759-1763.
Abstract: The fact that snoring and obstructive apnea only occur during sleep means that effective neuromuscular functioning of the upper airway during sleep is vital for the maintenance of unimpeded breathing. Recent clinical studies in humans have obtained evidence demonstrating that upper airway neural receptors sense the negative pressure generated by inspiration and "trigger," with a certain delay, reflex muscle activation to sustain the airway that might otherwise collapse. These findings have enabled us to propose a model in which the mechanics is coupled to the neuromuscular physiology through the generation of reflex wall stiffening proportional to the retarded fluid pressure. Preliminary results on this model exhibit three kinds of behavior typical of unimpeded breathing, snoring, and obstructive sleep apnea, respectively. We suggest that the increased latency of the reflex muscle activation in sleep, together with the reduced strength of the reflex, have important clinical consequences

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Abstract: The intensity of snoring was measured in 73 patients with snoring or sleep apnea using a noise meter. The mean intensity of snoring at 50 cm in front of the mouth was 61.7 dB in the supine position and 53.7 dB in the lateral position. There existed a definite correlation between the logarithmic transformation of the intra-esophageal pressure amplitude and the intensity of snoring in the supine and lateral decubitus positions. These findings suggest that the intensity of snoring may be a useful index for sleep-related breathing disorders

345. Jeannin, L. 1999. [Pulmonary auscultation revisited? (editorial)]. *Rev.Mal Respir.* 16:1059-1062.

346. Jones, A., R. D. Jones, K. Kwong, and Y. Burns. 1999. Effect of positioning on recorded lung sound intensities in subjects without pulmonary dysfunction. *Phys.Ther.* 79:682-690.
Abstract: BACKGROUND AND PURPOSE: Physical therapists often use positioning to assist in the reexpansion of collapsed lung segments. An increase in lung sound intensity on auscultation is considered indicative of lung expansion. This study was designed to examine whether clinical interpretation of auscultatory findings is warranted. SUBJECTS: The subjects (5 male, 6 female) were young physical therapist students without pulmonary dysfunction (mean age=20.4 years, mean height=166.3 cm, mean weight=57.5 kg). Subjects with lung disease were excluded because pulmonary pathology is difficult to standardize. METHODS: Lung sounds electronically recorded over the posterior chest wall of subjects in sitting and side-lying positions were compared. Measures included peak intensity, frequency at maximum power, and median frequency. RESULTS: In the sitting position, inspiratory sounds recorded over the left posterior chest wall were louder than those recorded on the right side. In the side-lying positions, the sound intensity recorded from the dependent chest wall was louder than that recorded from the nondependent chest wall. In side-lying positions, the upper hemithorax is "nondependent," and the side in contact with the bed is "dependent." Sound intensities recorded over both posterior chest walls in the sitting position were louder than those recorded over the same lung area in the nondependent side-lying position. There was no difference in the sound intensity recorded between the sitting and dependent side-lying postures. CONCLUSION AND DISCUSSION: When comparative auscultation of the chest wall is used by physical therapists to assess the adequacy of pulmonary ventilation, patient posture and regional differences in breath sound intensity can influence clinical interpretation

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Abstract: Nasal obstruction is one of the major symptoms of allergic rhinitis. In the study of the mechanism of nasal obstruction, experiments on animal are useful. In adult humans, acoustic rhinometry has been used to evaluate nasal obstruction by determining nasal cavity dimensions in terms of cross-sectional areas as a function of the distance from the nostril. We modified the equipment used on humans to assess dimensions of nasal airway geometry of small experimental animals. The purpose of this study was to investigate the accuracy of measurement of the modified acoustic rhinometry applied to small experimental animals using nasal cavity models and guinea pigs. Measurement of the nasal cavity models (made of cylindrical silicone tubes) showed that the acoustic rhinometry estimated 85.5% of actual area and 79.0% of actual volume. In guinea pigs, nasal cavity volume determined by the acoustic rhinometry was 73.7 +/- 20.0% of actual volume. The actual volume was estimated by impression material instilled into the nasal cavity of the animals (IM volume), and volume determined by acoustic rhinometry significantly correlated with IM volume. Furthermore, there was a significant negative correlation between the volume and nasal airway resistance in guinea pigs. Measurement of the nasal airway resistance is the method frequently used in the evaluation of the nasal obstruction in guinea pigs. These results suggest that acoustic rhinometry is useful in evaluating nasal obstruction in small experimental animals

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350. Kitaoka, H., R. Takaki, and B. Suki. 1999. A three-dimensional model of the human airway tree. *J.Appl.Physiol* 87:2207-2217.
Abstract: A three-dimensional (3D) model of the human airway tree is proposed using a deterministic algorithm that can generate a branching duct system in an organ. The algorithm is based on two principles: 1) the amount of fluid delivery through a branch is proportional to the volume of the region it supplies; and 2) the terminal branches are arranged homogeneously within the organ. These principles define the basic process of branching: generation of the dimensions and directionality of two daughter branches is governed by the properties of the parent branch and the region the parent supplies. The algorithm is composed of nine basic rules and four complementary rules. When the contour of an organ and the position of the trunk are specified, branches are successively generated by the algorithm. Applied to the human lung, the algorithm generates an airway tree that consists of approximately 54,000 branches. Its morphometric characteristics are in good agreement with those reported in the literature. The algorithm and the 3D airway model are useful for studying the structure-function relationship in the lung

351. Kiyokawa, H., M. Yonemaru, S. Horie, I. Kasuga, Y. Ichinose, and K. Toyama. 1999. Detection of nocturnal wheezing in bronchial asthma using intermittent sleep tracheal sounds recording. *Respirology.* 4:37-45.
Abstract: Common clinical features of bronchial asthma include bronchoconstriction during the night, particularly while asleep. Although bronchoconstriction reduces the quality of life and can cause life-threatening events, a clinical technique for evaluating bronchoconstriction during sleep has not been widely applied. In this study, we measured nocturnal wheezing by intermittent sleep tracheal sounds recording (ISTSR) to detect bronchoconstriction during the hours of sleep. Using ISTSR, we studied the number and duration of nocturnal wheezing episodes in 27 adult patients with bronchial asthma. Nocturnal wheezing was detected in 36 of

39 recordings. Although the pattern of hourly nocturnal wheezing count (hourly NWC pattern) varied among subjects, there appeared to be a reproducible pattern within individuals. When wheezing alternated between long and short duration, bronchoconstriction tended to be more severe. The NWC in 1 h (NWC/H) was positively correlated with subjective symptoms and inversely correlated with the morning per cent peak expiratory flow. The hourly NWC was significantly greater at 05:00 than that at midnight. Intermittent sleep tracheal sounds recording has potential to be a non- invasive clinical tool for detecting nocturnal bronchoconstriction during hours of sleep in patients with asthma

352. Kunkel, M., U. Wahlmann, and W. Wagner. 1999. Acoustic airway profiles in unilateral cleft palate patients. *Cleft Palate Craniofac.J.* 36:434-440.
Abstract: OBJECTIVE: This study investigates the nasal airway in unilateral cleft palate patients by means of a noninvasive, objective diagnostic method that provides topographic information about the airway profile. DESIGN: A consecutive sample of patients was measured. SETTING: Cleft palate rehabilitation center of the University of Mainz, Germany. PATIENTS: Forty-nine subjects were investigated: 34 full-grown patients with complete unilateral cleft lip and palate and 15 controls with subjective normal nasal patency. INTERVENTION: A transnasal series of three acoustic measurements of nasal volume was performed per nostril; measurements were taken both before and after decongestion with 0.3 mg xylometazoline per nostril. Minimum cross-sectional area, nasal volume, and decongestion capacity were calculated for both the cleft side and the contralateral side and for both nasal sides in controls. RESULTS: Pathologic obstructions (<0.4 cm2) were detected on the cleft side in 75% of patients but were detected in only 15% of patients on the contralateral side ($p < .001$). The valve area of the cleft side (0.32 +/- 0.2 cm2) yielded significantly ($p < .001$) lower cross-sectional values compared with the contralateral side (0.56 +/- 0.1 cm2). Total nasal volume was determined to be 35% smaller on the cleft side ($p < .001$). Significantly higher decongestion capacity was verified on the cleft side, thus indicating mucosal hypertrophy. CONCLUSION: Despite a wide range of interindividual variability, we recognized a characteristic "descending W"" airway pattern in cleft palate patients. Acoustic rhinometry seems to be a powerful tool for acquiring topographic information about the individual airway profile. It has proven helpful in visualizing the location and amount of pathologic obstructions, rendering it especially useful for preoperative investigation and quality control in corrective cleft nose surgery

353. Lachmund, J. 1999. Making sense of sound: Auscultation and lung sound codification in nineteenth-century French and German medicine. *Science Technology & Human Values* 24:419-450.
Abstract: With the introduction of the technique of auscultation in nineteenth-century medicine, the auditory became a most important means of producing diagnostic knowledge. The correct classification and interpretation of the sounds revealed by auscultation, however remained an issue of negotiation and often controversy throughout the mid-nineteenth century. This article examines the codification of lung sounds within two cultural and geographic contexts:first, the original approach as it was developed by Laennec and his followers in Paris that came to be dominant in French medicine, and second, the alternative approach that grew out of Joseph Skoda's reception of Laennec's method in Vienna and became widely adopted in the German-speaking world. On one hand, it will be argued that lung sound classifications attempted a standardization of the perception and the interpretation of auscultation sounds. On the other hand, it will be shown that the development of auscultation sounds was shaped by the local context in which it took place This article seeks to shed light on the way in which auditory experiences were instrumentalized for epistemic purposes in medicine. Furthermore, it discusses the role of standardization both as a mechanism for the universalization of knowledge and as a contextually bounded practice

354. Lamm, C., J. Mandeli, and M. Kattan. 1999. Evaluation of home audiotapes as an abbreviated test for obstructive sleep apnea syndrome (OSAS) in children. *Pediatr.Pulmonol.* 27:267-272.
Abstract: Snoring occurs commonly in children and is sometimes associated with obstructive sleep apnea syndrome (OSAS). Based on clinical history alone, it is difficult to distinguish primary snoring, characterized by noisy breathing during sleep without apnea or hypoventilation, from snoring indicative of OSAS. An overnight polysomnogram (PSG) is required to establish a definitive diagnosis of OSAS. Because sleep evaluations are costly and resources are limited, we evaluated whether a home audiotape recording could accurately identify children with OSAS. We studied 36 children referred by pediatricians and otolaryngologists for possible OSAS. Parents completed a questionnaire about their child's sleep and breathing and made a 15-min audiotape of the child's breath sounds during sleep. Overnight PSGs were performed on all patients. There were 29 patients who completed the study: 15 patients in the Primary Snoring group (apnea/hypopnea index < 5) and 14 patients in the OSAS group (apnea/hypopnea index > or = 5). No significant statistical differences existed between the two groups for physical characteristics or questionnaire responses. Seven observers analyzed the audiotapes for the presence of a struggle sound and respiratory pauses. The median sensitivity of the audiotape as a predictor of OSAS was 71% (range 43-86%), and the median specificity was 80% (range 67-80%). The presence of a struggle sound on the audiotape was the parameter most predictive of OSAS. There was a good level of agreement among the seven audiotape observers, as demonstrated by a mean and range kappa statistic of 0.70 (0.50-0.93) for the 21 pairs of observers. Using a clinical score to predict OSAS, the sensitivity was 46%, and the specificity was 83%. We conclude that findings on a home audiotape can be suggestive of OSAS, but are not sufficiently specific to reliably distinguish primary snoring from OSAS

355. Lee, B. W., P. D. Hill, J. Osborne, and E. Osman. 1999. A simple audio data logger for objective assessment of snoring in the home. *Physiol Meas.* 20:119-127.
Abstract: We have developed a portable device for patient use in logging snoring loudness in the home, for guiding treatment decisions and measuring the clinical effectiveness of treatment. The device uses a free field microphone and is positioned on a bedside table. The prototype devices contain no inherently expensive components and are simple to operate (producing only 5% patient error to date). They are portable, battery powered, rugged and produce digital data which are easily and automatically analysed, and these design parameters enable the devices to be used for first line patient assessment. Of the 75 recordings made so far from 30 patients, 85% were successful, yielding clinically useful data. Because it is sound levels which are recorded and not replayable sounds, patient privacy is maintained, resulting in excellent patient acceptance (to date no patient has refused). The device has a dynamic range of 45-90 dB sound pressure level and a frequency range of 30 Hz-5 kHz. Because snoring intensities often vary significantly throughout the night the device can measure continuously over 8 h

356. Leung, A. K. and H. Cho. 1999. Diagnosis of stridor in children. *Am.Fam.Physician* 60:2289-2296.
Abstract: Stridor is a sign of upper airway obstruction. In children, laryngomalacia is the most common cause of chronic stridor, while croup is the most common cause of acute stridor. Generally, an inspiratory stridor suggests airway obstruction above the glottis while an expiratory stridor is indicative of obstruction in the lower trachea. A biphasic stridor suggests a glottic or subglottic lesion. Laryngeal lesions often result in voice changes. A child with extrinsic airway obstruction usually hyperextends the neck. The airway should be established immediately in children with severe respiratory distress. Treatment of stridor should be directed at the underlying cause

357. Liistro, G., C. Veriter, and D. Stanescu. 1999. Influence of gas density on simulated snoring. *Eur.Respir.J.* 13:679-681.
Abstract: According to a recent theoretical model, snoring is related to instability of the upper airway (UA). Factors promoting UA instability include increased gas density. The aim of this study was to test the influence of gas density on simulated snoring production and supraglottic resistance. Supraglottic pressure and flow rate (V') were measured in 10 healthy seated subjects during simulated snoring. Subjects breathed three different gas mixtures: Helium-oxygen, He 79%- O2 21% (He-O2); air; and sulphur hexafluoride-oxygen, F6S 79%-O2 21% (F6S-O2) administered in a random order. Supraglottic resistance (Rsg) was measured on its linear range during quiet breathing and V' was measured at the onset and middle of snoring. Linear Rsg increased and V' conversely decreased with gas density. These data are in agreement with predictions of a mathematical model of the upper airway showing that snoring occurs at lower flow rates when gas density is increased

358. Mangione, S. 1999. The teaching of chest auscultation in U.S. internal medicine and family practice medicine residencies. *Acad.Med.* 74:S90-S92.

359. Mangione, S. and L. Z. Nieman. 1999. Pulmonary auscultatory skills during training in internal medicine and family practice. *Am.J.Respir.Crit Care Med.* 159:1119-1124.
Abstract: We conducted a multicenter, cross-sectional assessment of pulmonary auscultatory skills among medical students and housestaff. Our study included 194 medical students, 18 pulmonary fellows, and 656 generalists-in-training from 17 internal medicine and 23 family practice programs in the Mid- Atlantic area of the United States. All participants listened to 10 pulmonary events recorded directly from patients, and answered by completing a multiple choice questionnaire. Proficiency scores were expressed as the percentage of respondents per year and type of training who correctly identified each event. In addition, we calculated a series of cumulative scores for sound recognition, disease identification, and basic knowledge of lung auscultation. Trainees' cumulative scores ranged from 0 to 85 for both internal medicine and family practice residents (median = 40). On average, internal medicine and family practice trainees recognized less than half of all respiratory events, with little improvement per year of training, and were not significantly better than medical students in their scores. Pulmonary fellows had the highest diagnostic and knowledge scores of all groups. These data indicate that there is very little difference in auscultatory proficiency between internal medicine and family practice trainees, and suggest the need for revisiting these time-honored skills during residency training

360. McCarthy, O. R. 1999. Getting a feel for percussion. *Vesalius.* 5:3-10.
Abstract: When Auenbrugger introduced percussion it was direct or immediate percussion of the chest. Corvisart was the first to recognise that percussion not merely gave a sound but also a sensation to the percussing fingers. When Piorry introduced mediate percussion the sensation was more readily appreciable. However, there were many astute clinicians who ignored the sensation and these included Stokes, Hope, Latham and Gerhard. To this day some popular handbooks of physical signs do not mention this valuable component of percussion

361. McLeod, R. L., G. G. Mingo, C. Herczku, M. R. Corboz, S. I. Ramos, F. Gennaro-Culver, O. Pedersen, and J. A. Hey. 1999. Changes in nasal resistance and nasal geometry using pressure and acoustic rhinometry in a feline model of nasal congestion. *Am.J.Rhinol.* 13:375-383.
Abstract: This is the first report describing the use and pharmacological characterization of nasal patency by both pressure rhinometry and acoustic rhinometry (AcR) in an experimental cat model of nasal congestion. In pressure rhinometry studies, aerosolized compound 48/80 (0.1-3.0%), a mast cell liberator, increased nasal airway resistance (NAR) 1.2 +/- 0.6, 5.8 +/- 0.5, 8.6 +/- 1.1 and 7.9 +/- 1.5 cmH2O.L/minute, respectively. Increases in NAR produced by compound 48/80 were associated with a 395% increase in histamine concentration found in the nasal lavage fluid. Pretreatment with the alpha- adrenoreceptor agonist, phenylpropanolamine (PPA; 0.1-3.0 mg/kg, i.v.), and the NO synthetase inhibitor, NG-nitro-L-arginine (L-NAME; 10 mg/kg, i.v.) attenuated the increases in NAR produced by compound 48/80. The histamine H1 antagonist chlorpheniramine (1.0 mg/kg, i.v.) and the H2 antagonist, ranitidine (1.0 mg/kg, i.v.) had no decongestant activity. Also without decongestant activity were the muscarinic antagonist atropine, the cyclooxygenase inhibitor indomethacin, and the 5-HT blocker methysergide. Aerosolized histamine (0.1-1.0%) also produced a dose dependent increase in NAR. In studies using acoustic rhinometry (AcR), intranasal application of compound 48/80 (0.1-1.0%) elicited pronounced decreases in nasal cavity volumes and minimum cross- sectional area (Amin). Pretreatment with PPA (3 mg/kg, i.v. or 10 mg/kg, p.o.) attenuated the decreases in nasal volume and Amin. The effects of topical intranasal histamine (0.1-1.0%) on nasal geometry were similar to compound 48/80. We conclude that the cat is a useful model for evaluating the pharmacological actions of potential nasal decongestants. Furthermore, we also conclude that AcR is a useful method for noninvasive assessment of nasal patency in a preclinical setting

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Abstract: The effects of antigen and histamine on the changes of nasal passage patency in 112 guinea pigs with or without allergic rhinitis were evaluated by acoustic rhinometry. The percent change of volume from the nostril to 2 cm into the nasal cavity showed significant reduction of 31.10 +/- 4.11% at 10 minutes and 31.10 +/- 4.11% at 30 minutes after antigen challenge in sensitized guinea pigs. The pretreatment with ketotifen, an H1-histamine receptor antagonist as well as mast cell stabilizing drug, blocked dose-dependently the effects of antigen on those changes in volume. Furthermore, instillation of 10(4) micrograms/mL histamine reduced significantly nasal passage patency to 33.77 +/- 4.63% at 10 minutes and 42.76 +/- 3.32% at 30 minutes after challenge compared with that before challenge and ketotifen inhibited the effects of histamine, which indicated that histamine is an important mediator of allergic upper airway responses in guinea pigs. These results show that acoustic rhinometry is a useful technique to assess the nasal blockade in allergic guinea pigs

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Abstract: Palatal snoring produces explosive peaks of sound at very low frequency (approximately 20 Hz). Using a digital sound trace a ratio of peak amplitude to root mean square amplitude can be calculated. This Peak Factor Ratio is significantly higher for palatal snores than non- palatal snores ($P < 0.01$). This acoustic method will be useful for selecting patients for palatal surgery as it is non-invasive and could be used in a home monitor

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Abstract: The effect of ambient sounds, generated during breathing, that may reach a sensor at the chest surface by transmission from mouth and nose through air in the room, rather than through the airways, lungs and chest wall, is studied. Five healthy male non-smokers, aged from 11 to 51 years, are seated in a sound-proof acoustic chamber. Ambient respiratory noise levels are modified by directing expiratory flow outside the recording chamber. Low-density gas (HeO2 = 80% helium, 20% oxygen) is used to modify airway resonances. Spectral analysis is applied to ambient noise and to respiratory sounds measured on the chest and neck. Flow-gated average sound spectra are compared statistically. A prominent spectral peak around 960 Hz appears in ambient noise and over the chest and neck during expiration in all subjects. Ambient noise reduction decreases the amplitude of this peak by 20 +/- 4 dB in the room and by 6 +/- 3.6 dB over the chest. Another prominent spectral peak, around 700 Hz in adults and 880 Hz in children, shows insignificant change, i.e. a maximum reduction of 3 dB, during modifications of ambient respiratory noise. HeO2 causes an upward shift in tracheal resonances that is also seen in the anterior chest recordings. Ambient respiratory noise explains some, but not all, peaks in the spectra of expiratory lung sounds. Resonance peaks in the spectra of expiratory tracheal sounds are also apparent in the spectra of expiratory lung sounds at the anterior chest

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Abstract: In this paper, a new efficient feature extraction method based on the fast wavelet transform is presented. This paper especially deals with the assessment of process parameters or states in a given application using the features extracted from the

wavelet coefficients of measured process signals. Since the parameter assessment using all wavelet coefficients will often turn out to be tedious or leads to inaccurate results, a preprocessing routine that computes robust features correlated to the process parameters of interest is highly desirable. The method presented divides the matrix of computed wavelet coefficients into clusters equal to rowvectors. The rows that represent important frequency ranges (for signal interpretation) have a larger number of clusters than the rows that represent less important frequency ranges. The features of a process signal are eventually calculated by the euclidean norms of the clusters. The effectiveness of this new method has been verified on a flank wear estimation problem in turning processes and on a problem of recognizing different kinds of lung sounds for diagnosis of pulmonary diseases

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Abstract: A corrected derivation is provided for the relationship between the impulse response of a wave tube termination and pressure signals measured at two different locations within the tube. This derivation yields exactly the same final result as was reported previously by Louis et al. (1993), despite the omission of the active source term in that earlier derivation. This technique has become the basis of an important medical diagnostic technology. This report revises and corrects the earlier theory upon which that technology rests

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Abstract: In order to found the stethacoustic nomenclature on objective facts, we suggest to express lung sounds in a way taking first into account acoustical physics. Indeed the physicoacoustical definition of lung sounds has to take place before its psychoacoustical definition. Acoustical physics identifies only four kinds of vibrations: simple and complex periodical vibrations, transient and continuous non periodical vibrations. Lung sounds are bound to fall into one of those four categories. Phonopneumograms in time and frequency domain allow an objective classification of breath and adventitious lung sounds and introduce a simplification into the nomenclature which recognizes only four sorts of lung sounds, all of them included in these two categories: 1 degree breath sounds include normal and bronchial breath sounds, 2 degrees adventitious sounds include crackles (for every discontinuous sound) and wheezes (for every continuous sound). Objective parameters add their specific characteristics in terms of pitch, complexity, Hz-frequency, timing in the respiratory cycle and duration. The proposal of a new nomenclature is justified because it is supported by measurable physical phenomena. The solution of semantic problems should enable clinicians to progress toward a worldwide consensus

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Ref Type: Thesis/Dissertation

369. Rietveld, S., M. Oud, L. H. Rijssenbeek-Nouwens, D. Vaghi, and E. H. Dooijes. 1999. Characteristics and diagnostic significance of spontaneous wheezing in children with asthma: results of continuous in vivo sound recording. *J.Asthma* 36:351-358.
Abstract: The characteristics and diagnostics of wheezing during induced airway obstruction are well documented. The present study addressed (a) the characteristics of spontaneous wheezing with respect to a possible distinction between wheezes during in vivo versus induced airway obstruction, and (b) the relationship between in vivo wheezing and fluctuations in peak expiratory flow (PEF). Tracheal sounds were continuously recorded from 50 children and adolescents with asthma and 10 without asthma in the home environment. Wheezes underwent a qualitative analysis, including their concomitant sound frequencies. Presence of wheezing was scored by two examiners independently and was related to PEF. Spontaneous wheeze varied from solitary rhonchi to prolonged rhythms of loud stridor, and resembled the "induced" wheezes recorded previously. Power spectra showed that the spectral contents (frequency distribution) were comparable, although the in vivo patterns were more prolonged in duration. The diagnostic sensitivity and specificity of wheezing for a reduction in PEF of >20% were 88% and 92%, respectively. It was concluded that in vivo wheeze resembled induced wheeze and was a diagnostically reliable symptom with respect to asthma exacerbations

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Abstract: For continuous monitoring of the respiratory condition of patients, e.g., at the intensive care unit, computer assistance is required. Existing mechanical devices, such as the peak expiratory flow meter, provide only with incidental measurements. Moreover, such methods require cooperation of the patient, which at, e.g., the ICU is usually not possible. The evaluation of complicated phenomena such as asthmatic respiratory sounds may be accomplished by use of artificial neural networks. To investigate the merit of artificial neural networks, the capacities of neural networks and human examiners to classify breath sounds were compared in this study. Breath sounds were in vivo recorded from 50 school-age children with asthma and from 10 controls. Sound intervals with a duration of 20 seconds were randomly sampled from asthmatics during exacerbation, asthmatics in remission, and controls. The samples were digitized and related to peak expiratory flow. From each interval, two full breath cycles

were selected. Of each selected breath cycle, a Fourier power spectrum was calculated. The so-obtained set of spectral vectors was classified by means of artificial neural networks. Humans evaluated graphic displays of the spectra. Human examiners could not clearly discriminate between the three groups by inspecting the spectrograms. Classification by self-classifying neural networks confirmed the existence of at least three classes; however, discrimination of 11 classes seemed more appropriate. Good results were obtained with supervised networks: as much as 95% of the training vectors could be classified correctly, and 43% of the test vectors. The three patient groups, as discriminated in advance, do not correspond with three sharply separated sets of spectrograms. More than three classes seem to be present. Humans cannot take up the spectral complexity and showed negative classification results. Artificial neural networks, however, are able to handle classification tasks and show positive results.

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Abstract: This study tested the hypothesis that cough frequency during induced airway obstruction in children and adolescents with asthma relates significantly to other symptoms. The second hypothesis was that cough during remission may often be a conditioned or voluntary response. In experiment 1, tracheal sounds were recorded from 30 participants with asthma during a histamine challenge test. In experiment 2, tracheal sounds were recorded from 30 participants with and 30 without asthma during a standardized physical exercise task. Cough and respiratory wheeze were assessed from the sound records by two examiners independently. The results showed that cough during airway obstruction did not relate to other variables. Only the second hypothesis was supported. In both experiments the frequency of cough was independent of lung function (forced expiratory volume in 1 sec [FEV1]), wheezing, dyspnea, and severity of asthma. The percentage of participants with asthma who coughed in experiment 1 increased from 21% (baseline) to 71% after histamine inhalation. During experiment 2, the cough percentage increased from 52% to 69% in asthmatics, and from zero to 57% in controls. It was concluded that cough in asthma is not diagnostically useful for assessment of airway obstruction. Excessive baseline cough among asthmatics could be the result of acquired responses to anticipated exercise-induced symptoms

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Abstract: A 79-year-old woman was admitted to our hospital with complaints of wheezing and dyspnea. Adenoid cystic carcinoma was diagnosed from the findings on biopsy specimens obtained by fiberoptic bronchoscopy. The tumor was resected and end-to-end anastomosis was performed. Precision analyses of lung sounds were conducted before and after the operation. During eupnea the tracheal sounds prior to operation contained an accentuated, high-frequency component at about 1,500 Hz. The tracheal sounds included a single monophonic wheeze during deep inspiration and 5 wheezes during forced expiration. By contrast, lung sounds in the chest wall were almost normal both before and after the operation. We concluded that increases in high-frequency components in tracheal sounds and the manifestation of various wheezes can be useful in diagnosing tracheal stenosis and/or tumors

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Abstract: Recently we proposed that exercise-induced pulmonary haemorrhage (EIPH) results from locomotory-impact-induced trauma by impact of the scapula on the chest wall during footfall and the consequent transmission of waves through the lung. A computational model has been developed to demonstrate that wave amplification and focusing occur in the dorsocaudal tip of the lung for waves originating on the anterior subscapular surface. The propagation of an acoustic wave was investigated in a simplified 2-dimensional representation of a vertical anterio-dorsal section of horse lung. It was demonstrated that a complicated pattern of waves is transmitted from the scapula to the dorsal region. Wave motion was characterised using the instantaneous rate of change of pressure with time (dp/dt) which is associated with lung injury. Due to wave reflection and focusing, dp/dt is transiently very high on the spinal and diaphragmatic lung walls, particularly in the vicinity of the dorsal tip. The model therefore predicts that lung injury may occur in the region in which EIPH is reported to originate

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Abstract: The reproducibility of nasal patency measurements was assessed by acoustic rhinometry and active rhinomanometry using previously described Toronto methodologies. Six subjects with normal upper airways were tested with both procedures on six separate occasions within a 2- month period. Topical decongestant was applied to minimize the effects of mucosal variation on the nasal airway. The mean coefficients of variation (mean +/- s.d; %) over time of the measurements were 8.1 +/- 4.1 and 9.7 +/- 5.2 for minimal unilateral cross-sectional area and 4.8 +/- 1.8 and 5.5 +/- 3.5 for nasal volume (0-5 cm) of the right and left sides, respectively. For active rhinomanometry, the mean coefficients of variation (mean +/- s.d.; %) over time of the measurements were 15.9 +/- 7.3, 12.9 +/- 4.6, and 8.5 +/- 2.8 for right, left and combined nasal airflow resistance. The intraclass correlation coefficient

was 0.76, 0.70, and 0.96 for right, left, and combined nasal resistance, 0.91 and 0.87 for right and left minimal cross sectional area, and 0.86 and 0.69 for right and left nasal volumes, respectively, also confirming a high level of reproducibility for both methods. In conclusion, performed by an experienced operator under controlled circumstances, the reproducibility of both methods of nasal patency assessment compared favorably with many widely accepted clinical tests

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Abstract: We have recently found that changes in lung sounds correspond well with a 20% fall in the forced expiratory volume in 1 s (FEV1) after methacholine challenge in asthmatic children. Up to now, little was known about the agreement between a 20% fall in FEV1 and a change in lung sounds after repeated bronchial challenge. In this study we investigated the agreement between the total cumulative histamine dose causing a fall in FEV1 of 20% or more (PD20) and the detection of a change in lung sounds (PDlung sounds) after two bronchial challenges on different occasions in asthmatic children. Fifteen asthmatic children (nine boys), mean age 10.8 years (range 9-15), were studied. All performed two histamine challenge tests on 2 days, with a 24 h to 1 week interval. Lung sounds were recorded over the trachea for 1 min and stored on tape. Lung sounds were analysed directly and also scored from the tape-recording by a blinded second investigator. Wheeze, cough, and an increase in respiratory rate were assessed. The relationship between PD20 and PDlung sounds was calculated by Bland and Altman's measurement of agreement. Eleven children had a positive challenge test (PD20 < or = 16.0 mg ml-1) on both test days; four had a positive challenge on one test day. In 24 out of 26 positive challenges, wheeze, cough, prolonged expiration and/or increased respiratory rate were detected one dose- step before, or at the dose-step of histamine that induced a fall in FEV1 of 20% or more. In two challenges, PD20 was not detected by a change in lung sounds. In four out of four negative challenges (PD20 > 16.0 mg ml-1) no change in lung sounds could be detected. Good agreement between the logarithm of PD20 and the logarithm of PDlung sounds was found on both test days. The mean difference was 0.04 and the limits of agreement (d +/- 2 SD of the differences) were 0.04 +/- 0.41. A good agreement was found between the total cumulative histamine dose causing a fall in FEV1 of 20% or more and the detection of a change in lung sounds after two bronchial challenges on different occasions in asthmatic children

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Abstract: Bilateral breath sounds are routinely auscultated after endotracheal intubation to verify that the endotracheal tube (ETT) tip is properly positioned. We conducted the present study to ascertain whether the eye of the Murphy tube has an influence on the reliability of auscultation of breath sounds in detecting endobronchial intubation. Twenty patients undergoing scheduled oral and maxillofacial surgery participated in this study. After the induction of general anesthesia, either the Magill tube or the Murphy tube was inserted through the nose into the trachea. The fiberoptic bronchoscope was inserted through the ETT, and the distance from the nares to the carina of the trachea was measured. When breath sounds from the left side of the chest changed and disappeared while the ETT was being advanced, the distance from the nares to the ETT tip was measured. Unilateral auscultatory change was not observed until the ETT tip was advanced beyond the carina and inserted 1.5 +/- 0.4 cm into the right mainstem bronchus when the Magill tube was used and 2.0 +/- 0.4 cm when the Murphy tube was used (P < 0.01). Breath sounds disappeared when the ETT tip was further advanced up to 3.2 +/- 0.3 cm from the carina. We demonstrated that the eye of the Murphy tube reduces the reliability of chest auscultation in detecting endobronchial intubation. Implications: The Murphy eye was designed to allow ventilation of the lung when the bevel of the endotracheal tube is occluded. We demonstrated that the eye of the Murphy tube reduces the reliability of chest auscultation in detecting endobronchial intubation

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Abstract: To understand the basic characteristics of the human body vibration induced by low frequency noise and to use it to evaluate the effects on health, we designed a measuring method with a miniature accelerometer and carried out preliminary measurements. Vibration was measured on the chest and abdomen of 6 male subjects who were exposed to pure tones in the frequency range of 20 to 50 Hz, where the method we designed was proved to be sensitive enough to detect vibration on the body surface. The level and rate of increase with frequency of the vibration turned out to be higher on the chest than on the abdomen. This difference was considered to be due to the mechanical structure of the human body. It also turned out that the measured noise-induced vibration negatively correlated with the subject's BMI (Body Mass Index), which suggested that the health effects of low frequency noise depended not only on the mechanical structure but also on the physical constitution of the human body

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Ref Type: Thesis/Dissertation

379. Wilson, K., R. A. Stoohs, T. F. Mulrooney, L. J. Johnson, C. Guilleminault, and Z. Huang. 1999. The snoring spectrum: acoustic assessment of snoring sound intensity in 1,139 individuals undergoing polysomnography. *Chest* 115:762-770.

Abstract: STUDY OBJECTIVES: To quantify the snoring sound intensity levels generated by individuals during polysomnographic testing and to examine the relationships between acoustic, polysomnographic, and clinical variables. DESIGN: The prospective acquisition of acoustic and polysomnographic data with a retrospective medical chart review. SETTING: A sleep laboratory at a primary care hospital. PARTICIPANTS: All 1,139 of the patients referred to the sleep laboratory for polysomnographic testing from 1980 to 1994. INTERVENTIONS: The acoustic measurement of snoring sound intensity during sleep concurrent with polysomnographic testing. MEASUREMENTS AND RESULTS: Four decibel levels were derived from snoring sound intensity recordings. L1, L5, and L10 are measures of the sound pressure measurement in decibels employing the A-weighting network that yields the response of the human ear exceeded, respectively, for 1, 5, and 10% of the test period. The Leq is a measure of the A-weighted average intensity of a fluctuating acoustic signal over the total test period. L10 levels above 55 dBA were exceeded by 12.3% of the patients. The average levels of snoring sound intensity were significantly higher for men than for women. The levels of snoring sound intensity were associated significantly with the following: polysomnographic testing results, including the respiratory disturbance index (RDI), sleep latency, and the percentage of slow-wave sleep; demographic factors, including gender and body mass; and clinical factors, including snoring history, hypersomnolence, and breathing stoppage. Men with a body mass index of > 30 and an average snoring sound intensity of > 38 dBA were 4.1 times more likely to have an RDI of > 10. CONCLUSIONS: Snoring sound intensity levels are related to a number of demographic, clinical, and polysomnographic test results. Snoring sound intensity is closely related to apnea/hypopnea during sleep. The noise generated by snoring can disturb or disrupt a snorer's sleep, as well as the sleep of a bed partner

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Abstract: We describe a new clinical sign in a case series of three patients who developed pneumothoraces during mechanical ventilation in the intensive care unit. All three patients were in the supine position. Two patients had x-rays that were inconclusive before insertion of chest drains and the third had a pneumothorax diagnosed on clinical findings alone. On each occasion we were able to diagnose pneumothorax using sternal percussion and simultaneous auscultation. The method relies on percussion of the sternum while simultaneously ausculating the anterior (superior) chest on the side of the suspected pneumothorax. The stethoscope is then placed on the other side of the chest. The percussion sound on the affected side has an exaggerated, resonant and booming quality. The percussion note is exaggerated partly because a stethoscope is used and partly because, in the supine patient, air localizes upwards to the anterior thorax

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Abstract: In spite of increasing mechanization in medicine and reliance on "high-tech" diagnostic tools, bedside clinical skills of the attending physician can still identify findings that are missed by the more sophisticated devices. Using a stethoscope, we relied on our skills in inspection, palpation, percussion, auscultation, as well as echocardiography and phonocardiography to diagnose a patient whose murmur was very reminiscent of the D-sharp pizzicato in the Cello Sonata in F, Opus 99, by Johannes Brahms. Initial echocardiography was not helpful. We suspected an anomalous chorda and confirmed this with phonocardiography and a second echocardiography. Although advances in cardiac imaging are extremely helpful, the use of simple clinical skills, in addition to being fun, is not obsolete. Cardiopulmonary auscultation should receive more emphasis in the medical school curriculum and clinical training

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Abstract: OBJECTIVE: To determine what information sources are used during a remote diagnosis task. MATERIALS AND METHODS: Experienced trauma care providers viewed segments of videotaped initial trauma patient resuscitation and airway management. Experiment 1 collected responses from anesthesiologists to probing questions during and after the presentation of recorded video materials. Experiment 2 collected the responses from three types of care providers (anesthesiologists, nurses, and surgeons). Written and verbal responses were scored according to detection of critical events in video materials and categorized according to their content. Experiment 3 collected visual scanning data using an eyetracker during the viewing of recorded video materials from the three types of care providers. Eye-gaze data were analyzed in terms of focus on various parts of the videotaped materials. RESULTS: Care providers were found to be unable to detect several critical events. The three groups of subjects studied (anesthesiologists, nurses, and surgeons) focused on different aspects of videotaped materials. CONCLUSION: When the remote events and activities are multidisciplinary and rapidly changing, experts linked with audio-video-data connections may encounter difficulties in comprehending remote activities, and their information usage may be biased. Special training is needed for the remote decision-maker to appreciate tasks outside his or her speciality and beyond the boundaries of traditional divisions of labor

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Abstract: Tracheal/chest auscultation for wheeze and transcutaneous oximetry have both been suggested as measures of outcome in bronchial provocation tests in young children. This study aimed to compare the sensitivity and safety of these two techniques as end-points for methacholine challenge in children aged <4 yrs. Seventy-two methacholine challenges were performed in 39 children aged <4 yrs with recurrent wheeze. Arterial oxygen saturation (Sa,O2) and transcutaneous oxygen pressure tcPO2 continuously, and the test was terminated when wheeze was heard or at Sa,O2 <91%. tcPO2 was not used as an end-point. Wheeze or desaturation occurred at < or =8 mg x mL(-1) methacholine in every test. One child had transient clinical cyanosis, but no other ill-effects were seen. Fifty-six tests (78%) were terminated for wheeze, seven (10%) for fall in Sa,O2 and nine (12%) showed simultaneous responses in both parameters. Twenty-eight tests (39%) contained a fall in tcPO2 >3 kPa but six of these also showed a significant rise. Fifty-three tests (75%) contained a fall in tcPO2 >15%, but 20 of these also showed a significant rise. Tracheal/chest auscultation with Sa,O2 monitoring is a sensitive and relatively safe end-point for bronchial challenges in preschool children. The erratic pattern of transcutaneous oxygen pressure response in some children casts doubt on its reliability as a proxy measure of bronchial obstruction

384. Ademovic, E., J. C. Pesquet, and G. Charbonneau. 1998. Time-scale segmentation of respiratory sounds. *Technol.Health Care* 6:53-63.
Abstract: Respiratory sounds are composed of various events: normal and so-called adventitious sounds. These phenomena present a wide range of characteristics which make difficult their analysis with a single technique. Adapted time-frequency and time-scale techniques allow to fit best, under constraints, the accuracy of analysis of a time segmentation and, by the way, make feasible the study of complex signals. We present here new approaches based only on the wavelet packet decomposition to segment respiratory sounds

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Abstract: Wheezes are abnormal sounds which are known to be relevant to Chronic Obstructive Pulmonary Diseases (COPD). The analysis of such signals is especially useful in patient monitoring or pharmacology. Respiratory sounds are dependent on the flow and the volume. Furthermore, they can be the result of a complex mixture of events. The analysis of lung sounds can be greatly improved with time-frequency techniques because these methods highlight the evolution of the spectra of events. In this paper, we present the application of the Adaptive Local Trigonometric Decomposition (ALTD) to lung sound analysis. This analysis provides an optimal representation of the signal in the time-frequency domain with a lattice which is adapted in time. In our work, the parameterization of the ALTD is studied for the detection of wheezing phenomena

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Abstract: Nineteen percent of women are habitual snorers, yet most snoring studies report only on male snorers. The aim of this study was to identify the factors responsible for habitual snoring in women. Twenty-four snorers and 16 controls were studied prospectively in a special snoring clinic. Snorers were shorter ($p = .005$) and heavier ($p = .001$), and with greater body mass index (BMI: $p < .001$), collar size ($p = .002$), and submental skinfold thickness ($p = .001$) than controls. The area of the posterior pharyngeal wall visible on oral examination was smaller in snorers ($p = .005$). Acoustic rhinometry areas and volumes were similar in the two groups. Nasal flow-volume loops showed reduced expiratory ($p = .01$) and inspiratory ($p = .07$) flow in snorers. Inspiratory flow correlated inversely with nasal symptoms ($p < .05$). The factors that best predict habitual snoring in women are a high BMI, a high nasal symptom score, and heavy weight. Of these, BMI is the most powerful

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Ref Type: Computer Program
Abstract: Combines real time videos of actual exams with diagrams that highlight proper procedures and placement of the stethoscope. Also includes audio sections that precisely re-create normal and adventitious breath sounds, and a self-assessment test

388. Borisyuk, A. O. 1998. Noise field in the human chest due to turbulent flow in a larger blood vessel. *Flow Turbulence and Combustion* 61:269-284.
Abstract: An acoustic model of a larger human blood vessel is developed. This model takes into account the main features of the acoustic generation and propagation of noise in the human chest from the source (turbulent pressure fluctuations in blood flow) to a receiver resting on the skin, and allows the consideration of a simple stenotic narrowing in the vessel. The low Mach number turbulent wall pressure models of Corcos, Chase, Ffowcs Williams, and Smol'yakov and Tkachenko are used to describe random sources in the vessel. The relationships obtained permit one to analyse the dependence of the resultant acoustic field in the thorax

on the parameters of the blood flow and the vessel, and show the possibility of finding characteristic signs of the presence of a stenosis by comparison of noise fields from intact and diseased arteries

389. Cagatay, G. E., B. Sankur, Y. P. Kahya, and S. Raudys. 1998. Visual classification of medical data using MLP mapping. *Comput.Biol.Med.* 28:275-287.
Abstract: In this work we discuss the design of a novel non-linear mapping method for visual classification based on multilayer perceptrons (MLP) and assigned class target values. In training the perceptron, one or more target output values for each class in a 2-dimensional space are used. In other words, class membership information is interpreted visually as closeness to target values in a 2D feature space. This mapping is obtained by training the multilayer perceptron (MLP) using class membership information, input data and judiciously chosen target values. Weights are estimated in such a way that each training feature of the corresponding class is forced to be mapped onto the corresponding 2-dimensional target value

390. Chen, S. C., K. J. Chang, and C. Y. Hsu. 1998. Accuracy of auscultation in the detection of haemopneumothorax. *European Journal of Surgery* 164:643-645.
Abstract: Objective: To assess the accuracy of auscultation in the detection of haemopneumothorax. Design: Prospective study. Setting: University hospital, Taiwan. Patients: 148 patients with chest injuries admitted between July 1994 and August 1996. Main outcome measures: Correlation between the results of auscultation and radiographic findings in 148 patients with injuries to the chest. 83 (56%) had internal injuries, of whom 38 had pneumothoraces, 24 haemothoraces, and 21 haemopneumothoraces. Results: Auscultation had a sensitivity of 84%, a specificity of 97%, an accuracy of 89% and a positive predictive value of 97% in the detection of these injuries. Conclusions: Auscultation is not as accurate as chest radiography. Chest tubes can be inserted before chest radiography in patients in whom auscultation has indicated an injury. A chest radiograph is essential in those patients with normal breath sounds to exclude a haemopneumothorax that had been missed by auscultation

391. Djupesland, P. G. and K. C. Lodrup Carlsen. 1998. Nasal airway dimensions and lung function in awake, healthy neonates. *Pediatr.Pulmonol.* 25:99-106.
Abstract: Possible relations between nasal airway dimensions and measures of lung function are not well established. It has been suggested that a major part of airway resistance is found in the nose. However, little is known about the shape of tidal flow volume (TFV) loops in relation to nasal caliber. We therefore investigated whether lung function assessed by tidal breathing in healthy newborn infants was affected by nasal airway dimensions. Nasal airway dimensions were measured in 17 healthy newborn babies (mean age, 2.7 days) by acoustic rhinometry before and immediately after lung function measurements. Lung function was evaluated by TFV loops and passive respiratory mechanics (single-breath occlusion technique), first with both nostrils open, and subsequently immediately after occlusion of the larger of the two nostrils, causing at least a 50% reduction in nasal minimum cross-sectional area (MCA). Neither the TFV expiratory ratios (time and volume to reach peak flow to total time and volume, respectively [t(PTEF)/t(E) and V(PTEF)/V(E), respectively]), nor resistance or compliance of the total respiratory system differed significantly regardless of whether one or both nostrils were open. With one nostril closed there were no significant effects on any of the measured lung function parameters. We conclude that in healthy awake neonates reducing the cross-sectional area of nasal dimensions by 50% does not affect TFV loops or passive respiratory mechanics

392. Djupesland, P. G. and B. Lyholm. 1998. Changes in nasal airway dimensions in infancy. *Acta Otolaryngol.* 118:852-858.
Abstract: Thirty-nine infants, previously examined as neonates, were re-examined at 1 year of age with continuous wide-band noise acoustic rhinometry using a specific probe optimized for infants, to determine the dimensional growth and maturation of nasal airway geometry in otherwise healthy infants. During the first year of life, the acoustically determined dimensions of the nasal airways increased significantly. The total minimal cross-sectional area increased by 67% (0.21 cm2-->0.35 cm2), the volume of the anterior 4 cm of the nasal airway by 36% (1.80 cm3-->2.44 cm3) and the distance to the minimum cross-sectional area by 19% (0.78 cm-->0.93 cm). The rhinometric values of male infants were significantly larger than those of females. However, after adjusting for the significantly larger anthropometric values of males, the difference disappeared, indicating that it was mainly due to body size and not directly to gender. A highly significant correlation ($r=0.44$, $p < 0.006$) was observed between the minimum cross-sectional area and head circumference, which anatomically are the most closely related rhinometric and anthropometric values. Furthermore, when differentiating between infants with or without signs of nasal congestion during the fortnight preceding the rhinometric evaluation, a reduction in the total volume of the anterior 4 cm (17% $p <0.02$) and minimum cross-sectional area (12%, ns) was observed after adjustment. We conclude that the optimized acoustic rhinometric probe is a useful investigative modality, permitting studies of upper airway physiology of healthy and diseased infants

393. Doherty, M. J., D. P. Spence, D. Graham, B. M. Cheetham, X. Q. Sun, and J. E. Earis. 1998. A vibrating trachea. *Thorax* 53:230-231.
Abstract: A case of relapsing polychondritis presenting as tracheomalacia is reported in which an unusual low pitched sound was heard at the mouth and over the chest wall during expiration. The sound was associated with expiratory airflow limitation and

oscillation on the flow trace of approximately 50 Hz. Spectral analysis of the sound showed it to have the characteristics of sounds produced by flutter in flow limited flexible tubes. These observations suggest that the sound was produced by airflow induced flutter in the trachea and main airways and is further evidence in support of the dynamic flutter theory of wheeze production

394. Du, M., J. Sun, and R. Chen. 1998. [Crackle detection and classification based on matched wavelet transform]. *Sheng Wu Yi.Xue.Gong.Cheng Xue.Za Zhi.* 15:400-405.
Abstract: In this paper, we present a method for crackle detection which is based on 'matched' wavelet transform. We first modeled crackles as a mathematical function. Then we designed a matched mother wavelet based on this model. Applying a soft-threshold to the results of the continuous wavelet transform to suppress noise further, we obtained the optimal scale Crackles were detected based on the envelope of the signal at optimal scale, and could be classified based on energy distribution with scale. The theory, methods and experimental results are given in detail

395. Frey, U., M. Silverman, R. Kraemer, and A. C. Jackson. 1998. High-frequency respiratory impedance measured by forced-oscillation technique in infants. *Am.J.Respir.Crit Care Med.* 158:363-370.
Abstract: Measurements of respiratory input impedance (Zin) in infants using forced oscillations at the airway opening up to 256 Hz have been shown to include a first antiresonance (ar,1). We wondered whether features derived from high-frequency Zin change during methacholine-induced airway obstruction in infants, whether those changes could be explained by a lumped parameter model as in dogs (providing a value for respiratory resistance [Rrs]), or whether they are similar to Zin data in human adults with airway obstruction. In 13 wheezy infants (age 58 +/- 19 wk) Zin(omega) was assessed at baseline, and in nine infants after methacholine challenge, using a provocation dose defined by fall of more than 30% in VmaxFRC (rapid chest-compression technique). Following methacholine challenge, VmaxFRC decreased significantly ($p < 0.0005$), the frequency at which ar,1 occurred (far,1) increased significantly ($p = 0.0007$), and the relative maximum in the real part at far,1 [Zinre(far,1)] increased significantly ($p = 0.02$), whereas Rrs did not change. We conclude that in wheezy infants ar,1 is highly sensitive to changes in lung mechanics. Although ar,1 cannot be explained by a simple lumped-parameter model, it is likely due to wave propagation phenomena, as in human adults. In either case, far,1 potentially contains information about airway wall compliance, which is important for the understanding of flow limitation in infant wheezing disorders

396. Frey, U., A. C. Jackson, and M. Silverman. 1998. Differences in airway wall compliance as a possible mechanism for wheezing disorders in infants. *Eur.Respir.J.* 12:136-142.
Abstract: High-frequency input impedance measurements (Z(f)) provide useful noninvasive information on airway geometry and especially airway wall mechanics in the canine and human adult respiratory system. Using the high-speed interrupter technique (HIT), we have shown that it is possible to measure high-frequency Z(f) in infants up to 900 Hz, including antiresonant phenomena which are known to be related to wave propagation velocity. This implies that the first antiresonant frequency (far,1) is a function of airway wall compliance. Since, airway wall mechanics are particularly important for the flow limitation phenomena, we wondered whether we could find evidence that airway wall properties were important for the occurrence of flow limitation during incremental methacholine challenge in infants. We measured Z(f) from 32-900 Hz and maximal flow at functional residual capacity (V'maxFRC) by the rapid chest compression technique in 10 infants (aged 36-81 weeks) with wheezing disorders. far,1 increased significantly at very low doses of mch before any decline could be detected in V'maxFRC. We hypothesize that these changes in far,1 are determined by mch-induced decrease in airway wall compliance. High- speed interrupter technique in combination with rapid chest compression technique can be used to study developmental differences in airway function (particularly of airway wall properties) and their contribution to airway disease and response to bronchodilator therapy in infants

397. Frey, U., M. Silverman, R. Kraemer, and A. C. Jackson. 1998. High-frequency respiratory input impedance measurements in infants assessed by the high speed interrupter technique. *Eur Respir J* 12:148-158.
Abstract: High-frequency input impedance (Z(f)) measurements, including antiresonances, provide useful noninvasive information on airway geometry and especially airway wall mechanics in the canine and human adult respiratory system. A knowledge of airway wall mechanics would be particularly important in understanding flow limitation phenomena in infants. High-frequency Z(f) has not been measured in infants above 256 Hz, because the high impedance of the infantile respiratory system would be expected to result in low amplitudes of oscillatory flow at higher frequencies. The aim of this study was to develop a technique to measure high-frequency Z(f) in infants and to elucidate the nature of the antiresonance phenomena in the Z(f) spectrum in infants. Z(f) was measured from 32-900 Hz during rapid airflow interruption by the high-speed interrupter technique (HIT) in 18 infants (aged 24-149 weeks) with wheezing disorders. The HIT enables the excitement of higher flow amplitudes at high frequencies using a pseudostep forcing function. In all infants Z(f) showed a mean (SD) first antiresonance (far,1) of 172 (35) Hz (real part of Z(f) at far,1 (Z(f)re(far,1)): 4.9 (1.1) kPa x L(-1) x s) and in five infants a second antiresonance (far,2) of 564 (51) Hz (Z(f)re(far,2): 2.0 (0.7) kPa x L(-1) x s). The antiresonances were found to be related to wave propagation in the airways (acoustic antiresonances), because they increased by a factor of approximately 2 when He-O2 was inhaled. This implies that far,1 and its harmonics are a function of airway wall compliance. In conclusion, the first and second antiresonances may be helpful in understanding flow

limitation in wheezing disorders in infants, because flow limitation is related not only to airway diameter but also to airway wall compliance

398. Fukakusa, M., T. Sato, and H. Furuhata. 1998. [Use of an accelerometer to measure coughing]. *Nihon Kokyuki.Gakkai Zasshi* 36:343-346.
Abstract: Coughing was detected by measuring body-surface acceleration. Twenty- seven patients with a chief complaint of coughing were studied. The sensor used is an apparatus for sound communication in aircraft, in which cranial vibrations that occur as the pilot speaks are converted into acceleration waves. An acceleration sensor was fixed to the body of each subject. The acceleration of the chest wall was recorded as a voltage change. Subjects rested in bed to exclude acceleration due to body movement. Acceleration waves of large amplitude were recognized during coughing. Conversation or laughter only caused very weak acceleration waves. Sound has often been used as an indicator of coughing, because coughing was thought to be one kind of human vocalization. However, distinguishing speaking from coughing was difficult, and complicated analysis was necessary. We regarded coughing as a movement causing acceleration of the body surface, and measured it without using sound. We plan to collect data on acceleration of the body surface in 3 dimensions simultaneously. After a continuous long- term recorder of coughing is developed the effects of antitussive drugs can be assessed

399. Grenier, M. C., K. Gagnon, J. Genest, Jr., J. Durand, and L. G. Durand. 1998. Clinical comparison of acoustic and electronic stethoscopes and design of a new electronic stethoscope. *Am.J.Cardiol.* 81:653-656.
Abstract: This clinical study was performed to evaluate the advantages and limitations of 3 acoustic stethoscopes and 3 electronic stethoscopes. It shows that it is possible to design a new electronic stethoscope by considering the advantages of both the acoustic and electronic stethoscopes

400. Hadjileontiadis, L. J. and S. M. Panas. 1998. A wavelet-based reduction of heart sound noise from lung sounds. *Int.J.Med.Inf.* 52:183-190.
Abstract: Heart sounds produce an incessant noise during lung sounds recordings. This noise severely contaminates the breath sounds signal and interferes in the analysis of lung sounds. In this paper, the use of a wavelet transform domain filtering technique as an adaptive de-noising tool, implemented in lung sounds analysis, is presented. The multiresolution representations of the signal, produced by wavelet transform, are used for signal structure extraction. In addition, the use of hard thresholding in the wavelet transform domain results in a separation of the nonstationary part of the input signal (heart sounds) from the stationary one (lung sounds). Thus, the location of the heart sound noise (1st and 2nd heart sound peaks) is automatically detected, without requiring any noise reference signal. Experimental results have shown that the implementation of this wavelet-based filter in lung sound analysis results in an efficient reduction of the superimposed heart sound noise, producing an almost noise-free output signal. Due to its simplicity and its fast implementation the method can easily be used in clinical medicine

401. Hilberg, O., B. Lyholm, A. Michelsen, O. F. Pedersen, and O. Jacobsen. 1998. Acoustic reflections during rhinometry: spatial resolution and sound loss. *J.Appl.Physiol* 84:1030-1039.
Abstract: The accuracy of the acoustic reflections method for the evaluation of human nasal airway geometry is determined by the physical limitations of the technique and also by the in vivo deviations from the assumptions of the technique. The present study 1) examines the sound loss caused by nonrigidity of the nasal mucosa and viscous loss caused by complex geometry and its influence on the estimation of the acoustic area-distance function; 2) examines the optimal relation between sampling frequency and low-pass filtering, and 3) evaluates advantages of breathing He-O2 during the measurements on accuracy. Measurements made in eight plastic models, with cavities exactly identical to the "living" nasal cavities, revealed only minor effects of nonrigidity of the nasal mucosa. This was confirmed by an electrical analog model, based on laser vibrometry admittance measurements of the nasal mucosa, which indicated that the error in the acoustic measurements caused by wall motion is insignificant. The complex geometry of the nasal cavity per se (i.e., departure from circular) showed no significant effects on the measurements. Low-pass filtering of the signal is necessary to cut off cross modes arising in the nasal cavity. Computer simulations and measurements in models showed that the sampling frequency should be approximately four times the low-pass filtering frequency (i.e., twice the Nyquist frequency) to avoid influence on the result. No advantage was found for the the use of He-O2 vs. air in the nasal cavity

402. Kim, C. S., B. K. Moon, D. H. Jung, and Y. G. Min. 1998. Correlation between nasal obstruction symptoms and objective parameters of acoustic rhinometry and rhinomanometry. *Auris Nasus Larynx* 25:45-48.
Abstract: Acoustic rhinometry and rhinomanometry have been used to assess nasal airway patency objectively. We compared nasal obstruction symptoms before and after decongestion with several parameters of these objective tests. The patients assessed their nasal obstruction using a visual analogue scale (VAS). Cross-sectional areas and nasal resistance were measured by acoustic rhinometry and rhinomanometry before and after topical application of 1% phenylephrine solution in 32 patients with nasal obstruction symptoms. There was no significant correlation between the difference in the VAS and the difference in nasal resistance. There was also no significant correlation between the difference in the VAS and minimal cross-sectional area and

cross- sectional areas at 3.3 cm (CA3.3), CA4.0 and CA6.4 from the nosepiece both in the wide and narrow sides and in both nasal cavities before and after nasal decongestion. It is concluded that rhinomanometry and acoustic rhinometry may have no diagnostic value in estimating the severity of nasal obstruction symptoms

403. Korenbaum, V. I., Y. V. Kulakov, and A. A. Tagiltsev. 1998. A new approach to acoustical evaluation of human respiratory sounds. *Biomed.Instrum.Technol.* 32:147-154.
Abstract: The authors developed a method for more precise detection and analysis of the physical features of respiratory and voice sound transmission to the chest wall. Based on their findings using this method, they designed several devices for acoustic examination and evaluation of components of human respiratory sounds. These devices analyze forced expiratory sounds, distinguish between air-borne and structure-borne sounds, and distinguish abnormalities in voice transmission to the chest wall. Tests of the devices on human subjects confirmed the validity of the authors' theoretical models, which offer promise for the development of a new class of medical diagnostic instruments

404. Kraman, S. S., H. Pasterkamp, M. Kompis, M. Takase, and G. R. Wodicka. 1998. Effects of breathing pathways on tracheal sound spectral features. *Respir.Physiol* 111:295-300.
Abstract: The spectra of sounds recorded over the trachea of adults typically reveal peaks near 700 and 1500 Hz. We assessed the anatomical determinants of these peaks and the conditions contributing to their presence. We studied five adult subjects with normal lung function, measuring sounds at the suprasternal notch and on the right cheek. The subjects breathed at target airflows of 15 and at 30 ml sec(-1) kg(-1) both through the mouth with nose clips and then through the mouth and nose using a cushioned face mask. The mouth breathing maneuvers were performed with three lengths (3.6, 21.1 and 38.6 cm) of 2.6 cm diameter tubing between the mouth and the pneumotachograph. The nose breathing maneuver was performed with the longest tube (between the mask and pneumotachograph). The signals occurring at the target flows +/- 20% were used to create averaged, spectral estimates. We found that all subjects had two predominant spectral peaks; a approximately 700 Hz peak loudest over the cheek and a approximately 1500 Hz peak loudest over the trachea. The frequency of both peaks negatively correlated with body height (and presumably, airway length). There was no systematic effect of breathing phase, flow rate or length of the tube connecting the mouth to the pneumotachograph on the spectral peaks. Breathing into the mask and breathing through the nose did markedly alter the spectra. We conclude that the higher tracheal sound peak reflects resonance within the major airways and is relatively independent of extrathoracic influences during mouth breathing through a tube

405. Kunkel, M., U. Wahlmann, and W. Wagner. 1998. Objective evaluation of velopharyngeal function by acoustic reflection measurements. *Mund Kiefer Gesichtschir.* 2 Suppl 1:S158-S162.
Abstract: OBJECTIVE: To investigate whether acoustic pharyngometry is capable of discriminating velopharyngeal mobility in cleft and non-cleft subjects by determination of epipharyngeal volume changes with active muscle function. DESIGN: Case control study, consecutive sample. SETTING: Cleft palate rehabilitation centre. PATIENTS: Thirty-three consecutive cleft palate patients, among them 10 following pharyngeal flap surgery and 32 controls without velopharyngeal pathology. INTERVENTION: Transnasal acoustic measurements of airway cross-sectional area in the state of relaxed and tensed pharyngeal muscles. Determination of epipharyngeal volume changes by integrating the difference of the airway profile from the choane for a distance of 5 cm (EV0-5). Measurements of defined changes in the epipharynx served as reference. RESULTS: Acoustic pharyngometry is capable of discriminating ($P < 0.05$: U test, Mann-Whitney) the volume effect of velopharyngeal mobility in CP patients (6.5 cm3) from the control group (8.0 cm3). A 'pharyngeal flap type' and a 'non-pharyngeal flap type' of restriction was observed. The individual effect of velopharyngoplasty on pharyngeal mobility can thus be determined. CONCLUSION: Acoustic pharyngometry is a non-invasive, quantitative investigation technique which seems well suited for the evaluation of velopharyngeal mobility. We expect it to be a helpful tool in objectively monitoring the effect of therapeutic intervention on velopharyngeal mobility, and it may provide a better understanding of the pattern of movement in CP patients

406. Liistro, G., D. Rodenstein, and G. Aubert. 1998. [Diagnosis of nocturnal respiratory disorders. Review of portable monitoring devices. Analysis and evaluation of different polysomnography signals]. *Rev.Mal Respir.* 15:733-741.
Abstract: Polysomnography in an attended hospital laboratory setting is the gold standard for the diagnosis of sleep-related breathing disorders. However, this method is expensive and waiting lists are long. Portable recording devices that can be used at home have been recently developed to improve upon the problems of polysomnography. We review the recent portable devices validated by polysomnography and discuss their precise role in the assessment of sleep-related respiratory disorders

407. Manecke, G. R., Jr. and P. J. Poppers. 1998. Esophageal stethoscope placement depth: its effect on heart and lung sound monitoring during general anesthesia. *Anesth.Analg.* 86:1276-1279.
Abstract: Although the esophageal stethoscope has been used for many years, the effect of the depth of placement on the quality of the sounds obtained has never been investigated. The amplitude and frequency characteristics of the first and second heart sound and of inspiratory and expiratory breath sounds were determined at various stethoscope depths (from the distal tip) in 17

healthy anesthetized adults. The amplitude for each type of sound varied markedly with depth. Maximal amplitude for S1 was at 34 +/- 3 cm, for S2 at 27 +/- 2 cm, for inspiratory breath sound at 28 +/- 2 cm, and for expiratory breath sound at 26 +/- 2 cm. There was a positive linear correlation between the depth of maximal amplitude of these sounds and patient height. Peak frequency, in general, did not change with depth. We conclude that investigators should measure and document depth when performing studies involving the esophageal stethoscope. Implications: Analysis of sound from the esophageal stethoscope at various depths reveals that placement depth greatly affects the sounds. A depth of 28-32 cm is recommended for clinical use; S1, S2, and inspiratory and expiratory sounds have a high amplitude in that range

408. Mansfield, J. P., D. C. Shannon, and G. R. Wodicka. 1998. Acoustic method to quantitatively assess the position and patency of infant endotracheal tubes: preliminary results in rabbits. *Pediatr.Pulmonol.* 26:354-361.
Abstract: In this preliminary laboratory study, an acoustical method was evaluated to quantitatively assess the position and patency of an infant-size endotracheal tube (ETT) by in vivo and in vitro measurements. The method consists of emitting an audible sound pulse into the ETT and the airways, and deriving position and patency information from the timing and characteristics of the returning echoes. The method's capacity to measure ETT changes of position in the tracheae of five anesthetized New Zealand white rabbits (weight, 4.3- 4.9 kg; age, 1.5-3 years) was found to be accurate to 0.7 +/- 3.6 mm (mean +/- 95% CI) over a distance of 5 cm. The method was also shown to reliably differentiate between tracheal, bronchial, and esophageal intubations by means of an acoustically inferred diameter of the passageway just beyond the ETT tip. To assess the accuracy of estimating lumen obstruction, in vitro acoustical measurements were performed in different size ETTs (2.5, 3.0, 3.5, and 4.0 mm inner diameter), with obstructions ranging from 5-100% reduction in cross- sectional area. The system identified the sizes of these obstructions to within +/-7%. This technology has the potential for continuous, computer-based monitoring of breathing-tube function through instantaneous detection of ETT malposition or obstruction before it leads to a serious medical condition

409. Martinet, X., J. L. L'Helgouarc'h, I. Roche, P. Favoulet, P. Goudet, and P. Cougard. 1998. [Laennec, re-inventor of the stethoscope?]. *Presse Med.* 27:1534-1535.
Abstract: According to our common medical culture, some facts are simply unquestionable, for instance Laennec invented the stethoscope. But was he the first one? On a recent trip to Egypt we visited the temple of Kom Ombo, built prior to the roman period and renowned as a medical care center. Today, the tourist is fascinated by the magnificent hieroglyphics on the well-preserved walls testifying to significant advances in various fields of medicine including ophthalmology and gynecology. We were particularly interested by the basreliefs presenting vivid drawings of some of the first medical instruments. We easily identified curettes, scissors, a balance, forceps for dental extraction, and a surgical saw, but were captivated by two other instruments. The first one looked a lot like what Laennec invented around 1820. The second one was amazingly similar to the instrument we use everyday, with a distal opening and flexible tubes (woven papyrus?) leading to proximal ear pieces. Our Egyptian guide was formal: the stethoscope was invented in Egypt. The scientific impact of our observations leaves something to be desired, but did make us think about the huge gap between the advancement of medical knowledge in ancient Egypt and Laennec's (re)-invention. Exposed to a similar gap in history, what would our documents stored on CD and video tapes have to say to future touring doctors?

410. Melbye, H. 1998. [The usefulness of clinical pulmonary examination in the diagnosis of bronchial obstruction]. *Tidsskr.Nor Laegeforen.* 118:1999-2003.
Abstract: In order to evaluate the usefulness of physical examination of the chest in diagnosing bronchial obstruction, 11 doctors recorded their findings in 692 adult chest patients. Spirometry was carried out after the physical examination. Two categories of patients were selected; patients with known or suspected pulmonary disease (n = 209) and patients who had consulted their doctors for other reasons (n = 483). Bronchial obstruction defined as either FEV1 < 70% predicted or FEV1 < 70% of FVC, was found in 74 of the "pulmonary patients" and 55 of the "non-pulmonary" patients. In the group of patients with bronchial obstruction, a pathological or less certain sign of chest disorder was found in 91% of the "pulmonary" patients, and in 42% of the "non-pulmonary" patients ($p < 0.000001$). Strenuous respiration was registered in 41% of the "pulmonary" patients with bronchial obstruction, whereas sensitivity was only 2% in the other group. Where there were two or more pathological chest findings, the risk of bronchial obstruction occurring was 66% among the "pulmonary" patients, as opposed to 37% in the "non-pulmonary" group. Physical examination of the chest appeared to be very useful in the detection of bronchial obstruction in patients with pulmonary symptoms, but of limited value in screening for bronchial obstruction

411. Melbye, H., I. Aaraas, J. Hana, and A. Hensrud. 1998. Improving pulmonary auscultation as a tool in the diagnosis of bronchial obstruction--results of an educational intervention. *Scand.J.Prim.Health Care* 16:160-164.
Abstract: OBJECTIVE: To study the effect of an educational intervention on general practitioners' (GPs') ability to diagnose bronchial obstruction after clinical examination. DESIGN: Based on physical chest examination 11 GPs assessed the degree of bronchial obstruction by estimating the patient's predicted forced expiratory volume in one second (FEV1%). Half way in the study the GPs were taught new knowledge on associations between lung sounds and bronchial airflow. The agreements between estimated and measured FEV1% predicted before and after this educational intervention were compared. SETTING: 11 GPs in five

health centres in northern Norway took part. PATIENTS: 351 adult patients were included in phase 1, and 341 in phase 2. MAIN OUTCOME MEASURES: Estimated and measured FEV1% predicted were compared in subgroups of patients according to clinical findings in phase 1 and 2. The effect of the intervention on the doctors' weighting of various chest signs could thus be evaluated. Kappa agreement and correlation between estimated and measured FEV1% predicted in both phases were determined. RESULTS: The agreement between estimated and measured FEV1% predicted increased from Kw (weighted Kappa) = 0.33 in phase 1 to Kw = 0.43 in phase 2 (95% confidence interval 0.35-0.52). The GPs laid more relevant emphasis on rhonchi in their estimates after the educational intervention, while too much weight was laid on uncertain chest findings in phase 2. CONCLUSION: The study shows a potential for better use of physical chest examination in the diagnosis of bronchial obstruction

412. Michelson, P. H. and S. A. McColley. 1998. Wheezing or stridor: intrinsic and extrinsic lesions causing noisy breathing. *Allergy Asthma Proc.* 19:81-84.

413. Millqvist, E. and M. Bende. 1998. Reference values for acoustic rhinometry in subjects without nasal symptoms. *Am.J.Rhinol.* 12:341-343.
Abstract: Reference values for acoustic rhinometry are presented from 334 individuals without nasal symptoms between 4 years and 61 years old. There was a significant correlation between the minimal cross-sectional area (MCA) and nasal volume. Although the reproducibility of the method was good, the MCA varied widely. MCA correlated weakly to weight, height, age, and body mass index. Our data suggest that acoustic rhinometry is valuable for inter-individual comparisons

414. Miyazaki, S., Y. Itasaka, K. Ishikawa, and K. Togawa. 1998. Acoustic analysis of snoring and the site of airway obstruction in sleep related respiratory disorders. *Acta Otolaryngol.Suppl* 537:47-51.
Abstract: Seventy-five adult patients with sleep related respiratory disorders were examined by polysomnography with simultaneous recordings of the intraluminal pressure of the upper airway and snoring sound. Obstructed sites in the upper airway during sleep were determined by comparing the amplitude of respiratory fluctuation of the pressures in the epipharynx, mesopharynx, hypopharynx and esophagus. A definite correlation existed between the intensity of snoring sound and the amplitude of respiratory fluctuation of the intraesophageal pressure. Based on the results of the intraluminal pressure partitioning, the subjects were divided into the soft palate type (28), the tonsil/tongue base type (14), the combined type (27) and the larynx type (6). The average value of fundamental frequency (ff) was 102.8+/-34.9 Hz in the soft palate type, 331.7+/-144.8 Hz in the tonsil tongue base type, 115.7+/-58.9 Hz in the combined type and around 250 Hz in the larynx type

415. Murata, A., Y. Taniguchi, Y. Hashimoto, Y. Kaneko, Y. Takasaki, and S. Kudoh. 1998. Discrimination of productive and non-productive cough by sound analysis. *Intern.Med* 37:732-735.
Abstract: There are two types of coughs, productive and non-productive; the former is caused by excess airway secretions. The analysis of cough may provide important clues not only to aid diagnosis, but also for the selection of drugs for treatment. In this study, cough sounds recorded in a free acoustic field from patients with productive cough and non-productive cough due to chronic airway diseases were compared with those of voluntary cough of healthy subjects and were analyzed by sound spectrogram and time-expanded waveform. All cough sounds could be separated into two or three phases. The implementation of the novel technique to record cough sounds in the free acoustic field and to analyze the sounds of the high frequency range enable recognition of the characteristics of the cough sounds in phase 2 of the cough

416. Nicoll, S. J. and C. J. King. 1998. Airway auscultation. A new method of confirming tracheal intubation. *Anaesthesia* 53:41-45.
Abstract: Unrecognised accidental oesophageal intubation remains an important cause of morbidity and mortality in anaesthetic practice. We have evaluated a new method of distinguishing tracheal from oesophageal intubation using a simple adaptation of an ordinary stethoscope which is inserted into the patient end of the breathing system. We call this technique 'airway auscultation'. Characteristic sounds are heard with the stethoscope during inflation and deflation which allow the observer to diagnose the position of the tube. When the tube is in the trachea loud breath sounds are heard. In contrast, when the tube is in the oesophagus either squeaks or a flatus-like noise is heard or else there is no sound. In 100 healthy adults two observers rapidly identified 99 intubations correctly in a randomised single-blind trial. We recommend further widespread evaluation of this device as it appears to be an effective, simple and rapid method of detecting oesophageal intubation and confirming tracheal intubation which may be of particular use in situations where capnography is not available

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Abstract: The measurement of nasal resistance is important for understanding the pathophysiology of nasal obstruction. However, it is difficult to define the normal range of nasal resistance because of various physiological factors. Several authors have reported that nasal resistance is not correlated with the sensation of nasal obstruction. On the other hand, acoustic rhinometry was

introduced by Hilberg et. al. (1989) to determine the geometry of the nasal cavity. The method based on sound reflection analysis provides an estimate of the cross- sectinal area of the nasal cavity as a function of the distance from the nostril. Recently, the measurement by acoustic rhinometry is becoming popular also in our country. However, the assessment by acoustic rhinometry may be different from that by measuring nasal resistance because the cross-sectional area is measured without studying the air flow. The aim of this study was to investigate the benefit of acoustic rhinometry using a nasal model. First, 4 pieces of nasal model LM005 (KOKEN, Co., Japan) made of silicone were coated with resinous putty. Then, the changes in the area-distance curve were measured with an acoustic rhinometer RHIN 2100 (SRE, Co., Denmark) in which this putty was scraped off gradually from anterior to posterior. In the next study, the quality of coated putty was increased at three points of the nasal area: anterior part, middle part, and posterior part. Thereafter the changes in the area-distance curve were observed in the same way. As a result, neither a decrease or an increase in the putty changed the area-distance curve at the posterior part. Therefore, it is suitable that the degree of the changing of nasal mucosa is defined as the change in the nasal volume between the top the I-notch and the end of the C-notch. In conclusion, acoustic rhinometry is useful to investigate nasal obstruction, especially the change in the nasal mucosa. Therefore, further clinical study is required for the different purpose of measuring nasal resistance

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Abstract: We have developed a device (Glan Clwyd Snore Box) suitable for the objective measurement of the loudness and duration of snoring. The device is simple for the patient to operate, portable, battery powered, and able to produce objective results. We have used the Snore Box to record the snoring at home and during sleep studies in the hospital. Twenty-nine patients were studied. Overall the Snore Index recorded in the home was greater than in the hospital ($P < 0.001$), the average difference being 67 snores/h. We conclude that snoring is more appropriately assessed at home than in the hospital. We suggest the deficit arises from sleeping in an unfamiliar environment and the presence of several wires connecting the patient to the recording monitor which interfere with natural sleep in the hospital setting

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Abstract: BACKGROUND: Over the past several years, there has been a resurgence of interest in telemedicine. Despite this renewed interest, some health care providers remain skeptical regarding the effectiveness of telemedicine for the delivery of health care. OBJECTIVE: The objective of this prospective, crossover study was to determine if there was any difference between care delivered using video conferencing-based telemedicine technology and that given by a traditional face-to-face encounter in a pulmonary medicine clinic. METHODS: Two pulmonologists sequentially examined 40 individuals via video conferencing-based telemedicine technology and by the traditional face-to-face method. Two additional pulmonologists, in a blinded fashion, compared the results for consistency in the history, examination with focus on auscultation of the lungs, diagnostic impression, and evaluation and treatment plans. RESULTS: Evaluation of patients by telemedicine was as effective as the traditional mode. The telemedicine physician and the physician examining the patient in the traditional manner were able to elicit the same key complaints and hear the same adventitious sounds on auscultation of the lungs. CONCLUSION: Telemedicine can enable the provision of high-quality care in a pulmonary clinic setting

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Abstract: Sprague Dawley rats, previously infected with Phase-I Bordetella pertussis, developed more severe abnormal respiratory sounds than normal animals, but not coughing, when exposed to aerosolized capsaicin, one of several cough-inducing agents tested. Stethoscope examination suggested that greater production of pulmonary mucus might be occurring after capsaicin challenge of the infected animals, compared to the uninfected controls. Rats of three other strains gave characteristically different responses from the Sprague Dawleys. The administration of capsaicin to B. pertussis-infected rats may provide useful insights into the pathophysiology of excess mucus secretion in human pertussis

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Abstract: Auscultation of lung sounds in patient transport vehicles such as an ambulance or aircraft is unachievable because of high ambient noise levels. Aircraft noise levels of 90-100 dB SPL are common, while lung sounds have been measured in the 22-30 dB SPL range in free space and 65-70 dB SPL within a stethoscope coupler. Also, the bandwidth of lung sounds and vehicle noise typically has significant overlap, limiting the utility of traditional band-pass filtering. In this study, a passively shielded stethoscope coupler that contains one microphone to measure the (noise-corrupted) lung sound and another to measure the ambient noise was constructed. Lung sound measurements were made on a healthy subject in a simulated USAF C-130 aircraft environment within an acoustic chamber at noise levels ranging from 80 to 100 dB SPL. Adaptive filtering schemes using a least-mean-squares (LMS) and a normalized least-mean-squares (NLMS) approach were employed to extract the lung sounds

from the noise-corrupted signal. Approximately 15 dB of noise reduction over the 100-600 Hz frequency range was achieved with the LMS algorithm, with the more complex NLMS algorithm providing faster convergence and up to 5 dB of additional noise reduction. These findings indicate that a combination of active and passive noise reduction can be used to measure lung sounds in high noise environments

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Abstract: In this paper, a wavelet packet-based method is used for detection of abnormal respiratory sounds. The sound signal is divided into segments, and a feature vector for classification is formed using the results of the search for the best wavelet packet decomposition. The segments are classified as containing crackles, wheezes or normal lung sounds, using Learning Vector Quantization. The method is tested using a small set of real patient data which was also analysed by an expert observer. The preliminary results are promising, although not yet good enough for clinical use

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Abstract: BACKGROUND: The reliable interpretation of the nasal provocation test in allergy diagnosis requires objective and measurable monitoring parameters for clinical practice. The clinical usefulness of the nasal provocation test has been limited by scanty knowledge of the specificity and sensitivity of the test and a lack of reference values. OBJECTIVE: To test and compare three objective monitoring parameters of a nasal provocation test in occupational allergic rhinitis. To evaluate the magnitude of the nasonasal effects in a unilateral allergen challenge. METHODS: The monitoring parameters of the nasal reaction were derived from the minimum cross-sectional area on acoustic rhinometry, the nasal resistance on active anterior rhinomanometry and the amount of nasal secretion measured at 15 min intervals for 60 min. Twenty-three bovine-allergic dairy and beef cattle farmers and 19 exposed, non-allergic control subjects were challenged first with a control solution and then with the cow allergen. RESULTS: All the three monitoring parameters showed high specificity and sensitivity in finding allergic and non-allergic subjects. The secretion parameter was found to be slightly superior to the acoustic rhinometry and rhinomanometry parameters. The side difference in the nasal response between the allergen-challenged and the contralateral diluent- challenged cavity was significant for all the parameters among the allergic subjects. The contralateral secretion amount was 1/3 of the ipsilateral secretion, indicating the magnitude of the contralateral nasonasal reflex. A nasonasal reflex was also noted in the nasal patency monitoring. The coefficient of variation was significantly lower for the acoustic rhinometry than for the rhinomanometry (P=0.0001). The optimal threshold values for a positive test were a secretion amount of 100 mg, a 15% decrease in the minimum cross- sectional area and a 50% increase in the resistance for the observation period of 30 min and correspondingly 210 mg, 30% and 100% for 60 min. CONCLUSION: The low-pressure aspiration of the nasal secretion from the anterior part of the nasal cavity was found to be a reliable and practical monitoring parameter to be used together with acoustic rhinometry or rhinomanometry in the nasal provocation test for clinical purposes. Although significant nasonasal effects took place in the unilateral allergen challenge, the response was more prominent in the allergen-challenged than in the contralateral diluent-challenged nasal cavity in most allergic subjects

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Abstract: Inverse filtering is a digital signal processing technique which may be applied to speech-like sounds to remove resonances introduced by upper airway cavities to leave a residual signal which is, in principle, spectrally flat and strongly related to the excitation source. The filter parameters, normally computed by a form of linear prediction analysis, are indicative of the frequencies and bandwidths of the resonances. This paper briefly outlines the principle of inverse filtering and describes two applications in the study of upper airway sounds for diagnostic purposes. The first application is concerned with the non-invasive measurement of variations in upper airway dimensions which occur with changes in posture. Results show that differences in the resonance frequencies caused by changes in posture can be measured, these being of the order of about 10% in normals. The measurement of such changes is known to be useful in the assessment of patients with sleep apnoea. The second application concerns the evaluation of vocal tract abnormalities resulting from infection in the larynx. Parameters derived from the residual are believed to be indicative of the existence and severity of a hoarse voice. Results have been obtained which support this theory

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Abstract: The paper deals with a method of spectral tussography of a cough push sound by means of a microphone, followed by signal transduction, by using the computer programme developed. Patients with acute pneumonia upon admission and before discharge and healthy individuals were examined. The method of spectral tussography is safe, easy-to-use, and helpful in mass screening, applicable to solution of different problems faced by experts, to differential diagnosis of chronic non-specific diseases of the lung

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Abstract: Spontaneous cough is a symptom with diffuse diagnostic significance for childhood asthma. Information on the interrelations between presence/frequency of cough and other symptoms of asthma are not available to the physician. Tracheal sounds were continuously recorded in the homes of 60 children with and 30 without asthma, at 72 and 24 h, respectively. Presence and frequency of cough and presence of wheeze were scored by trained examiners. Wheeze was used to indicate airway obstruction during hours when peak expiratory flow (PEF) values were not available. PEF and self-reported dyspnea were assessed every 4 h. Results showed that asthmatics coughed significantly more often than control subjects during exacerbations, but not during remission. The highest diagnostic sensitivity percentages of cough were 72% for wheeze and 69% for a reduction in PEF > 20%. However, the diagnostic specificity was poor, 41% for wheeze and 34% for a reduction in PEF > 20%. Cough and dyspnea were independent. Three children did not cough during exacerbations. Persistent, isolated cough was observed in two children. It was concluded that spontaneous cough is modestly predictive of asthmatic exacerbations, but not of a diagnosis of asthma or severity of asthma

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Abstract: The aim of this study was to analyse inspiratory crackles in patients with Pulmonary Fibrosis (PF) and Bronchiectasis (BE). One case of Chronic Obstructive Pulmonary Disease (COPD) has also been included. The relationships between the time of occurrence of crackles (T) in the breath cycle and the corresponding flow at the mouth (F) and volume (V) have been investigated. The linear correlations between the flow, volume and time have been investigated by Pearson's R-test and the same variables have been analysed by Principal Component Analysis (PCA) in order to verify the effective dimension of these data. The results show a strong correlation between the time of occurrence and the volume in all the examined cases. PCA shows that in all cases F and V account for more than 90% of variation. These results suggest that placing crackles on the flow-volume plane does not cause loss of information

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Abstract: A versatile PC-based lung sound analyzer has been developed for short- term recording and analysis of respiratory sounds in research and clinical applications. The system consists of two sound sensors, a flow sensor, a filtering signal amplifier and a PC with a data acquisition card and software for measurement and analysis of the sounds. The analyses include phonopneumography, time expanded waveform analysis, spectral analysis with time averaged Fast Fourier Transform, frequency analysis in time domain (sonogram), and automatic detection and waveform analysis of crackles. Short-term repeatability of spectral parameters of tracheal and lung sounds was studied in 10 healthy subjects. The coefficients of variation (CoV) of the averaged quartile frequencies (F25, F50 and F75) of lung sounds during flow-controlled tidal breathing were 3.7, 4.0 and 8.9% in expiration and 2.7, 3.5 and 4.5% in inspiration, respectively. CoVs of the averaged F25, F50 and F75 of expiratory tracheal sounds were 6.9, 3.0 and 2.4%, and those of inspiratory tracheal sounds 6.3, 2.6 and 3.3%, respectively. Examples of lung sound analysis of samples containing adventitious sounds such as crackles and wheezes are presented. The results indicate that the median frequency has the best repeatability of quartile frequencies of breath sounds and they suggest that the variations of those parameters are low enough for diagnostic purposes. The results also suggest that the analyzer can be a useful new tool for pulmonary research in the fields of physiological and clinical short-term studies of respiratory sounds

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Abstract: Snoring is a common sleep-related behaviour. Increased body mass index (BMI), cranio-facial anatomical features, and older age have been linked to the occurrence of snoring. While mostly middle-aged populations have been studied for the occurrence of snoring and sleep- related breathing abnormality, this study was designed to assess the subjective report of snoring and the objective measurement of snoring at the two extremes of human age. The study design called for measurement of snoring in two age groups (college students; n=155 and older subjects; mean age 64.1 yrs n=134) with a mean age difference of 45 yrs. Snoring was assessed with a validated recording device. A validated questionnaire was used to subjectively assess snoring and obtain relevant sleep-related information. Students and older subjects differed in the self-report of snoring. While 83% of students reported "never" or "rarely" snoring only 35% of older subjects fell into these categories. Measurement of snoring during sleep revealed that students spent more time during sleep with continuous snoring than older subjects. In older subjects, a reduction in continuous snoring was accompanied by an increase in apnoeic snoring. Subjective snoring frequency correlated with continuous

snoring in students only. A positive family history of snoring increased the odds ratio for self- reported snoring but not for recorded snoring. It has been shown that snoring frequency can vary depending on age and that the congruency between perceived snoring frequency and recorded snoring is influenced by the age of an individual

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Abstract: This paper describes a real time system for the analysis of pulmonary sounds. The system performs various types of time-domain and spectrographic analysis. It is able to display time-domain waveforms obtained from microphones detecting lung sounds, their power spectra and a real-time linear prediction model instantaneously for the immediate identification of interesting features. Details of the system are presented with examples of clinical research carried out using spectrographic analysis

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Abstract: This paper is concerned with devising a standard procedure for determining the gain and phase responses of the analogue filters used to pre-process pulmonary signals prior to their digitisation. The customary high-pass filtering, in particular, will strongly affect the time-domain wave-shapes of digitised signals and this must be taken into account when analysing the signals. Several means of determining the effect of the high-pass filtering are investigated and a measurement procedure is proposed which may be easily carried out using simple laboratory equipment

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Abstract: The aim of the present study was to assess the clinical utility of acoustic rhinometry (AR) compared with active anterior rhinomanometry (AAR) in the evaluation of nasal patency in subjects with nasal septal deviation. Fifty patients were divided into three groups based upon the part of the nasal cavity where the septal deviation was situated (anterior: up to 2.5 cm; middle: between 2.5 and 4.5 cm; posterior: between 4.5 and 8 cm measured from the columella). The control group consisted of 15 subjects with no nasal complaints and no history of nasal disease. Inspiratory and expiratory nasal airway resistance (NAR) at 75 Pa and at 150 Pa before and after decongestion were measured by AAR. Minimal Cross-sectional Area (MCA), distance of MCA, and nasal volume (Vol) were measured before and after decongestion by AR (Rhino 2000). Subjective nasal patency was assessed by Visual Analogue Score (VAS). In the statistical analysis the deviated unilateral nasal cavities were compared with the randomly chosen unilateral nasal cavities of normal subjects. Both techniques AR and AAR were sufficiently sensitive to reveal severe deviations in the anterior nasal cavity (MCA, Volant, NAR75, NAR150, $p < 0.05$). The techniques were less sensitive in cases of middle and posterior deviations (MCA, Volmid, Volpost, MCAmid, MCApost, NAR75, $p > 0.05$). The nondecongested inspiratory and expiratory NAR at 150 Pa were the only parameter that differed from normal in cases of posterior deviations. The VAS correlated better with NAR than with MCA. MCA correlated more frequently with expiratory than with inspiratory NAR

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Abstract: The separation of pathological discontinuous adventitious sounds (DAS) from vesicular sounds (VS) is of great importance to the analysis of lung sounds since DAS are related to certain pulmonary pathologies. An automated way of revealing the diagnostic character of DAS, by isolating them from VS, based on their nonstationarity, is presented in this paper. The proposed algorithm uses two adaptive network-based fuzzy inference systems to compose a generalized fuzzy rule-based stationary-nonstationary filter (GFST-NST). The training procedure of the fuzzy inference systems involves the outputs of the wavelet transform-based stationary-nonstationary filter (WTST-NST), proposed by Hadjileontiadis and Panas [1]. The basic idea of the GFST-NST was initially proposed by the authors with the introduction of the fuzzy rule-based stationary-nonstationary filter (FST-NST) [2], tested with the separation of crackles from VS. The main contribution of this paper is the modification of the structure of the FST-NST filter to a serial- type fuzzy filter that, unlike the parallel operation of the FST-NST filter, sends a predicted stationary signal (VS) into the predictor of the nonstationary (DAS). Applying the GFST-NST filter to fine-coarse crackles and squawks, selected from three lung sound databases, the coherent structure of DAS is revealed and they are separated from VS. The separation performance of the GFST-NST filter was evaluated through quantitative and qualitative indexes that proved its efficiency and superiority against the FST-NST filter. When compared to the WTST-NST filter, the GFST-NST filter performed similarly in accuracy and objectiveness, but in a faster way. Thus, the GFST-NST filter combines the separation accuracy of the WTST-NST filter with the real-time implementation of the FST-NST filter, so it can easily be used in clinical medicine as a module of an integrated intelligent patient evaluation system

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Abstract: The nasal cavities of 51 healthy volunteers were examined using acoustic rhinometry before and after nasal decongestant. Several specific dimensions were studied, which included the minimum cross- sectional area, and three volumes

corresponding to the anterior, middle and posterior regions of the nasal airway. An average acoustic rhinometry trace was constructed for the whole group of subjects, before and after decongestion, from data extracted from the raw data files written to the computer hard disk for each subject. A 27.5% ($P < 0.0001$) increase in the minimum cross-sectional area was observed, with no shift in its position. The greatest increase in nasal dimensions was seen in the anterior and middle parts of the nose, however, significant changes were also seen in the posterior nasal cavity and post nasal space. There are a number of possible sources of artefact. First, confusion of the first and second minima may produce apparent movement of the minimum cross-sectional area following nasal decongestion. Second, a postulated change in the acoustic path length may lead to apparent changes in volume in certain regions of the nose. Third, a variable and uncontrollable degree of sound energy loss will occur into the opposite nasal cavity beyond the posterior border of the septum. An apparent increase in the dimensions of this region will be seen as the opposite cavity decongests. We feel that all users of the acoustic rhinometer need to be aware of these potential sources of artefact, and attention needs to be focused on an agreed definition of the components of the acoustic rhinometry trace

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Abstract: A new method to represent and evaluate crackles on the flow-volume plane is described. Characteristic crackle patterns were found in patients with pneumonia, bronchiectasis, chronic obstructive pulmonary disease, heart failure and cryptogenic fibrosing alveolitis. In addition to visual assessment, simple statistical parameters were used to describe the observed pathological phenomena

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Abstract: In this paper, an automatic method to detect and analyze crackles in digitised respiratory sounds is presented. The method is based on two steps: (1) a threshold (T) value is applied to the first derivative absolute value (FDAV) of lung sound to locate the "zone of interest" and (2) in this zone a crackle is detected if certain conditions are verified. The first derivative (FD) is evaluated by means of a derivative-smoothing filter, preserving areas under the spectral lines of the signal (moment zero), its mean position in time (first moment) and its spectral line width (second moment). The conditions to verify step 2 concern the following: the number and height of the peaks of FDAV and their distances from the starting point of the crackle, within a temporal window TW. This method shows good performances as an automatic detector (sensitivity 84% and specificity 89%), and is specifically designed to find the starting point of the crackle

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Abstract: A new automatic wheeze detection method which is based on image processing techniques applied to the sonagram was developed here. In the calculation of the sonagram, autoregressive and FFT spectrum estimation methods were compared. The method was validated in four wheezing asthmatic patients by a pulmonary physician. Nine out of ten wheezes longer than 250 ms were detected. Very short wheezes were not detected. The false positive amount of wheezing in control subjects was only about 1%. The method extracts also information about the frequency, duration, flow and volume associated with the wheezes

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Abstract: We have developed a guinea pig model for cough related to allergic airway inflammation. Unanesthetized animals were exposed to capsaicin aerosols for 10 min, and cough frequency was counted during this period. The cough evaluation was performed by the following three methods: visual observation, acoustic analysis, and monitoring of pressure changes in the body chamber. These analyses clearly differentiated a cough from a sneeze. To elucidate the relationship between cough response and airway inflammation, animals were immunosensitized and multiple challenged. Sensitized guinea pigs presented no specific changes microscopically, but multiple-challenged animals showed an increased infiltration of inflammatory cells into the airway. Cough number in response to capsaicin increased significantly from 4.7 +/- 1.4 coughs/10 min in normal animals to 10.6 +/- 2.0 coughs/10 min in sensitized animals and further to 22.8 +/- 1.3 coughs/10 min in multiple-challenged animals. This augmented cough frequency was significantly inhibited by the inhalation of tachykinin- receptor antagonists and by oral ingestion, but not inhalation, of codeine phosphate. The results suggest that airway inflammation potentiates an elevation of cough sensitivity in this model

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Abstract: The generation and transmission process of transmitted sound signals (TSS) is analyzed and a mathematical model of TSS is established in this paper. The power cepstral characteristics of TSS are studied based on the mathematical model and a new analysis method of acoustic transmission of respiratory system using homomorphic processing technique is proposed. The

experimental results show that the normal respiratory system has only one formant, while the abnormal respiratory system presenting lung consolidation has two formants and the second formant plays important role in that system. This new method is a simple and effective one

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Abstract: STUDY OBJECTIVE: To determine whether the environment of a moving ambulance affects the ability of our-of-hospital care providers to auscultate breath sounds. METHODS: Out-of-hospital care providers assessed breath sounds with a previously described breath-sounds model in a quiet environment (control) and in a moving ambulance. The setting was a nonurban emergency medical services system and an interhospital transport agency based at a 600-plus-bed tertiary care center. The participants were physicians, transport nurses, and advanced life support EMS providers routinely involved in the emergency out-of-hospital treatment and transportation of the ill and injured. The accuracy with which participants identified the presence or absence of breath sounds in the two environments was compared with the use of the chi 2 test, with the alpha-value set at .05. RESULTS: The accuracy of breath-sounds assessment in the control environment was 96% (251 of 260); the sensitivity was 96% and the specificity 97%. The accuracy of breath-sounds assessment in the experimental environment was 54% (140 of 260); the sensitivity was .09% and the specificity 98%. Participants were significantly less likely to hear breath sounds in the moving ambulance than in the quiet room (P < .001). CONCLUSION: Assessment of breath sounds is hampered by the environment of a moving ambulance

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Abstract: This paper is concerned with the problem of cancellation of heart sounds from the acquired respiratory sounds using a new joint time- delay and signal-estimation (JTDSE) procedure. Multiresolution discrete wavelet transform (DWT) is first applied to decompose the signals into several subbands. To accurately separate the heart sounds from the acquired respiratory sounds, time-delay estimation (TDE) is performed iteratively in each subband using two adaptation mechanisms that minimize the sum of squared errors between these signals. The time delay is updated using a nonlinear adaptation, namely the Levenberg- Marquardt (LM) algorithm, while the function of the other adaptive system-which uses the block fast transversal filter (BFTF)-is to minimize the mean squared error between the outputs of the delay estimator and the adaptive filter. The proposed methodology possesses a number of key benefits such as the incorporation of multiple complementary information at different subbands, robustness in presence of noise, and accuracy in TDE. The scheme is applied to several cases of simulated and actual respiratory sounds under different conditions and the results are compared with those of the standard adaptive filtering. The results showed the promise of the scheme for the TDE and subsequent interference cancellation

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Abstract: Acoustic rhinometry (AR) evaluates the geometry of the nasal cavity with acoustic reflections and provides information about nasal cross- sectional areas (CSA) and nasal volume within a given distance. The accuracy of the information obtained by AR was compared with that of magnetic resonance imaging (MRI) of the nasal cavity. Five healthy subjects were evaluated with AR and the MRI before and after the application of a long-acting nasal decongestant spray, to eliminate possible interference of the nasal cycle with both measurement techniques. The MRI images of 2 mm coronal sections of the nasal cavity were traced by three independent observers and the CSAs were calculated by computer-aided imaging digitization, to be compared with the calculated CSAs obtained with the AR at the corresponding distance from the nasal tip. Digitized data from the MRI images were also used to calculate the nasal volume within the first 6 cm from the nasal tip and compared with the AR volume measurements. The interobserver variation of digitized MRI data predecongestant and postdecongestant was not significant. The correlations of CSA and volume measurements between the AR and MRI were high (0.969) after the application of the decongestant. The correlation between the AR and MRI measurements before the decongestant was low (0.345). This may have been the result of interference of the nasal cycle during the long MRI measurements (1 hour) or other unknown factors. We conclude that AR measurements of nasal CSAs and volumes provide accurate information when compared with the MRI of the decongested nasal airway

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Abstract: Spikes such as QRS complex in ECG, epileptic seizures in EEG, fine crackles in vesicular sound and glottal closure instants in voiced sound are of diagnostic importance. Various methods of spike detection use the amplitude and frequency characteristics of the spikes. Because of the high frequency content, the spikes appear in the error signal when a linear prediction filtering scheme is used. The authors use the method of midprediction filtering for the detection of the spikes. In this method, the present sample is predicted as a weighted average of p recent past and p immediate future samples. The symmetrical nature of midprediction causes the spikes to appear in the error signal with their original basewidths. This can help in improving the reliability

of spike detection, as both the amplitude and the duration of the spike can be considered as decision making parameters. It is observed that the high frequency gain of the midprediction filter is higher compared to the high frequency gain of the LPC or endprediction filter. As a result, this method works better than linear prediction for the detection of spikes

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Abstract: The nasal airways of 94 healthy term infants (37-42 weeks gestational age) were examined by continuous wide-band noise acoustic rhinometry under standardized conditions on the second or third day postpartum. Validation of the flexible infant probe on tubular plastic models with dimensions similar to the nasal cavity of newborn infants showed a correlation coefficient of 0.98. The mean and standard deviation (SD) of the total minimal cross-sectional area (TMCA), the distance from the nostril to the MCA (DMCA) and the total volumes between the nostril and 45 mm into the nasal cavity (TVOL45) were 0.20 +/- 0.05 cm2, 0.76 +/- 0.29 cm and 2.14 +/- 0.39 cm3 respectively. In general, both anthropometric and rhinometric mean values were higher in males (n = 52) compared to females (n = 42), and the difference was statistically significant for TMCA and head circumference. We conclude that the technical properties, small size and flexible tube of the miniprobe make it uniquely suited for objective assessment of the nasal airways in infants and small children. The RHIN 2000/2100 miniprobe (S.R. Electronics Aps, Lynge, Denmark) is the first infant probe commercially available, making standardization and comparison of results easier

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Abstract: Acoustic analysis of cough both in the time and frequency domain has been reported using voluntary and spontaneous cough. The main aim of this study was to discover whether such analysis of capsaicin-induced cough enables differences between normal subjects to be recognized. We present data from 13 healthy subjects (with normal lung function and no history of respiratory disease) using a new method of acoustic analysis, which presents the data in three graphical forms: 1) spectrogram; 2) overall spectral energy, 3) root mean square (RMS) pressure plots. Using the RMS sound pressure traces, different subjects had either two peaks, a single peak or multiple peaks. The occurrence of single and multiple peaks has previously been associated with disease states but we found them in normal subjects. The number of peaks and the visual pattern of the spectrogram was reproducible within and specific to each individual over time. During a peal of coughs in a single expiration, the peak amplitude of successive coughs decreased as lung volume reduced. Despite similarities in the overall spectral energy between individuals, there were marked differences in the small visual details of the spectrograms. However, in an individual, these small details were remarkably constant both within and between days, and can be regarded as a "cough signature". This type of spectrographic analysis provides a new approach to the analysis both of normal and abnormal cough sounds, and has identified similarities and differences in capsaicin-induced cough in normal individuals. It has potential as a tool with which to study the pathophysiology of cough

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Abstract: Assessment of upper airway mechanics in patients with obstructive sleep apnea/hypopnea (OSA) can be carried out qualitatively from indirect signals (flow pattern, snoring, strain gauges, inductance plethysmography) or quantitatively by means of invasive estimation of esophageal pressure. The forced oscillation technique (FOT) is a noninvasive method of potential interest for quantitatively assessing airway obstruction in the sleeping patient. The aim of this work was to ascertain in a model study whether FOT could provide an index of airway obstruction when applied at the conditions of total and partial occlusions similar to the ones found in patients with OSA. An airway analog closely mimicking upper airway collapsibility was constructed and mechanically characterized by the relationship between its flow, upstream and downstream pressures as well as by means of FOT. We simulated total collapse (apnea), different levels of partial collapse with flow limitation (hypopnea), and release of airway obstruction when the collapsible analog was used as an artificial upper airway in a spontaneously breathing subject submitted to continuous positive airway pressure (CPAP) up to 14 cm H2O.s/L. The results showed that the amplitude of airway impedance measured by FOT was a suitable index to detect obstruction in collapsible segments. We concluded from this realistic model study that FOT could be a valuable tool for quantitatively assessing airway obstruction in patients with OSA treated with CPAP. This noninvasive technique is potentially useful both in studying upper airway mechanics in detail and in automatically monitoring airway obstruction in routine studies

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Abstract: Codeine is generally accepted as the standard antitussive against which new antitussive medications are compared. This presents a problem because the support for codeine's antitussive activity comes from studies on cough in animals, and chronic

and induced cough models in man, whereas antitussives are almost exclusively used for the treatment of cough associated with acute upper respiratory tract infection (URTI). The aims of this study were twofold. Firstly, to study the antitussive efficacy of codeine in cough associated with URTI and, secondly, to validate a sound meter as tool for quantifying cough. The efficacy of codeine was assessed in a double-blind, stratified, placebo- controlled, parallel-group, clinical trial using three different measures of cough: cough sound-pressure levels (CSPLs) measured on a sound meter; subjective scores of cough severity; and cough frequency recorded by means of a microphone connected to an ink-pen recorder. A group of 82 subjects (51 females and 31 males; mean age 23.5 years, range 18-46 years) with cough owing to acute URTI were included in the study. The study took place on two separate study days. On study day 1 cough measurements were made before and 90 min after treatment with a single dose of either 50 mg codeine or matched placebo in capsule form. The same three measures of cough were repeated 2-5 days later (study day 2). On study day 1 a highly significant ($P < 0.0001$) decrease in all three measures of cough was found after treatment with both placebo and codeine yet there was no significant difference between the treatment groups. A highly significant ($P < 0.0001$) decrease in the three measures of cough was also found between days 1 and 2. The results demonstrate that codeine is no more effective than placebo in reducing cough associated with acute URTI, as measured by CSPLs, cough frequency or subjective symptom scores. This result might be explained on the basis of two central pathways for cough; a reflex pathway via the brain-stem which is sensitive to codeine and a voluntary pathway via the cortex which is unaffected by codeine. The results also demonstrate that the sound-level meter appears to be a potentially useful investigative tool for the assessment of cough and antitussive efficacy

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Abstract: The measurement of the conventional interrupter resistance (Rint) is dependent on pressure equilibration between alveolar and airway opening pressure, which is often not achieved in the presence of severe airways obstruction or in small children. The damping properties (d) of postocclusional oscillatory pressure transients after rapid flow interrruption can be assessed independent of complete pressure equilibration, and we have previously shown them to be correlated to resistive properties of the respiratory system. We wanted to determine whether these transients were an expression of acoustic properties of the air in the airways, or whether they were caused by an interaction of gas and lung tissue, and whether d was more sensitive than Rint to changes in airway mechanics. Bronchial challenge tests were carried out with cumulative doses of inhaled carbachol in 10 healthy children (aged 7-14 yrs) and 50 asthmatic children (aged 5-15 yrs). The airflow interruptions were performed with a combined nebulizer-shutter head, allowing resistance measurements with each breath. The frequency, and the damping factor of the postocclusional pressure transients changed significantly during carbachol challenge in both groups of children. The provocation dose (PD) at which the damping factor (d) of the oscillatory pressure transients increased more than 2 SD above the baseline mean ("variance-based", PDvb) was lower than the PDvb of the end-interruption resistance (Rint, EI). These changes in frequency and damping factor were reversible after inhaling salbutamol. These findings suggest that the damping properties of the postocclusional pressure transients after flow interruption can be used as a sensitive parameter to assess changes in airway mechanics during bronchial challenge test in children in whom pressure equilibration is frequently not achieved during airflow interruption due to airways obstruction

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Abstract: Respiratory input impedance (Zin) over a wide range of frequencies (f) has been shown to be useful in determining airway resistance (Raw) and tissue resistance in dogs or airway wall properties in human adults. Zin measurements are noninvasive and, therefore, potentially useful in investigation of airway mechanics in infants. However, accurate measurements of Zin at these f values with the use of forced oscillatory techniques (FOT) in infants are difficult because of their relatively high Raw and large compliance of the face mask. If pseudorandom noise pressure oscillations generated by a loudspeaker are applied at the airway opening (FOT), the power of the resulting flow decreases inversely with f because of capacitive shunting into the volume of the gas in the speaker chamber and in the face mask. We studied whether high-frequency respiratory Zin can be measured by using rapid flow interruption [high-speed interrupter technique (HIT)], in which we expect the flow amplitude in the respiratory system to be higher than in the FOT. We compared Zin measured by HIT with Zin measured by FOT in a dried dog lung and in five healthy adult subjects. The impedance was calculated from two pressure signals measured between the mouth and the HIT valve. The impedance could be assessed from 32 to 800 Hz. Its real part at low f as well as the f and amplitude of the first and second acoustic resonance, measured by FOT and by HIT, were not significantly different. The power spectrum of oscillatory flow when the HIT was used showed amplitudes that were at least 100 times greater than those when FOT was used, increasing at $f > 400$ Hz. In conclusion, the HIT enables the measurement of high-frequency Zin data ranging from 32 to 800 Hz with particularly high flow amplitudes and, therefore, possibly better signal-to-noise ratio. This is particularly important in systems with high Raw, e.g., in infants, when measurements have to be performed through a face mask

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Abstract: Fifty-one wheezing babies (WB) under two years of age and 20 controls (C) within the same age range were submitted to a bronchial provocation test (BPT) with methacholine. The appearance of wheezing on pulmonary auscultation was used to determine PCW (provocative concentration of methacholine causing wheezing). For all tests, methacholine diluted in saline at increasing concentrations (0.025, 0.125, 0.25, 0.5, 1.0, 2.5, 5.0 and 10.0 mg/ml) was delivered with O2 (5 ml/min) via a face mask. Solution was inhaled through the mouth and nose during two minutes of quiet tidal breathing via a nebulizer containing a 2 ml volume. No collateral effects were observed, except for tachypnea and tachycardia. There was a statistically significant difference between the PCW for WB (2.3 mg/ml) and the PCW for C (9.2 mg/ml). A 5 mg/ml concentration of methacholine provides the clearest distinction between the WB and C groups. Indeed, we observed that 96% of WB and 25% of C demonstrated PCW below this concentration. In the WB group, those with mild symptoms had higher PCW values. When the BPT was repeated in 27 WB at an 8-month interval, statistically significant differences between the two PCV values were observed. The highest PCW values were evidenced in the second BPT. The use of BPT with methacholine could establish PCW as a parameter of bronchial hyperreactivity in infants

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Abstract: The separation of pathological discontinuous adventitious sounds (DAS) from vesicular sounds (VS) is of great importance to the analysis of lung sounds, since DAS are related to certain pulmonary pathologies. An automated way of revealing the diagnostic character of DAS by isolating them from VS, based on their nonstationarity, is presented in this paper. The proposed algorithm combines multiresolution analysis with hard thresholding in order to compose a wavelet transform-based stationary-nonstationary filter (WTST-NST). Applying the WTST-NST filter to fine/coarse crackles and squawks, selected from three lung sound databases, the coherent structure of DAS is revealed and they are separated from VS. When compared to other separation tools, the WTST- NST filter performed more accurately, objectively, and with lower computational cost. Due to its simple implementation it can easily be used in clinical medicine

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Abstract: The use of higher-order statistics for diagnostic assessment and characterisation of lung sounds is presented in this article. The parametric approach of bispectrum estimation, which is a third-order spectrum, based on a non-Gaussian white noise driven autoregressive (AR) model, reveals information about lung sounds that is not contained in the ordinary power spectrum, such as the degree of nonlinearity and deviations from normality. Characterisation of source and transmission of lung sounds is achieved using an AR model based on third-order statistics. Furthermore, harmonic analysis of lung sounds is combined with the bicoherence index in order to obtain information regarding possible quadratic phase coupling among harmonic components of musical lung sounds. Experiments have shown that higher-order statistics can offer reliable evaluation of lung sounds characteristics, since their general properties and robustness in noiseless or noisy environments (lung sounds contaminated with additive symmetrical noise, e.g., Gaussian) proved to have superior advantages in objective analysis of pulmonary dysfunction

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Abstract: When recording lung sounds, an incessant noise source occurs due to heart sounds. This noise source severely contaminates the breath sound signal and interferes in the analysis of lung sounds. In this paper, an adaptive heart-noise reduction method, based on fourth-order statistics (FOS) of the recorded signal, without requiring recorded "noise-only" reference signal, is presented. This algorithm uses adaptive filtering to preserve the entire spectrum. Furthermore, the proposed filter is independent of Gaussian uncorrelated noise and insensitive to the step- size parameter. It converges fast with small excess errors and, due to the narrow-band nature of heart noise (HN), it requires a very small number of taps. Results from experiments with healthy subjects indicate a local HN reduction equal to or greater than 90%

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Abstract: A new adaptive method for heart sounds reduction from lung sounds, based on wavelet transform, is presented in this paper. The use of a wavelet transform domain filtering technique as an adaptive de-noising tool, implemented in lung sounds analysis, is introduced. The multiresolution representations of the signal, produced by wavelet transform, are used for signal structure extraction. Experimental results have shown that implementation of this wavelet-based filter in lung sound analysis results in an efficient reduction of heart sounds from lung sounds, producing an almost noise-free output signal

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Abstract: It is known that abductor paralysis (AP) of the vocal folds sometimes occurs in patients with multiple system atrophy (MSA), and some of them have sleep apnea and loud snoring during sleep. However, the site of obstruction and the sound source of the snoring are still unknown. We performed fiberscopic examinations under diazepam sedation in 8 MSA patients with AP and analyzed the snoring sound. We found that the peculiar snoring occurred with inspiratory vibration of the vocal folds, and there was no obstruction in this portion. Acoustic analysis showed that the fundamental frequency of vocal fold snoring was 260 to 330 Hz, which is different from that of ordinary soft palate snoring. Recognition of vocal fold snoring is important in the early diagnosis of MSA and sleep-related breathing disorders

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Abstract: Previous studies have indicated that respiratory sound signals may contain information useful in the detection of lung diseases. In this study, measurement and recordings of respiratory sound signal segments were obtained in normal subjects (non-smokers) and smokers in both inspiration and expiration phases. By using the autoregressive (AR) method, it is possible to produce power spectra of respiratory sound signals in inspiration and expiration phases for smokers and non- smokers of each group. The selection of the AR model order of the respiratory sound signals is achieved using Akaike criterion. The AR model order of 9 is required for completely described respiration sound signal segments in inspiration and expiration phases for both groups. The power spectra in the smoker group show larger distinct peaks at lower frequencies as well as more harmonics in both inspiration and expiration phases compared to the power spectra of the non-smoker group. Another diagnostic indicator was derived from the relative position of poles of the AR model of respiratory sound signals. In all smokers it was found that the first, third and fourth poles were closer to a unit circle than those in non-smokers ($P < 0.01$). It seems that the use of these indicators may be useful as early diagnostic tool for lung diseases

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Abstract: Cough is a common symptom of pulmonary diseases. For a number of reasons it would be of interest to have information about the frequency of coughs over a given period of time. So far, the cough recorders which are available are either too expensive or unwieldy. Hence, we developed a cough recorder linked to a portable, commercially available actigraph (about the size of a pack of cigarettes) that records coughing as an acoustic signal and ventral thorax movement. The signals are filtered via a band pass and sampled by a peak detektor with different time constants to separate the impulse character of the cough signal from the background noise level. The cough recorder registers coughing cumulatively over a period of one minute and has a storage time of one week. Since the acoustic signals are essential for the interpretation of the recordings, the analogue circuit was subjected to a separate validation programme. For this purpose, the distinction between active coughs of 10 volunteers (total number of coughs 550) and background noises (male and female voices and other defined noises, total number of noises 336) was tested. The complete assembly was then tested over night on 7 hospitalised patients with chronic cough. An infrared video camera system was used to make a reference recording of the overnight coughing. The results show that nearly every cough of the 10 volunteers was recorded ($r = 0.99$). 97.1% of the background noise was correctly interpreted. The complete recorder assembly correctly recorded 98.9% of the coughs (total 870) in the 7 patients. 4.8% of the background noise was erroneously registered as coughing. Summing up, it can be said that the portable cough recorder affords accurate recording of coughing over a period of one week, correctly distinguishing coughing from background noise

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Abstract: Polysomnographic recording is indispensable in the diagnosis of sleep apnea syndrome (SAS). However, this method has a number of drawbacks, for example, subjects cannot sleep naturally like at their homes, and the methodology involved is complicated. We have now developed Portable Type Sleep Apnea Detector (PSD) that needs to equipment to provide subject's body. This study was done to verify the usefulness of this device. Subjects were 50 patients (42 male and 8 female, average and S.D. of age: 47.0 +/- 14.5), who were suspected to have SAS. Polysomnography and sleep recording using PSD were performed simultaneously. PSD consisted of three sensors for respiratory movements, a sensor for breathing sounds and a data recorder. The recorder was an 8K32 type 4-channel Handycorder (Nippon Denki Sanei, 370 mm x 115 mm x 200 mm, 7.5 kg) and the sensor for respiratory movements was a thin plate (180 mm x 100 mm). The three sensors for respiratory movements were placed between the mattress and bedsheet, hence the subjects did not feel them during sleep. A sound sensor detected breathing sounds such as snoring. We defined whether a subject is in sleep or awake by the number of body movements recorded by this device. Apnea was defined as depressed or stopped respiratory movement with no snoring for a period longer than 10 seconds. Standard polysomnography which consisted of electroencephalogram (2 channels), electrooculogram (2 channels), electromyogram (2 channels), electrocardiogram (1 channel), oral (1 channel) and nasal airflow (1 channel) and chest movements (1 channel) were performed. Sleep stages were evaluated according to the standard methods. The apnea hypopnea index (AHI) was defined as the number of apneas and hypopneas per sleep- hour. Significant correlation between each type of sleep apneas, AI and AHI as

measured by two methods, was found (obstructive type: r = 0.929; p < 0.001, central type: r = 0.880; p < 0.001, mixed type: r = 0.952; p < 0.001, AI and AHI: r = 0.956; p < 0.001). It was concluded that this device is useful for screening SAS

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Abstract: An algorithm for the simulation of normal and pathological lung sounds is developed. The simulation algorithm is implemented on a personal computer as well as on a digital signal processor system in real time. Normal, bronchial and tracheal breathing sounds can be generated, and continuous and discontinuous adventitious lung sounds can be added. The attributes of the individual sound components, such as loudness, frequency, duration or number of occurrences within one breathing cycle, are controlled by the user. The quality of the simulations is evaluated by sending audio tapes to 15 experienced pulmonary physicians for a formal assessment. Each tape contains five simulated lung sounds and five real lung sounds from a commercially available teaching tape, presented in random order. Simulated lung sounds are slightly better rated in terms of realism and signal quality when compared to the recordings from the teaching tape. The differences are, however, not significant. 13 out of the 15 physicians feel that computer-based lung sound simulators would be a useful and desirable teaching tool for auscultation courses

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Abstract: Non-invasive acoustic airway monitoring was evaluated in an experimental study. Recording amplitude and travel time of acoustic pulse response, an area-distance function of the cross sectional dimensions of the endotracheal tube and the adjacent airway was calculated to obtain an acoustic pattern of the airway. Measurements on models and excised human cadaver lungs were performed to discover whether displacement or obstruction of the artificial airway can be detected in the acoustic equivalent. Regression analysis revealed a close correlation between displacement of tracheostomy tubes and the shifting of the acoustic area-distance function (corr. coeff. 0.97-1). Dispersion analysis confirmed reasonable reliability (coeff. of variation 0.6-2.1%). Location and amount of obstruction could likewise be identified. Thus acoustic mapping provides an adequate approximation of the true geometry of tracheostomy and endotracheal tubes. We conclude that acoustic monitoring may provide a powerful tool to achieve primary prevention of airway disturbances in intubated and mechanically ventilated patients, as geometrical changes of airway configuration can be detected even before they cause substantial effects on respiratory metabolism

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Abstract: Non-invasive acoustic airway-monitoring was evaluated in an experimental study. Recording amplitude and travel time of acoustic pulse response, an acoustic pattern of airway's geometry was then calculated. Measurements on models and excised human cadaver lungs were performed to discover whether displacement or obstruction of the artificial airway could be detected by its acoustic equivalent. Regression analysis revealed a close correlation between displacement of tracheostomy tubes and the shifting of the acoustic area-distance function (corr. coeff.: 0.97-1) and an adequate correlation between acoustic and planimetrical determination of cross-sectional area within the tubes (corr. coeff.: 0.78). Dispersion analysis confirmed reasonable reliability of acoustic cross-sectional measurements (Coefficients of variation: 0.6-2.1%). The acoustic mapping thus provides an excellent approximation of the true displacement and/or obstruction of tracheostomy and endotracheal tubes. We conclude that acoustic monitoring may provide a helpful tool for achieving an early warning system of airway disturbancies in intubated and mechanically ventilated patients, as geometrical changes of airway configuration may be detected before they lead to relevant effects on respiratory metabolism

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Abstract: Although auscultation is commonly used as a continuous monitoring tool during anesthesia, the breath sounds of anesthetized patients have never been systematically studied. In this investigation we used digital audio technology to record and analyze the breath sounds of 14 healthy adult patients receiving general anesthesia with positive pressure ventilation. Sounds recorded from inside the esophagus were compared to those recorded from the surface of the chest, and corresponding airflow was measured with a pneumotachograph. The sound samples associated with inspiratory and expiratory phases were analyzed in the time domain (RMS amplitude) and frequency domain (peak frequency, spectral edge, and power ratios). There was a positive linear correlation (R2 > 0.9) between inspiratory flow and sound amplitude in the precordial and esophageal samples of all patients. The RMS amplitude of the inspiratory and expiratory sounds was approximately 13 times greater when recorded from inside the esophagus than from the surface of the chest in all patients at all flows (p < 0.001). The peak frequency (Hz) was

significantly higher in the esophageal recordings than the precordial samples (298 +/- 9 vs 181 +/- 10, P < 0.0001), as was the 97% spectral edge (Hz) (740 +/- 7 vs 348 +/- 16, P < 0.0001). In the adult population esophageal stethoscopes yield higher frequencies and greater amplitude than precordial stethoscopes. Quantification of lung sounds may provide for improved monitoring and diagnostic capability during anesthesia and surgery

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Abstract: In contrast to numerous studies of the activity of the supraglottic voice resonator and its acoustic effect, little is known about the subglottic resonator and its function. In the present investigation the phonatory behavior of the lower airway (the "chest resonator") was studied and the quality of its acoustic output analyzed. Echo- tomographic analysis was used to study the tracheal diameter during various phonatory tasks. Acoustic analysis was also used, based on acoustic separation between the supra- and subglottic airways (including perceptual testing, sound pressure levels, and long-time spectral analysis). Evidence is presented of chest resonator activity having both perceptual and spectral effects

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Abstract: Adenoidal hypertrophy is the commonest cause of nasal obstruction in the pediatric population. It may cause marked morbidity as regards respiratory physiology, facial growth and middle ear function. Determination of adenoidal presence and size is not easy. Nasal endoscopy and radiology are the most accepted modes of diagnosis and each has its disadvantages. We have used acoustic rhinometry to determine the size of adenoids. Changes in nasal volume and resistance were recorded and an easy formula was devised to determined adenoid size. This technique is easy, non-invasive and reproducible with a 93.5% predictive value

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Abstract: OBJECTIVES: To assess the reliability of telemedicine examination and identify the issues to be addressed if the conduct of physical examination and the reading of images and tracings by telemedicine are to be as reliable as conventional examination and reading. METHODS: Patients were examined both conventionally and by telemedicine in 12 clinics, and the results were compared. There were 1826 matched pairs of observations. Cardiac auscultation, echocardiography, electrocardiography, electroencephalography, obstetric ultrasonography, ophthalmologic examination, physical therapy assessment, pulmonary auscultation, and the reading of chest radiographs with telemedicine cameras and monitors were studied. The main outcome measure was agreement between the telemedicine findings and a criterion standard. RESULTS: For ophthalmology, physical therapy, and cardiac auscultation, 91.2% of the conventional findings and 86.5% of the telemedicine findings were identical or similar to the criterion standard. The kappa coefficient on matched-pair analysis was 0.66. For pulmonary auscultation and reading of chest films with a telemedicine camera and monitor abnormalities were suppressed at default settings but subsequently revealed with extensive manipulation of system settings. For tracings and images, both conventional and telemedicine findings showed 92% reliability, with a kappa coefficient of 0.87. CONCLUSIONS: On the basis of these observations and the methods used, reliability varied with the type of examination, clinician experience with telemedicine, and participant knowledge of system limitations. Clinicians without experience or knowledge of system limitations missed findings of clinical importance. Improvements in equipment since the clinics were conducted in 1994 may have resolved some of these problems. Our findings raise doubts about the reliability of occasional telemedicine consultations by clinicians inexperienced in the technology

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Abstract: Voice produced on inhaled air is a form of phonation that has received relatively little attention despite its apparent usefulness in the assessment of vocal function. This preliminary investigation was designed to describe the general characteristics of vocalization driven by an ingressive phonatory airflow. Vocal fundamental frequency (F0), electroglottographic (EGG), and airflow measures were examined in 16 normal men and women, who alternated between inspiratory and expiratory voice. Mean F0

routinely increased during inspiratory voice segments, shifting on average 5.1 semitones above the subjects' comfortable expiratory voice frequency. EGG data showed inspiratory voice to be associated with a more symmetrical pattern of vocal fold contact characterized by a prolonged interval of increasing contact. Both short-term F0 variability (jitter) and EGG amplitude perturbation were significantly higher during inspiratory voice. Stroboscopic examination of four of the subjects showed caudal displacement of the larynx and lengthened vocal folds associated with inspiratory phonation. The absolute airflow rate was significantly greater for inspiratory phonation, on average 48.5% higher than during normal expiratory voice. It was also found that both inspiratory pulse and falsetto vibratory patterns could be produced by at least some of the subjects, indicating some control over the mode and frequency of vocal fold vibration when driven by an ingressive airflow

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Abstract: Breath sounds heard with a stethoscope over homologous sites of both lungs in healthy subjects are presumed to have similar characteristics. Passively transmitted sounds introduced at the mouth, however, are known to lateralise, with right-over-left dominance in power at the anterior upper chest. Both spontaneous breath sounds and passively transmitted sounds are studied in four healthy adults, using contact sensors at homologous sites on the anterior upper and posterior lower chest. At standardised air flow, breath sound intensity shows a right- over-left dominance at the anterior upper chest, similar to passively transmitted sounds. At the posterior lung base, breath sounds are louder on the left, with a trend to similar lateralisation in transmitted sounds. It is likely that the observed asymmetries are related to the effects of cardiovascular structures and airway geometry on sound generation and transmission

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Abstract: Wheeze as an indicator of airway obstruction during bronchoprovocation lacks sensitivity. We therefore studied whether induced airway narrowing is revealed by changes in normal (vesicular) lung sounds. Fifteen subjects with asthma and nine healthy controls, aged 8-16 years, performed a standardized methacholine challenge. Respiratory sounds were recorded with eight contact sensors, placed posteriorly over the right and left superior and basal lower lobes, and anteriorly over both upper lobes, the right middle lobe, and the trachea. Average spectra of normal inspiratory and expiratory sounds, excluding wheeze, were characterized in 12 asthmatics and 9 controls at flows of 1 +/- 0.2 L/sec. Airway narrowing was accompanied by significant changes in lung sounds, but not in tracheal sounds. Lung sounds showed a decrease in power at low frequencies during inspiration and an increase in power at high frequencies during expiration. These changes already occurred at a decrease in forced expiratory volume in 1 sec of less than 10% from baseline and were fully reversed after inhalation of salbutamol. Thus, lung sounds were sensitive to changes in airway caliber, but were not specific indicators of bronchial hyperresponsiveness

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Abstract: Diaphragmatic phonomyogram (PMG) evoked by maximal bilateral phrenic nerve stimulation has previously been described as a good index of contractility of fresh and fatigued diaphragm. In the present study we hypothesized that diaphragmatic contractility changes could be even more simply evaluated by recording the relationship between the PMG and the compound motor action potential (CMAP) amplitudes during graded submaximal unilateral phrenic nerve stimulation at various intensities. Relationships between CMAPs and PMGs from left and right hemidiaphragms were recorded by means of surface electrodes and miniature microphones placed over the lower rib cage (eighth intercostal space) in five healthy subjects before and after a diaphragmatic fatigue task. These relationships in each subject were linear. The slope of these relationships decreased by 61.1 +/- 20.7% and by 70.4 +/- 14.6% on the right and left side respectively, but the intercepts did not change significantly. By comparison, transdiaphragmatic twitch pressure during maximal bilateral stimulation (PdiT) declined by 49.4 +/- 15%. We conclude that PMG during submaximal unilateral phrenic nerve stimulation is a reliable index of diaphragm contractility changes caused by fatigue. Using this method we have shown that all diaphragmatic motor units can be affected by fatigue

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Abstract: The appearance of wheezes and changes in inspiratory breath (vesicular) sound intensity (BSI) were monitored in patients undergoing routine methacholine challenge test (MCT). The results were compared with changes in spirometry and to airway hyper-responsiveness (AH). Fifty- four patients were examined. Spirometry was performed before and after the inhalation of cumulative doses of methacholine starting from 25 micrograms; a fall in forced expiratory volume in 1 s (FEV1) by 20% or more was considered as significant. Lung auscultation was performed by two observers simultaneously using a special stethoscope

placed sequentially over the posterior right and left upper (interscapular region, 5 cm from the fourth thoracic vertebra) and lower lung zones (5 cm below the scapulae). Symptoms were recorded by the patients on a visual analogue scale. In 27 patients, the MCT was positive (MCT+) and in 27 patients it was negative (MCT-). Wheezes were identified at PD20 in 12 MCT+ patients while reduced BSI alone was found in 11 patients; in four patients, auscultation was normal. In 20 MCT+ patients, either wheezes, diminished BSI or both were heard, one to several steps before reaching PD20. In the MCT- group, wheezes were detected in two patients and diminished BSI in four. In MCT+ patients, the mean (+/-SD) perception of symptoms at end-challenge was 33% (+/-26), whereas in MCT- patients, it was 13.6% (+/-22). Complete inter-observer agreement was found in 95.7% of auscultations performed (Kappa coefficient = 0.846). Coupled to spirometry, lung auscultation may prove useful in airway challenge testing provided the concept is accepted that wheeze appearance and, by extension, an acute decrease in BSI, is as legitimate a manifestation of AH as a fall in FEV1

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Abstract: The discordance between the objective and subjective symptoms of asthma has major effects on proper medication and management. In 2 studies the influence of respiratory sounds in the process of symptom perception underlying breathlessness was investigated in children aged 7-17 years. In Experiment 1, asthmatic wheezing sounds were recorded in 16 children during histamine-induced airway obstruction. Breathlessness correlated significantly with rank order of amount of wheezing, but not with lung function. In Experiment 2, after standardized physical exercise, 45 asthmatic and 45 nonasthmatic children were randomly assigned to (a) false feedback of wheezing, (b) quiet respiratory sounds, or (c) no sound. Asthmatic children reported significantly more breathlessness in the 1st versus the 3rd condition. In conclusion, many asthmatic children were easily influenced by wheezing in their estimation of asthma severity, reflected in breathlessness

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Abstract: The aims of this study are to assess nasal valve cross-sectional areas in healthy noses and in patients with nasal obstruction after rhinoplasty and to evaluate the effect of an external nasal dilator on both healthy and obstructive nasal valves. Subjects consisted of (i) volunteers with no nasal symptoms, nasal cavities unremarkable to rhinoscopy and normal nasal resistance and (ii) patients referred to our clinic complaining of postrhinoplasty nasal obstruction. All subjects were tested before and after topical decongestion of the nasal mucosa and with an external nasal dilator. In 79 untreated healthy nasal cavities the nasal valve area showed two constrictions: the proximal constriction averaged 0.78 cm2 cross-section and was situated 1.18 cm from the nostril, the distal constriction averaged 0.70 cm2 cross-section at 2.86 cm from the nostril. Mucosal decongestion increased cross-sectional area of the distal constriction significantly ($p < 0.0001$) but not the proximal. External dilation increased cross- sectional area of both constrictions significantly ($p < 0.0001$). In 26 post-rhinoplasty obstructed nasal cavities, only a single constriction was detected, averaging 0.34 cm2 cross-section at 2.55 cm from the nostril and 0.4 cm2 at 2.46 cm from the nostril, before and after mucosal decongestion respectively. External dilation increased the minimum cross-sectional area to 0.64 cm2 in these nasal cavities ($p < 0.0001$). We conclude that the nasal valve area in patients with postrhinoplasty nasal obstruction is significantly smaller than in healthy nasal cavities as shown by acoustic rhinometry. Acoustic rhinometry objectively determines the structural and mucovascular components of the nasal valve area and external dilation is an effective therapeutical approach in the management of nasal valve obstruction

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Abstract: Geometric changes of the nasal airway in response to allergen challenge were measured by acoustic rhinometry (AR) and the sensitivity of the method was compared with that of rhinomanometry. Ten asymptomatic patients who suffered from ragweed allergic rhinitis were challenged out of season. The use of a custom-made noninvasive nasal adapter was an important feature of the measurement technique. A dose-dependent decrease in nasal cross-sectional area was found at and posterior to the entrance to the nasal valve. Both rhinometric and rhinomanometric methods were equivalent in sensing the changes in nasal patency due to allergen exposure ($p = 0.73$). Acoustic rhinometry, however, was simpler, more quickly performed and more comfortable for the subjects than was rhinomanometry by body plethysmography. AR is an alternative objective method for measurement of nasal mucosal responses, as in allergen challenge

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Abstract: The relationship between a new operational definition of sleep sounds and apnea was examined in a population of 69

patients referred for overnight evaluations in a sleep disorders center. The sample contained 18 women (mean age 53.6 years) and 51 men (mean age 48.4 years). Subjects underwent polysomnography (PSG) with concurrent graphical recording of sleep sound intensities throughout the night. An acoustical signature event (ASE) was defined as a loud sound preceded by at least 10 but no more than 90 seconds of silence. Multiple regression was performed using known correlates of apnea and ASE to predict PSG levels of respiratory disturbance. Of the commonly known correlates, only self-reported estimate of snoring and apnea severity explained significant variance to the respiratory disturbance index (RDI; $R2 = 0.24$, $p < 0.0001$). ASE was entered into the equation as the last step, significantly improving explained variance ($R2delta = 0.54$, $p < 0.0001$). The final equation R2 was 78% ($p < 0.0001$). An alternative analysis compared ASE findings to polysomnographic findings in each matched 30-second interval (60,231 observations) in an analysis of receiver's operating characteristics. This analysis resulted in $d' = 2.67$, indicating acceptable accuracy for screening

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Abstract: The objective registration of the human body functions is one of the main tasks of the modern and prospective medicine. The registration of the heart, brain, muscles etc. activity have a long tradition. The registration of sound processes, for instance coughing was not solved completely despite their diagnostic importance. The authors worked out a new non invasive and precise method for cough sound registration and analysis which allows evaluation of the sound pattern, intensity and time duration. Application of this method for registration and analysis of the cry of new-borns gave rise to doubts about its suitability for an assessment of other sounds related to respiratory organs, except that of a cough. We registered and analysed the sound samples from Hirschberg's and Szende's (1982) sound archive for the purpose of the evaluation of the acceptability of the described method. The sound phenomena (109 samples of coughing, crying, barking and breathing) we transcribed from a record on a tape. The recorded signal was converted by A/D converter and analysed by computer by means of our own application programme. The sound and its pattern was transformed into a graphical record. This examination was completed by a sound frequency analysis based on the fast Fourier transformation with help of a computer likewise with our own application programme. It was found out that the used method reflected well the quantitative an qualitative differences of the evaluated sound samples. The graphical records reliably expressed the acoustic sound timbre as it shows the records of dog's and seelion's barking, cough, cry and cackling stridor of new-borns. The histographic curves which expressed the sound pattern showed a principally similar course. The intensity of sound examples was different. The sound samples duration were very often longer as the measurable time extent of software (0-819.2 ms) and therefore its evaluation was omitted. The repeated evaluation of the same sound phenomenon gave equal values. The spectrographic analysis confirmed the differences in sound samples. The values of the evaluated cough and cry sounds do not differ principally from the values registered in the previous author's observations. The results proved that the described method of cough sound registration and analysis was suitable for evaluation of different sound phenomena related to respiratory organs. (Fig. 3, Ref. 14.)

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Abstract: The objective registration of the human body functions is one of the main tasks of the modern and prospective medicine. The registration of the heart, brain, muscles etc. activity have a long tradition. The registration of sound processes, for instance coughing was not solved completely despite their diagnostic importance. The authors worked out a new non invasive and precise method for cough sound registration and analysis which allows evaluation of the sound pattern, intensity and time duration. Application of this method for registration and analysis of the cry of new-borns gave rise to doubts about its suitability for an assessment of other sounds related to respiratory organs, except that of a cough. We registered and analysed the sound samples from Hirschberg's and Szende's (1982) sound archive for the purpose of the evaluation of the acceptability of the described method. The sound phenomena (109 samples of coughing, crying, barking and breathing) we transcribed from a record on a tape. The recorded signal was converted by A/D converter and analysed by computer by means of our own application programme. The sound and its pattern was transformed into a graphical record. This examination was completed by a sound frequency analysis based on the fast Fourier transformation with help of a computer likewise with our own application programme. It was found out that the used method reflected well the quantitative an qualitative differences of the evaluated sound samples. The graphical records reliably expressed the acoustic sound timbre as it shows the records of dog's and seelion's barking, cough, cry and cackling stridor of new-borns. The histographic curves which expressed the sound pattern showed a principally similar course. The intensity of sound examples was different. The sound samples duration were very often longer as the measurable time extent of software (0-819.2 ms) and therefore its evaluation was omitted. The repeated evaluation of the same sound phenomenon gave equal values. The spectrographic analysis confirmed the differences in sound samples. The values of the evaluated cough and cry sounds do not differ principally from the values registered in the previous author's observations. The results proved that the described method of cough sound registration and analysis was suitable for evaluation of different sound phenomena related to respiratory organs. (Fig. 3, Ref. 14.)

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Abstract: We investigated the role of changes in pulmonary function in posturally induced crackles (PIC) in 76 patients with various heart diseases. Regional ventilation was evaluated by spirometric gated ventilation scanning using 133Xe in 23 of these patients and its relationship to PIC was analyzed. A change from the sitting to the supine position was associated with a significant decrease in the percent functional residual capacity (FRC, $p < 0.01$) and significant increases in closing volume (CV), CV/vital capacity (VC) and closing capacity (CC)/FRC ($p < 0.01$) in the PIC-positive subjects. CV, CV/VC and CC/FRC did not differ significantly between PIC-positive ($n = 37$) and PIC-negative ($n = 39$) subjects in the sitting position, but in the supine position, these values were significantly higher in the PIC-positive group than in the PIC-negative group (CV: $p < 0.05$, CV/VC and CC/FRC: $p < 0.01$). These results suggest that airway closure was markedly increased in PIC- positive subjects in the supine position compared with PIC-negative subjects. Regional ventilation (V) was assessed in the sitting and the supine position from right lateral images divided into 9 segments from the base to the apex of the lung using spirometric gated ventilation scanning. There was no significant difference in regional ventilation in the sitting position between PIC-negative ($n = 11$) and PIC-positive ($n = 12$) subjects; in the supine position, regional ventilation decreased significantly at the base in the PIC-positive group. Findings suggest that PIC at the base of the lungs may be related to airway closure at the base of the lungs in the supine position in PIC-positive subjects

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Abstract: In the past 15 yrs, a number of investigators have applied spectral analysis to respiratory sounds recorded from the chest wall or the trachea in order to objectively characterize them and to relate them with different pulmonary diseases. In the present study, we have applied multivariate linear discriminant analysis to the spectral features of respiratory sounds. Lung sounds and the airflow velocity were recorded from 15 normal adults and 37 patients falling into three different disease categories: chronic obstructive lung disease, bronchial asthma and bronchiectasis. All patients had prominent adventitious lung sounds (i.e. either wheezes or crackles). Amplitude spectra of five selected inspiratory and expiratory sound segments of each subject were calculated using the Fast Fourier Transform algorithm. Multi-variate linear discriminant analysis was then applied to the normalized and averaged spectral area values calculated for 10 unequal and arbitrarily selected frequency bands for each patient in the frequency range between 80 Hz and 1 kHz. Inspiratory and expiratory sounds were treated separately. Discriminant functions were computed from the spectral area values and plotted on graphs to classify the subjects into one of the disease categories or as normal (training set). While some separation was achieved among the different disease groups, a clearer separation was evident between normals and patients as a whole on the basis both of inspiratory and expiratory sounds. Inspiratory and expiratory sound frequency bands having the largest weights in classification were determined. Admittedly, the specific results of this study are preliminary or even tentative in view of the inadequacies of sound recording and signal conditioning techniques that were available to us at the time of recording. However, we believe that the investigation serves to illustrate the potential of multivariate discriminant analysis in the diagnostic classification of patients on the basis of their lung sound patterns. We suggest that this technique be considered by investigators involved in lung sound research, because it also allows other patient variables to be combined with the selected parameters of lung sounds

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Abstract: In the processing and analysis of respiratory sounds, heart sounds present the main source of interference. This paper is concerned with the problem of cancellation of the heart sounds using a reduced-order Kalman filter (ROKF). To facilitate the estimation of the respiratory sounds, an autoregressive (AR) model is fitted to heart signal information present in the segments of the acquired signal which are free of respiratory sounds. The state-space equations necessary for the ROKF are then established considering the respiratory sound as a colored additive process in the observation equation. This scheme does not require a time alignment procedure as with the adaptive filtering-based schemes. The scheme is applied to several synthesized signals with different signal-to-interference ratios (SIR) and the results are presented

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Abstract: A device that determines cross-sectional area (CSA) of the airway by acoustic reflections (Hood, Inc) was used to measure subglottic area. Airway models were made from Plexiglas rings with known internal dimensions similar to clinically encountered stenoses of various lengths and diameters. Acoustic measurements of airway area were made and compared to actual CSA. There is a strong correlation between CSA measured acoustically and the actual area of simulated stenoses. However, when the CSA of the stenosis was < 0.64 cm2, the signal was impaired, resulting in overestimation of the stenotic CSA. In simulated stenoses with a CSA of < 0.38 cm2, acoustic measurement of the CSA beyond the stenotic segment was unreliable. Determination of the origin of stenosis was accurate with this method. The CSA of cadaver airways was also measured acoustically. The CSA 2.0 cm below the glottis of normal airways in males ranged from 1.28 to 2.74 cm2 and in females 0.87 to 1.43 cm2, with means of 2.16 and 1.09 cm2. It appears that acoustic measurement of CSA of subglottic stenosis is a feasible clinical technique that yields dimensions of the airway in situations in which direct measurements are impossible. It was suggested that this technique be used for assessment of subglottic stenosis and evaluation of the efficacy of treatment of subglottic stenosis

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Abstract: Snoring was described in literature even before medicine. Common definitions do not consider acoustic measurements of snoring. In this paper we discuss the main pathophysiological aspects of snoring and the snoring-sleep relationship as the generating mechanisms. Snoring can be analysed and measured by the following methods: 1) Leq-Equivalent Continuous Sound Level, which only quantifies noisiness, annoyance, and damage to the partner's and snorer's hearing; 2) Power Spectrum, with frequency values, formantic structure data and typical shape, which can help to distinguish simple snoring from heavy snoring with obstructive sleep apnoea syndrome (OSAS); 3) Linear Prediction Code (LPC) method, which can define the cross-sectional area (CSA) of the upper airways and which locates sites of obstruction. Simulated snoring analysis with LPC and with simultaneous fluoroscopy permits the definition of CSA and the identification of three snoring patterns: nasal, oral and oronasal. Snoring is an important sign of sleep-related breathing disorders (SRBD), of the upper airway resistance syndrome (UARS), and of the OSAS. Snoring is a symptom of nasal obstruction and is associated with cardiovascular diseases and nocturnal asthma as a trigger or causative factor; however, its acoustic features in these disorders are not well- defined. Home monitoring of snoring is very useful for epidemiology and is mandatory, together with heart rate and arterial oxygen saturation (Sa,O2), to screen SRBD

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Abstract: To determine whether acoustic reflection measurement of the upper airway can be used to identify tracheas that are difficult to intubate, we conducted a pilot study of adults with a documented history of unexpected failed endotracheal intubation (16 cases) and compared them with 16 controls with previous successful intubation. The two groups were matched by age, sex, height, and weight. Acoustic reflection measurements of airway cross-sectional area versus distance were made at six combinations of body (upright and supine) and neck (flexed, neutral, and extended) positions. Cumulative airway volumes were calculated from the incisors to the glottis, and these were subdivided into oral and pharyngeal volumes. For supine position with the neck extended, all patients who had been successfully intubated had pharyngeal volumes more than 43.4 mL (mean +/- SD, 56.9 +/- 8.3 mL), whereas pharyngeal volumes were less than 37.5 mL in all patients who had a history of unexpected failed intubation (mean +/- SD, 19.7 +/- 10.2 mL; P < 0.05). Using a cutoff of 40.2 mL, acoustic reflection enabled us to distinguish between patients with previous unexpected failed endotracheal intubation and those with previous successful intubation

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Abstract: Snoring, a symptom which may indicate the presence of the obstructive sleep apnoea syndrome (OSA), is also common in the general population. Recent studies have suggested that the acoustic characteristics of snoring sound may differ between simple snorers and OSA patients. We have studied a small number of patients with simple snoring and OSA, analysing the acoustic characteristics of the snoring sound. Seventeen male patients, 10 with OSA (apnoea/hypopnoea index (AHI) 26.2 events x h(-1)) and seven simple snorers (AHI 3.8 events x h(-1)), were studied. Full night polysomnography was performed and the snoring sound power spectrum was analysed. Spectral analysis of snoring sound showed the existence of two different patterns. The first pattern was characterized by the presence of a fundamental frequency and several harmonics. The second pattern was characterized by a low frequency peak with the sound energy scattered on a narrower band of frequencies, but without clearly identified harmonics. The seven simple snorers and two of the 10 patients with OSA (AIH 13 and 14 events x h(-1), respectively) showed the first pattern. The rest of the OSA patients showed the second pattern. The peak frequency of snoring was significantly lower in OSA patients, with all but one OSA patient and only one simple snorer showing a peak frequency below 150 Hz. A significant negative correlation was found between AHI and peak and mean frequencies of the snoring power spectrum ($p<0.0016$ and $p<0.0089$, respectively). In conclusion, this study demonstrates significant differences in the sound power spectrum of snoring sound between subjects with simple snoring and obstructive sleep apnoea patients

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Abstract: Even though it is well known that breath-sound amplitude (BSA) increases with airflow, the exact quantitative relationships and their distribution within the relevant frequency range have not yet been determined. To evaluate these relationships, the spectral content of tracheal and chest wall breath sounds was measured during breath hold, inspiration, and expiration in six normal men. Average spectra were measured at six flow rates from 0.5 to 3.0 l/s. The areas under the spectral curves of the breath sounds minus the corresponding areas under the breath-hold spectra (BSA) were found to have power relationships with flow (F), best modeled as BSA = k.F alpha, where k and alpha are constants. The overall mean +/- SD value of the power (alpha) was 1.66 +/- 0.35, significantly less than the previously reported second power. Isoflow inspiratory chest wall sound amplitudes were 1.99 +/- 0.70- to 2.43 +/- 0.65-fold larger than the amplitudes of the corresponding expiratory sounds, whereas tracheal sound amplitudes were not dependent on respiratory phase. Isoflow breath sounds from the left posterior base were 32% louder than those from the right lung base ($P < 0.01$). BSA-F relationships were not frequency dependent during expiration but were significantly stronger in higher than in lower frequencies during inspiration over both posterior bases. These data are compatible with sound generation by turbulent flow in a bifurcating network with 1) flow separation, 2) downstream movement of eddies, and 3) collision of fast-moving cores of the inflowing air with carinas, all occurring during inspiration but not during expiration

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Abstract: Objective measures of upper respiratory function are needed to understand the effects of inhaled toxicants on the nasal passages. Acoustic rhinometry (AR) is a simple new technique that determines nasal volume by measuring the cross-sectional area of the upper airway as a function of the distance along the nasal passage. This study compares acoustic rhinometry with the more traditional posterior rhinomanometry (NAR) and correlates these objective measures with the symptom of nasal congestion. Healthy young adults (n = 29) were studied on 4 days, each separated by at least 1 wk, in a climate-controlled environmental chamber for 6 h, with exposure to clean air or sidestream tobacco smoke (SS) (2 h, 1, 5, and 15 ppm CO). The coefficient of variation for single measurements was 8-15% (AR) and 4% (NAR); for across-day measurements it was 15-25% (AR) and 13-15% (NAR); and for between days it was 19-27% AR and 17-21% (NAR). These coefficients were similar in subjects with a history of environmental tobacco smoke sensitivity (ETS-S) and those with no history of ETS sensitivity (ETS- NS). At baseline, the perception of unilateral nasal congestion was significantly correlated with unilateral nasal dimensions or nasal resistance; the symptom of baseline bilateral nasal congestion (estimated for both nasal passages simultaneously) correlated less well with objective measures of nasal patency. Under challenge conditions (SS at 1-15 ppm CO), there were typically significant correlations between changes in unilateral congestion and both unilateral rhinomanometry and acoustic rhinometry, but correlations of bilateral congestion and measurable dimensions were much lower. ETS-S and ETS-NS subjects differed in correlations between bilateral subjective and objective measures: ETS-S subjects showed significant correlation between baseline congestion and NAR; in contrast, ETS-NS subjects showed significant correlation between baseline congestion and acoustic rhinometry. These results indicate that NAR and AR are complementary tests for use in inhalation challenge studies and have different correlations with nasal congestion under baseline and challenge conditions

503. Korpas, J., J. Sadlonova, and M. Vrabec. 1996. Analysis of the cough sound: an overview. *Pulm.Pharmacol.* 9:261-268.
Abstract: Coughing is presented by a sudden air expulsion from the airways which is characterized by a typical sound. This sound is so characteristic that it allows identification of the cough and its distinction from other vocal manifestations. The cough sound is a very important symptom of well over 100 diseases and other conditions of medical significance. Changes in its character may have

a considerable value in identifying the mechanisms of airway pathology present in respiratory diseases. The cough sound gives information about the pathophysiological mechanisms of coughing by indicating the structural nature of the tissue during therapy that leads to certain patterns of cough. Similarly the character of the cough sound gives information about the behaviour of the glottis and whether the glottis behaves differently in different pathological conditions. Analysis of the cough sound record has significant value in prognosis because its changes may indicate the effectiveness of therapy or the progress of disease. Despite recent progress in cough sound research the attention paid to this interesting physiological and clinical problem is still not sufficient to solve completely various open questions, including our correct knowledge of the mechanism of creation of cough sounds

504. Lee, H., A. Arroyo, and W. Rosenfeld. 1996. Parents' evaluations of wheezing in their children with asthma. *Chest* 109:91-93.
Abstract: OBJECTIVE: Wheezing is a widely used physical sign of asthma that physicians assess in evaluation of their asthmatic patients. It may be possible to teach the parents to recognize it and to assess its severity so as to help them make better informed judgment in monitoring their children with asthma. STUDY DESIGN: Parents were taught to recognize wheezing by placing their ear over the chest and in front of the open mouth of their child. One session lasting a few minutes was sufficient for teaching. Subsequently, the parent and a physician evaluated the child independently for the presence and the severity of wheezing categorized as easily, barely, and none detected, and results were compared. Severity of wheezing was also compared with peak expiratory flow rate (PEFR) whenever possible. RESULTS: Six hundred thirty-six observations were made in 89 parent-child pairs. Wheezing was detected by the physician in 64% of examinations and by the parents in 56% ($p < 0.001$ by chi 2). When the physician heard the wheezing easily on 240 occasions, the parents also heard it in 99%. When the physician heard the wheezing barely on 170 occasions, the parents heard it only on 68% of the time. Mean PEFR was 55% predicted when the parents heard the wheezing easily, 75% when heard barely, and 93% when not heard (the difference is significant, $p < 0.001$ by analysis of variance). CONCLUSIONS: Parents can be taught to detect wheezing in their child with considerable accuracy when it is easily detectable to a physician. Such skills should be helpful to the parents in monitoring their child with asthma and in deciding when to increase medications and when to seek emergency care

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506. Lenclud, C., G. Cuttitta, D. Van Gansbeke, A. Visconti, A. Van Muylem, V. Bellia, and J. C. Yernault. 1996. Evaluation of nocturnal bronchoconstriction by all night tracheal sound monitoring. *Thorax* 51:694-698.
Abstract: BACKGROUND: A study was undertaken to evaluate the reliability of a digital tracheal sound analyser (ELENS-DSA) in predicting nocturnal changes in airways resistance in asthmatic patients. This device allows continuous measurement of the proportion of the time occupied by wheezing (Wh%). METHODS: Nocturnal polygraphic studies with simultaneous continuous monitoring of tracheal sounds and airways resistance were performed in seven patients with nocturnal asthma. In order to evaluate the possible bias in wheezing estimation, each tracheal sound recording was passed through the automatic analyser and simultaneously monitored with earphones by an experienced observer. RESULTS: The device detected audible wheezing with an optimal sensitivity and specificity of 70%. Snoring was a minor cause of the relatively poor characteristics of the system. A close correlation ($p < 0.001$) between Wh% and airways resistance was observed only in those patients with the highest increase in resistance; when the results of all the subjects were pooled the correlation observed was poor. The predictive value of Wh% in detecting changes in airways resistance during 10 minute intervals was lower than 70%. The positive and negative predictive values of Wh% were raised to 79% and 83%, respectively, for 30 minute intervals. CONCLUSIONS: The ELENS-DSA system is a relatively crude means of detecting wheezing and assessing bronchoconstriction quantitatively. However, it is able to detect accurately nocturnal bronchoconstriction for 30 minute intervals. This finding, along with the fact that the monitoring is non-invasive, suggests that it may be a promising tool, especially for patients during sleep

507. Lukin, A., S. Polic, Z. Rumboldt, J. Bagatin, D. Rakic, and A. Kuzmanic. 1996. [Comparison of auscultation findings using a classic stethoscope (Litmann 2120) and electronically amplified stethoscope (Medmax2)]. *Lijec.Vjesn.* 118:127-128.
Abstract: Heart auscultation has one of the key roles in beside diagnosis, especially in patients with cardiovascular diseases. Sometimes, because of the human cars' low sensitivity, a problem emerges in the proper evaluation of heart sounds and murmurs of lower frequencies. Our study compared two stethoscopes, the classic acoustic stethoscope (Littmann 2120) and an electronic one with the sound amplifier and the noise filtering system (Medmax2) in 10 patients examined by 10 physicians. Significantly better detection of low frequency sounds was found in favour of electronic stethoscope (chi 2 = 17.9; $p < 0.0001$). It is concluded that the selective amplificator improves the stethoscope performance and has its place in everyday bedside practice, especially in departments of cardiology

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509. Malmberg, L. P., K. Kallio, S. Haltsonen, T. Katila, and A. R. Sovijarvi. 1996. Classification of lung sounds in patients with asthma, emphysema, fibrosing alveolitis and healthy lungs by using self-organizing maps. *Clin.Physiol* 16:115-129.
Abstract: The performance of the self-organizing map (SOM), an artificial neural network, was evaluated in the classification of lung sounds. Patients with asthma (n = 8), emphysema (n = 8) and fibrosing alveolitis (n = 8), and patients with healthy lungs (n = 8) were selected for the study. Fast Fourier transform (FFT) spectra from midinspiratory breath sounds recorded at the right lower lobe area were used to construct feature vectors in the learning and classification process of SOM. The sound segments did not contain wheezing sounds. The lung sounds of 25/32 (78%) patients were classified correctly, with an overall kappa (kappa) value of 0.71. The agreement between the clinical and proposed diagnoses based on classification of lung sounds was good among patients with emphysema (kappa = 0.92) and those with healthy lungs (kappa = 0.83), but only moderate among patients with asthma (kappa = 0.52) and fibrosing alveolitis (kappa = 0.54). This is due to the limitations in distinguishing breath sounds of asthmatics without wheezing sounds from those with crackles in fibrosing alveolitis by the spectral pattern alone. The results indicate that SOM based on FFT spectra is potentially useful in the classification of lung sounds, e.g. in health screening or in differential diagnosis of pulmonary disorders. To enhance the performance of SOM, other features of lung sounds should be combined with FFT spectra

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Abstract: Stridor in neonates and infants is a symptom that indicates partial obstruction of the large diameter airways. Its presence should prompt a thorough examination and workup. Steps in evaluating stridor include a careful history and physical examination and rapid assessment of the severity of the clinical situation. Infants with respiratory distress and severe stridor should be safely and urgently transported to a tertiary care center, and colleagues from the departments of otolaryngology and anesthesia-critical care should be alerted. An essential component of the physical examination is auscultation. The phase of respiration in which the stridor is heard best provides important clues to help localize its cause. Radiographs, including plain films, dynamic fluoroscopic airway films, contrast esophagography, CT, and MR imaging are useful in specific clinical situations, based on the likely differential diagnosis. The anatomic causes for stridor in infants and neonates are vast. Successful management depends on expert consultation, proper equipment, and a staff that is experienced in the management of pediatric airway problems. The trend over the past decade has been to significantly decrease morbidity and mortality and also to decrease the number of tracheotomies necessary to stabilize pediatric airways. The best treatment outcomes result when there is good cooperation and communication among pediatricians, otolaryngologists, pulmonologists, and anesthesiologists

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513. McCarthy, P. L. 1996. The pediatric clinical evaluation and pneumonia. *Curr.Opin.Pediatr.* 8:427-429.
Abstract: Pneumonia is a common serious illness in children with acute episodes of fever and in children with more prolonged episodes of fever, termed fevers of unknown origin. Recent studies have demonstrated that the clinical evaluation, including observation, history, and the physical examination, is highly sensitive in identifying children with acute episodes of fever who have pneumonia. The sensitivity of the clinical evaluation for pneumonia has been demonstrated for febrile infants younger than 90 days of age as well as older children. In children with fever of unknown origin, the chest roentgenogram is considered part of the diagnostic evaluation, but further research may define specific indications for its use based on observation, history, and physical examination

514. Mishima, M., Z. Balassy, and J. H. Bates. 1996. Assessment of local lung impedance by the alveolar capsule oscillator in dogs: a model analysis. *J.Appl.Physiol* 80:1165-1172.
Abstract: The alveolar capsule oscillator technique has shown that the response of the lung periphery to intravenous histamine injection in dogs is extremely inhomogeneous both in terms of local peripheral airway resistance (RA) and local peripheral elastance (EA) (M. Mishima, Z Balassy, and J. H. T. Bates. J. Appl. Physiol. 77: 2140-2148, 1994). To assess the physical extent of the local lung region identified by this technique, we performed computer simulations using an asymmetrical branching model of the canine lung proposed by K. Horsfield, W. Kemp, and S. Philips (J. Appl. Physiol. 52: 21-26, 1982). The acoustic impedance of the model from 26 to 200 Hz as seen from the alveolar capsule oscillator was calculated. RA and EA were estimated from the simulated acoustic impedance between 26 and 200 Hz and were found to be 492 hPa.s.l-1 and 156,300 hPa/l, respectively. These values are similar to those found experimentally in previous studies. By simulating data using the model in various stages of completeness, we determined that approximately 50% of RA is determined by the acinus to which the alveolar capsule is attached, whereas the remainder is determined by airways < or = 1 mm diameter that converge on this acinus. By contrast, EA was determined almost entirely (95%) by the acinus directly under the capsule. Inhomogeneous peripheral airway constriction altered

RA severalfold but did not affect EA by >5%. This suggests that the previously observed changes induced in EA by bronchial challenge reflect real changes in intrinsic tissue elastance rather than merely regional mechanical inhomogeneities

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516. Nakano, H., Y. Ohnishi, J. Maekawa, Y. Ishii, T. Nakamura, K. Matsuzawa, and N. Narita. 1996. [Automated analysis of all-night records of tracheal sound to detect sleep disordered breathing]. *Nihon Kyobu Shikkan Gakkai Zasshi* 34:765-770.
Abstract: In sleep-disordered breathing, tracheal sounds disappear during apnea and vary cyclicly during hypopnea. We tried to detect these changes in tracheal sounds automatically with a personal computer, and we evaluated the diagnostic accuracy of this system for detecting sleep- disordered breathing. Polysomnography and tracheal sound recording were done in 33 subjects with possible sleep apnea/hypopnea syndrome. Eighteen had positive results defined as an apnea/hypopnea index greater than 15. Tracheal sounds were digitized and a personal computer was used to calculate short time power spectra (44-600 Hz) every 0.2 seconds by the fast Fourier transform. The moving averages (18 seconds) of the logarithms of the power spectra were calculated every 2 seconds. Transient falls in the moving averages of more than 12 dB were detected. Those that were lower than 5 dB above the level of background noise were classified as tracheal sound apneas. The number of falls of more than 12 dB and the number of tracheal sound apneas correlated strongly with the number of apneas plus hypopneas (r = 0.95) and with the number of apneas (r = 0.97), respectively. The sensitivity and specificity of tracheal sound analysis for the sleep apnea/hypopnea syndrome (as defined above) were 89% and 60%, respectively, when the criteria was more than 15 falls of more than 12 dB per hour. We conclude that tracheal sound analysis by this method is useful as a screening test for the sleep apnea/hypopnea syndrome

517. Nielsen, L. P., T. Bjerke, M. B. Christensen, B. Pedersen, T. R. Rasmussen, and R. Dahl. 1996. Assessment of the allergic reaction in seasonal rhinitis: acoustic rhinometry is a sensitive and objective method. *Clin.Exp.Allergy* 26:1268-1275.
Abstract: BACKGROUND: Seasonal allergic rhinitis constitutes an excellent in vivo model of an allergic mucosal inflammatory reaction. This offers the opportunity of studying the fundamentals of allergic inflammation in addition to improvement of knowledge on the basal pathophysiological mechanisms of the disease. So far, monitoring methods of disease activity and treatment efficacy have mainly been based upon subjective assessments, illustrating the impact of introducing reliable objective methods. OBJECTIVE: To investigate the allergic inflammatory reaction of seasonal rhinitis through different objective methods and evaluate these as indicators of disease activity and treatment efficacy. METHODS: Functional parameters, i.e. acoustic rhinometry and nasal metacholine challenge, and biological markers, i.e. blood eosinophil count, eosinophil cationic protein in serum (s-ECP) and nasal lavage fluid (n-ECP), were assessed before and at peak pollen season in 27 patients with grass pollen induced rhinitis. Patients were randomized to either nasal corticosteroid or placebo treatment and recorded nasal symptom scores. RESULTS: Acoustic rhinometry revealed a significant difference in favour of steroid treatment ($P < 0.05$) comparing nasal volumes before and during season. This difference primarily relied upon a decrease in the placebo group ($P = 0.05$). A reduction from baseline of s-ECP in the steroid group ($P < 0.01$) was obtained. N-ECP demonstrated a difference between treatment groups, although not significant. Symptom scores increased in all patients during the pollen season, although this was only significant in the placebo treated patients ($P < 0.01$). The remaining methods applied did not demonstrate further differences, either within or between treatment groups. CONCLUSION: Our results demonstrate acoustic rhinometry to be a sensitive and objective method of assessment of nasal obstruction. Furthermore, acoustic rhinometry and s-ECP reflect the impact of nasal steroid therapy on seasonal allergic rhinitis

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Abstract: An alveolar capsule oscillation technique was used to determine 1) the lobe pressure and volume at which airways close and reopen, 2) the effect of expiration rate on closing volume and pressure, 3) the phase in the breathing cycle at which airway closure occurs, and 4) the site of airway closure. Experiments were conducted in excised dog lobes; closure was detected by an abrupt increase in the input impedance of surfacemounted alveolar capsules. Mean transpulmonary pressure (Ptp) at closure was slightly less than zero (Ptp = -2.3 cmH2O); the corresponding mean reopening pressure was Ptp = 14 cmH2O. The expiration rate varied between 1 and 20% of total lobe capacity per second and had no consistent effect on the closing volume and pressure. When lung volume was cycled up to frequencies of 0.2 Hz, closure generally occurred on expiration rather than inspiration. These observations support the conclusion that mechanical collapse, rather than meniscus formation, is the most likely mechanism producing airway closure in normal excised dog lungs. Analysis of measured acoustic impedances and reopening pressures suggests that closure occurs in the most peripheral airways. Reopening during inspiration was often observed to consist of a series of stepwise decreases in capsule impedance, indicating a sequence of opening events

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Abstract: Methodology to evaluate the efficacy of antitussive drugs rely largely on subjective methods and cough counts. There are

few studies in cough due to natural disease especially using objective techniques. This paper presents data from a series of randomized, double blind, placebo controlled clinical trials in cough due to both chronic bronchopulmonary disease and acute upper respiratory tract infections. In these studies, cough was quantified using a standardized and validated computerized system for the acquisition and multidimensional analysis of the cough sound. Key objective parameters like cough counts, intensity, latency and total effort expended were studied. Guaiphenesin and bromhexine showed significant expectorant effects in patients with productive cough due to chronic bronchopulmonary disease. Differences were observed in speed of action, and objective and subjective measures, that probably indicate differences in drug action. More recently, three studies evaluated the antitussive drug dextromethorphan in non-productive cough due to uncomplicated upper respiratory tract infections. Reproducible cough suppressant effects were demonstrated after a single 30 mg dose using objective measures of cough counts, latency and total effort. These results establish the sensitivity and robustness of the cough quantitation methodology in the objective evaluation of cough treatments

520. Pasterkamp, H. and I. Sanchez. 1996. Effect of gas density on respiratory sounds. *Am.J.Respir.Crit Care Med.* 153:1087-1092.
Abstract: The generation of normal lung sounds by turbulent air flow has been questioned because gas density appears to have only a minor effect. We studied whether gas density has a greater influence on lung sounds at higher frequencies than traditionally measured. Six healthy adult men breathed air followed by a mixture of 80% helium and 20% oxygen (He-O2) at a target flow of 1.5 L/s. Flow and sounds at the trachea and posterior right lower lobe were simultaneously acquired by computer. Fourier analysis was applied to sounds at target flow +/- 0.2 L/s. Average power spectra were computed for each recording site, respiratory phase, and respired gas. He-O2 reduced the power of inspiratory lung sounds below 300 Hz by only 1.7 +/- 1.5 dB whereas power between 300 and 600 Hz was reduced by 4.6 +/- 1.4 dB ($p<0.05$). Tracheal sound power was reduced less consistently but all subjects showed an upward frequency shift in power maxima on He-O2, similar to formant shifts observed in helium speech. Our findings suggest that flow turbulence is the major determinant of lung sounds at higher frequencies. Current instruments for auscultation and recording of respiratory sounds may have to be modified to optimize their response in this higher frequency range

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Abstract: To investigate the effect of age and body size on normal lung sounds, we studied 10 newborn infants within 3 d after birth, nine children between 6 to 8 yr, and 10 adults between 25 and 37 yr of age. Lung sounds were recorded with a contact transducer over the posterior right lower lobe, and air flow was measured at the mouth. Computer analysis provided average power spectra of lung sounds at flows of 15 ml/s/kg. In children and adults measurements were also made at flows of 30 ml/s/kg. Lung sounds were referenced to background noise, measured at zero air flow. The spectra in infants contained less power below 300 Hz compared with children and adults, resulting in significantly higher quartile and spectral edge frequencies. Resonances of the thoracic cavity may explain some of the differences among the study groups. Sound attenuation above 300 Hz was similar at all ages. At increased air flows, lung sounds in children and adults were above background noise at frequencies as high as 2,000 Hz. High-frequency expiratory lung sounds of low intensity were present in all children and in eight of 10 adults at increased flows. Normal lung sounds of low intensity are present above traditionally accepted frequency limits and warrant further investigation

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Abstract: BACKGROUND: The ability of awake subjects with obstructive sleep apnea (OSA) to dilate their pharynx during inspiration may be defective. Airflow through a relatively more narrow pharyngeal passage should lead to increased flow turbulence and hence to louder respiratory sounds. We therefore studied the increase of tracheal sound intensity (TSI) in the supine position as an indicator of abnormal pharyngeal dynamics in patients with documented OSA. SUBJECTS AND METHODS: Sound was recorded with a contact sensor at the suprasternal notch in 7 patients with OSA (age, 52 +/- 8 years; body mass index, 29.0 +/- 3; apnea-hypopnea index, 58 +/- 17; means +/- SD), and in 8 control subjects, including obese subjects and snorers (age, 39 +/- 8 years; body mass index, 28.6 +/- 4). Subjects breathed through a pneumotachograph and aimed at target flows of 1.5 to 2 L/s, first sitting, then supine. Flow and sound signals were digitized at a 10-KHz rate. Fourier analysis was applied to sounds within the target flow range and average power spectra were obtained. Spectral power was calculated for frequency bands 0.2 to 1, 1 to 2, and 2 to 3 KHz. RESULTS: In the supine position, OSA patients had a significantly greater increase of inspiratory TSI than control subjects: 7.5 +/- 1.2 dB vs 1.7 +/- 3.4 dB ($p < 0.001$); 6.6 +/- 1.7 dB vs 1.3 +/- 3.9 dB ($p < 0.005$); and 12.2 +/- 3.2 dB vs 5.6 +/- 3.1 dB ($p < 0.001$) at low, medium, and high frequencies, respectively. Expiratory TSI also increased in supine subjects, but the change was significantly greater in OSA subjects only at high frequencies. These findings confirm our earlier observations that did not include obese subjects or snorers among control subjects. SUMMARY: Measuring posture effects on tracheal sounds is noninvasive and requires little time and effort. The greater increase of inspiratory TSI in supine OSA patients compared to subjects without OSA suggests a potential value for daytime acoustic screening

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Abstract: Ten subjects known to suffer from heavy snoring but not obstructive sleep apnoea were studied using the technique of sleep nasendoscopy. The mechanism of snoring was noted for each and sound recordings of the snoring noise were made. Six subjects were observed to snore using their soft palate only, three snored using only their tongue base and one snored using a combination of palate and tongue base. The sound recordings were subjected to computer analysis of waveform and frequency. Palatal flutter snoring and tongue base snoring appear to have distinct waveform and frequency patterns which allows them to be differentiated from each other

524. Quinn, S. J., L. Huang, P. D. Ellis, and J. E. Williams. 1996. The differentiation of snoring mechanisms using sound analysis. *Clin Otolaryngol.Allied Sci.* 21:119-123.
Abstract: Ten subjects known to suffer from heavy snoring but not obstructive sleep apnoea were studied using the technique of sleep nasendoscopy. The mechanism of snoring was noted for each and sound recordings of the snoring noise were made. Six subjects were observed to snore using their soft palate only, three snored using only their tongue base and one snored using a combination of palate and tongue base. The sound recordings were subjected to computer analysis of waveform and frequency. Palatal flutter snoring and tongue base snoring appear to have distinct waveform and frequency patterns which allows them to be differentiated from each other

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Abstract: The diagnostic significance of wheezes for childhood asthma has not been studied systematically (to our knowledge), even though alternative diagnostic methods are limited, especially with children too young for lung function testing. To fill this gap, tracheal sounds were continuously recorded of 70 school-aged children with and 30 without asthma during standardized physical exercise. Wheezes were digitally analyzed and compared with sound patterns previously recorded after histamine inhalation. Exercise-induced wheezes proved to be indistinguishable from sound patterns associated with histamine. The diagnostic sensitivity and specificity of any wheeze for a fall in FEV1 greater than 20% after exercise were, respectively, 86% and 99%. The sensitivity and specificity of any wheeze for a diagnosis of asthma were, respectively, 19% and 100%. Wheezes were often audible for a short time only, making traditional (stethoscopic) detection unlikely and thereby restricting clinical diagnostic significance. This suggests that the development of automated detection techniques may be warranted

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Abstract: A method is proposed for the detection of transients in biological signals. The method is based on enhancing the transient-to-background ratio by a series of operations such as background whitening, wavelet- based multiresolution decomposition and application of Teager's energy operator. The transients are extracted by judiciously thresholding this processed signal. The proposed detector is applied to the discrimination of crackles in pathological respiratory sounds. It is shown that both the crackle detection performance and ability to extract the transient waveforms correctly are superior to existing detectors in the literature

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Abstract: We postulated that the distinct pathophysiologic mechanisms of airway narrowing during the early (EAR) and the late (LAR) asthmatic responses to inhaled allergens are reflected by the generation or transmission of lung sounds in asthma. Therefore, we measured FEV1 and recorded lung sounds in eight mildly asthmatic subjects before a standardized allergen challenge (PRE), during the EAR, during the recovery phase at 2 h (MID), during the LAR at 7 h, and after inhalation of a bronchodilator (POST). The recordings were made during flow- and volume-standardized quiet breathing, and during maximal forced breathing maneuvers. Airflow-dependent power spectra were analyzed for lung sound intensity (LSI), quartile power points (Q25, Q50, Q75), and extent of wheezing (W). These sound characteristics were compared among the various stages of the challenge in the presence (EAR, LAR) and absence (PRE, MID, POST) of acute airway obstruction using ANOVA. LSI, Q25 - Q75, and W were all elevated during airway obstruction. When matched for percent fall in FEV1, during the EAR and the LAR (mean +/- SD: 26.7 +/- 4.0, and 28.9 +/- 5.7, respectively; p = 0.385), the increase in Q25, and Q50 with airflow during quiet expiration, as well as the extent of wheezing, were higher during the LAR than during the EAR (p < or = 0.042 and p < or = 0.012, respectively). At similar levels of FEV1 (p > or = 0.156), LSI on expiration was higher at POST than at PRE or MID (p < or = 0.067), whereas Q25

(p < or = 0.047) and Q50 (p < or = 0.064) were lower at POST than at PRE. During forced expiration W was higher at MID and POST than at PRE (p < or = 0.014). We conclude that LSI, frequency content, and the extent of wheezing vary during the subsequent stages of allergen-induced bronchoconstriction in asthma despite matched values of FEV1. This suggests that airflow-standardized phonopneumography is a sensitive method for detecting differences in the pathophysiology of airway narrowing in asthma

529. Sipila, J., S. Nyberg-Simola, J. Suonpaa, and P. Laippala. 1996. Some fundamental studies on clinical measurement conditions in acoustic rhinometry. *Rhinology* 34:206-209.
Abstract: Acoustic rhinometry is a new method to measure the patency of the nasal airway. In this study the clinical measuring conditions were systematically evaluated. The test-retest validity was analysed by repeated measurements in ordinary, not specially trained patients and was found to be at the level of approximately 15%. The need for acclimatization before measurements was tested by making a series of measurements on two separate occasions: one after a rest period following the patient's arrival at the nose laboratory, and a second in another session where no rest was allowed for. Statistically, no significant differences between the repeated measurements in the two occasions were found. However, there was a tendency towards smaller nasal volumes in the measures of the repeated recordings made without an acclimatization period. Therefore, it seems to be advisable to have an acclimatization period before acoustic rhinometry measurements

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Abstract: Overnight polysomnography (PSG) has been used to diagnose and assess the severity of obstructive sleep apnoea syndrome (OSAS) in children. The aim of this study was to determine whether home video-recording of children during sleep may be used for screening OSAS. In 58 children suspected of having OSAS, PSG results were compared with the corresponding analyses of 30 min video-recordings of each child sleeping at home. The video-recordings were evaluated by: 1) overall investigator's clinical judgement; and 2) a scoring system based on noisy breathing, movements, walking episodes, apnoea, chest retractions and mouth breathing. PSG results were highly correlated with the video test results, with agreement in 49 out of 58 (84%). In 36 of the 58 children, the PSG was abnormal compared with 41 out of 58 abnormal video tests. The sensitivity of the overall investigator judgement of video test was 94% (34 out of 36) and the specificity 68% (15 out of 22). Video scores > 10 were highly predictive of OSAS, whilst scores < 5 were associated with normality. Using a stepwise logistic regression analysis, each of the scoring variables was tested against the PSG results and an equation was formulated for predicting PSG by the video test. The equation predicted PSG results in 49 out of 58 (84%) cases. Thirty minutes of home video-recordings during sleep is a reliable screening method for obstructive sleep apnoea syndrome in children. This technique may, thus, improve patient selection for polysomnography

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Abstract: Previous studies have indicated that disorders producing crackling lung sounds may be different in terms of the waveform of the crackles or their timing in a respiratory cycle. In this study, we evaluated whether two-dimensional discriminant analysis of crackles has a better ability to separate pulmonary disorders than does a single-dimensional analysis. Cracking sounds of patients with cryptogenic fibrosing alveolitis (n = 10), bronchiectasis (n = 10), COPD (n = 10), heart failure (n = 10) and acute pneumonia (n = 11) and of those recovering from pneumonia (n = 9) have been studied. Variables indicating the timing of crackles during inspiration (beginning and endpoint of crackling) and their waveform (initial deflection width (IDW), two cycle duration (2CD) and largest deflection width (LDW)), were used for the analysis. The discrimination properties of one- and two-dimensional analyses with these variables were compared. The two-dimensional distances between the patient groups were the largest by combining IDW and the end-point of crackling. Cryptogenic fibrosing alveolitis was distinguished from bronchiectasis, COPD, heart failure and acute pneumonia without overlap. The differences between the diseases were illustrated two-dimensionally with ellipses. The two-dimensional analysis resulted in better separation between the groups than the use of single characteristics alone. This type of analysis can enhance the diagnostic power of acoustic pulmonary studies. It is also an informative visual way to find differences among pulmonary disorders

532. Sovijarvi, A. R., L. P. Malmberg, E. Paajanen, P. Piirila, K. Kallio, and T. Katila. 1996. Averaged and time-gated spectral analysis of respiratory sounds. Repeatability of spectral parameters in healthy men and in patients with fibrosing alveolitis. *Chest* 109:1283-1290.
Abstract: STUDY OBJECTIVE: To obtain a basis for assessment of changes in breath sound spectra in patients with pulmonary diseases, short-term and day- to-day repeatability of spectral parameters was studied. DESIGN: Breath sounds were recorded simultaneously from the trachea and from the chest twice at an interval of 15 min (short-term repeatability) and of 1 to 3 days (day-to-day repeatability). During recordings, air flow at the mouth was controlled, the target inspiratory and expiratory peak flow being 1.25 L/s. Inspiratory and expiratory breath sound spectra were averaged over 7 to 10 successive respiratory cycles. The

repeatability of sound intensity (RMS), frequency of maximum intensity (Fmax), and median frequency (F50) was analyzed with analysis of variance. PARTICIPANTS: Short-term repeatability was studied in 10 healthy nonsmoking men (age 25 to 44 years), and day-to-day repeatability was studied in 10 healthy nonsmoking men (age 23 to 41 years) and in 12 patients with clinically stable fibrosing alveolitis (age 35 to 82 years). RESULTS: Short-term coefficient of variation (CoV) of Fmax and F50 was 2.6 to 6.7% when recorded from the chest, and 6.2 to 8.7% when recorded from the trachea. Day-to-day CoV of Fmax and F50 in healthy subjects was 4.7 to 8.5% and 5.0 to 8.7% recorded from the chest or from the trachea, respectively. Inspiratory day-to-day variation in those parameters was higher in patients with fibrosing alveolitis. CoV of RMS was high, ranging from 18 to 47% in different subject groups and sampling situations. CONCLUSIONS: Repeatability of F50 of averaged flow- controlled lung sound spectra is good both in healthy subjects and in patients with fibrosing alveolitis. Thus, F50 of respiratory sound spectra may be useful in monitoring of changes induced by respiratory diseases and interventions. These results emphasize the importance of standardization of recording conditions and of analyzing techniques

533. Spence, D. P., D. R. Graham, G. Jamieson, B. M. Cheetham, P. M. Calverley, and J. E. Earis. 1996. The relationship between wheezing and lung mechanics during methacholine-induced bronchoconstriction in asthmatic subjects. *Am.J.Respir.Crit Care Med.* 154:290-294.
Abstract: Wheeze is a classic sign of airflow obstruction but relatively little is known of its mechanism of production or its relationship to the development of airflow obstruction. We studied eight asthmatic subjects age (mean +/- 5D) 42 +/- 5 yr, FEV1 2.46 +/- 0.36 L during an extended, symptom-limited methacholine challenge test. Breath sounds were detected by a microphone over the right upper anterior chest. Spectral analysis was by a fast Fourier transform algorithm. Mean FEV1 fell by 51 +/- 14% to 1.28 +/- 0.61 L during the challenge and airways resistance increased by 119 +/- 50%. There were no consistent changes in breathing pattern or tidal volume during the challenge. Wheeze occurred late in the challenge at the highest concentration of methacholine administered and only after expiratory tidal flow limitation had been reached. Five subjects developed wheeze on tidal breathing, the remaining three only wheezed on deep breathing. Wheezing sounds were reproducible between breaths, coefficient of variation of starting sound frequency was 4.2% and ending frequency 12%. Mean frequency of expiratory wheezes was 669 +/- 100 Hz and inspiratory wheezes 710 +/- 76 Hz. Expiratory wheeze fell in pitch during a breath (mean fall in sound frequency 187 +/- 43 Hz) but inspiratory wheezes were more variable. Expiratory wheezes occurred late in the respiratory cycle at a mean of 58% of the maximal tidal expiratory flow, whereas inspiratory wheezes occurred around maximal tidal inspiratory flows, suggesting that the mechanisms of production of inspiratory and expiratory wheezes may be different. In this model, the presence of wheeze during tidal breathing was a sign of severe airflow limitation

534. Sprikkelman, A. B., M. H. Grol, M. S. Lourens, J. Gerritsen, H. S. Heymans, and W. M. van Aalderen. 1996. Use of tracheal auscultation for the assessment of bronchial responsiveness in asthmatic children. *Thorax* 51:317-319.
Abstract: BACKGROUND: It can be difficult to assess bronchial responsiveness in children because of their inability to perform spirometric tests reliably. In bronchial challenges lung sounds could be used to detect the required 20% fall in the forced expiratory volume in one second (FEV1). A study was undertaken to determine whether a change in lung sounds corresponded with a 20% fall in FEV1 after methacholine challenge, and whether the occurrence of wheeze was the most important change. METHODS: Fifteen children with asthma (eight boys) of mean age 10.8 years (range 8-15) were studied. All had normal chest auscultation before the methacholine challenge test. Lung sounds were recorded over the trachea for one minute and stored on tape. They were analysed directly and also scored blindly from the tape recording by a second investigator. Wheeze, cough, increase in respiratory rate, and prolonged expiration were assessed. RESULTS: The total cumulative methacholine dose causing a fall in FEV1 of 20% or more (PD20) was detected in 12 children by a change in lung sounds - in four by wheeze and in eight by cough, increased respiratory rate, and/or prolonged expiration. In two subjects altered lung sounds were detectable one dose step before PD20 was reached. In three cases in whom no fall in FEV1 occurred, no change in lung sounds could be detected at the highest methacholine dose. CONCLUSION: Changes in lung sounds correspond well with a 20% fall in FEV1 after methacholine challenge. Wheeze is an insensitive indicator for assessing bronchial responsiveness. Cough, increase in respiratory rate, and prolonged expiration occurs more frequently

535. Stewart, J. 1996. A measured breath: new techniques in pulmonary imaging and diagnosis. *CMAJ.* 154:847-850.
Abstract: The development by Dr. Hans Pasterkamp and his team at the University of Manitoba, Winnipeg, of computer software for acoustic imaging of the chest originated in the need for a noninvasive, nonthreatening way to obtain information about lung function and lung disease in infants and children. Pasterkamp's team is developing a single computer program with potential applications in three areas: the measurement of lung sounds in addition to lung function, the multiple-site mapping of chest sounds to help identify the site of disease, and the assessment of upper airways, with potential use in the diagnosis of obstructive sleep apnea. Computer-assisted acoustic imaging promises to augment and enhance more traditional methods of pulmonary testing

536. Subburaj, S., L. Parvez, and T. G. Rajagopalan. 1996. Methods of recording and analysing cough sounds. *Pulm.Pharmacol.* 9:269-279.

Abstract: Efforts have been directed to evolve a computerized system for acquisition and multi-dimensional analysis of the cough sound. The system consists of a PC-AT486 computer with an ADC board having 12 bit resolution. The audio cough sound is acquired using a sensitive miniature microphone at a sampling rate of 8 kHz in the computer and simultaneously recorded in real time using a digital audio tape recorder which also serves as a back up. Analysis of the cough sound is done in time and frequency domains using the digitized data which provide numerical values for key parameters like cough counts, bouts, their intensity and latency. In addition, the duration of each event and cough patterns provide a unique tool which allows objective evaluation of antitussive and expectorant drugs. Both on-line and off- line checks ensure error-free performance over long periods of time. The entire system has been evaluated for sensitivity, accuracy, precision and reliability. Successful use of this system in clinical studies has established what perhaps is the first integrated approach for the objective evaluation of cough

537. Walker, R. P., W. M. Gatti, N. Poirier, and J. S. Davis. 1996. Objective assessment of snoring before and after laser-assisted uvulopalatoplasty. *Laryngoscope* 106:1372-1377.
Abstract: Laser-assisted uvulopalatoplasty (LAUP) is an outpatient staged surgical procedure for the treatment of snoring. Each patient undergoes a series of procedures with the end point being patient and bed partner satisfaction in most cases. The purpose of this study was to objectively evaluate the frequency, pattern, and volume of snoring in patients prior to and following each LAUP procedure. A sonographic device, SNAP, which records oronasal respiration, was used to assess patients at home. A digital analysis of the frequency, pattern, and volume was then performed. Twenty-seven patients have been completely evaluated with this recording device. The findings demonstrate that the LAUP procedure alters the snoring sound. The maximum, average, and velum-like respiratory noise loudness all showed a statistically significant decrease when comparing the preoperative snoring to the final recording after treatment was completed. In addition, the fundamental frequency of the snoring increased significantly after each LAUP procedure. No change was seen in the snoring index following treatment. These objective results correlated well with the subjective responses of the patients and their bed partners. These findings are consistent with the hypothesis that the LAUP procedure alters snoring in a favorable manner by both objective data and subjective accounts

538. Wigder, H. N., D. R. Johnson, S. Cohan, R. Felde, and R. Colella. 1996. Assessment of lung auscultation by paramedics. *Ann.Emerg.Med.* 28:309-312.
Abstract: STUDY OBJECTIVE: To determine how accurately paramedics interpret common lung sounds on an audiotape in comparison with emergency physicians. METHODS: We carried out a prospective comparison of blinded lung sound interpretation using a standard teaching tape. Our subjects were 67 experienced paramedics and 22 new paramedics from urban and suburban emergency medical services systems comprising municipal and private ambulance providers; and 18 emergency physicians. Five common lung sounds were played three times, in different sequences, and with additional patient history provided for each repetition. The members of each group listened to the same tape and were asked to identify the lung sounds. RESULTS: Emergency physicians had a median score of five of five possible correct responses in each of the three trials. This score was significantly higher than those of experienced and new paramedics. Experienced paramedics (P = .001) and new paramedics (P = .002) significantly increased their median scores over the three trials with additional medical history. We found no significant difference between experienced and new paramedics in any of the three trials. CONCLUSION: In our study, paramedics did not assess lung sounds as accurately as emergency physicians, and experienced paramedics did not interpret sounds more accurately than new paramedics. Correct identification of lung sounds improved significantly for paramedics when medical history was known

539. Wilkins, R. L., J. E. Hodgkin, and B. Lopez. 1996. Lung sounds a practical guide, 2nd ed ed. Mosby, St. Louis, Mo.
Abstract: Describes how to identify and interpret lung sounds, and uses case examples to show how to apply the lung sounds to patient care plans

540. Zucconi, M., L. Ferini-Strambi, V. Castronovo, A. Oldani, and S. Smirne. 1996. An unattended device for sleep-related breathing disorders: validation study in suspected obstructive sleep apnoea syndrome. *Eur.Respir.J.* 9:1251-1256.
Abstract: Portable devices for the diagnosis of obstructive sleep apnoea (OSA) are considered to be an acceptable alternative to polysomnography (PSG), but their validation is essential. The aim of our study was to validate a device specifically designed for OSA diagnosis. Twenty nine suspected OSA patients were studied with simultaneous nocturnal PSG and an unattended recording device (MicroDigitrapper-S) (M-S). The device measured body position, snoring sound, oronasal flow, thoracic and abdominal effort, heart rate and percentage arterial oxygen saturation (Sa,O2%). We compared the apnoea plus hypopnoea index (AHI) and Sa,O2% results of PSG with that of the system's automatic analysis (M-SA). We also performed a semiautomatic analysis (M-SS) with visual editing of the raw data. Results at different AHI cut-off levels were analysed to obtain an indication of accuracy in diagnosis and severity. Both M-SA and M-SS showed a sensitivity and specificity of 100% at the cut-off level of AHI > 10. When increasing the cut-off levels, M-SA sensitivity decreased (55% for AHI > 40), while specificity remained high (95%). This was improved to a clinically acceptable level of agreement by M-SS analysis (sensitivity 91% and specificity 94%). In conclusion, the MicroDigitrapper-S device showed a good sensitivity and specificity for the diagnosis of OSA. However, the device could not

predict the severity of OSA precisely enough. In severe cases (apnoea plus hypopnoea index > 40), semi-automatic scoring was necessary to obtain a more accurate detection of the severity of the disease

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Abstract: Methacholine and adenosine 5'-monophosphate bronchial challenges were performed in 54 young children--39 with asthma and 15 with other chronic airway diseases (CADs), with the use of the auscultative method. Children with asthma were sensitive to both methacholine and adenosine; children with CAD responded only to methacholine. We conclude that bronchial challenge with adenosine can help differentiate asthma from CAD in young children

542. Beck, R., M. Odeh, A. Oliven, and N. Gavriely. 1995. The acoustic properties of snores. *Eur.Respir.J.* 8:2120-2128.
Abstract: This study was undertaken in an attempt to characterize the acoustic properties of snoring sounds in the time and frequency domains, and to correlate between these properties and the mechanical events underlying their production. Three experimental set-ups were used: 1) Dog model-- six mongrel dogs, in which partial upper airway obstruction was created by an implanted supraglottic balloon. Flow, supraglottic pressure, and snoring sounds were recorded during different degrees of obstruction. Fifteen to 20 snores from each dog (total 100 snores) were analysed. 2) Simulated human snores--Six simulated snores from each of four subjects were recorded in two locations (trachea and ambient) with simultaneous airflow, and their correlations examined. 3) Snoring patients--snores were recorded with an ambient microphone from nine subjects with "heavy" snoring and no obstructive sleep apnoea (OSA). Forty to 50 snores from each subject were analysed (total of 400 snores). The snoring sound was analysed in the time (time-expanded waveform) and frequency (power spectrum) domains. After analysing these snores, we were able to identify two dominant patterns which are distinctly different from each other: the "simple-waveform" and the "complex- waveform". The complex-waveform snore is characterized by repetitive, equally-spaced, train of sound structures, starting with a large deflection followed by a decaying amplitude wave. In the frequency domain, it is characterized by multiple, equally-spaced peaks of power (comb-like spectrum). Simple-waveform snores have a quasi-sinusoidal waveform, with a range of variants, and almost no secondary internal oscillations. Their power spectrum contains only 1-3 peaks, of which the first is the most prominent. We developed a mathematical representation of these waveforms, which is presented along with its implications. The complex-waveform snores result from colliding of the airway walls and represent actual brief airway closure. Simple-waveform snores are of higher frequency and probably result from oscillation around a neutral position without actual closure of the lumen

543. Blowes, R. W., P. Yiallouros, and A. D. Milner. 1995. Lung sounds in neonates with and without an added dead space. *Pediatr.Pulmonol.* 19:348-354.
Abstract: Previous studies have reported great difficulty in recording lung sounds from neonates and have found conflicting results. We studied lung sounds in neonates during the inspiratory phase of the respiratory cycle as monitored by inductive plethysmography (A) and by a pneumotachograph and a face mask (B) which added a dead space of 12 mL. Sixteen term babies were tested 12 hr to 6 days (median 45 hours) after birth. Lung sounds were recorded and then analysed using overlapping and non-overlapping fast Fourier transforms. The two methods of analysis showed a difference in intensity but not in frequency. Fourteen babies provided enough breaths for comparison; a total of 596 inspirations were analysed. The intensity of lung sounds on occasion B was higher in all but two babies with a mean B/A ratio of 2.4. The mean (SD) power on occasions A and B was 13.9 (8.5) mW and 26.9 (21.0) mW, P = 0.02, respectively. In all but 4 babies the B/A ratios of the median (f50) and 90th centile (f90) frequencies were scattered randomly within 20% of unity. The mean (SD) f50 on occasions A and B was 205.5 (51.1) Hz and 225.8 (32.3) Hz, P = 0.10, respectively; the mean f90 was 370.3 (91.0) Hz and 396.1 (67.8) Hz, P = 0.25, respectively. Linear regression showed that there is a third-order polynomial relationship between sound intensity and air flow at the mouth. A weaker positive association exists between frequency and air flow, showing that the median and 90th centile frequencies approach an asymptote as flow increases.(ABSTRACT TRUNCATED AT 250 WORDS)

544. Bohadana, A. B., R. Peslin, H. Uffholtz, and G. Pauli. 1995. Potential for lung sound monitoring during bronchial provocation testing. *Thorax* 50:955-961.
Abstract: BACKGROUND--The use of lung sound monitoring during bronchial provocation testing has not been clearly demonstrated. The appearance of wheeze and changes in inspiratory breath sound intensity have been analysed and related to changes in spirometric parameters and to airways hyperresponsiveness. METHODS--Lung sounds were recorded in 38 patients undergoing a routine carbachol airway challenge (CAC) test. Spirometric testing was performed before and after the inhalation of each of five cumulative doses of 320 micrograms carbachol; a fall in forced expiratory volume in one second (FEV1) by 20% or more was considered as significant. Lung sound analysis was carried out using a computerised system. RESULTS--The CAC test was positive (CAC+) in 21 patients and negative (CAC-) in 17. At the final stage of the challenge, wheeze was identified in 10 positive patients (48%) and in one negative patient (6%); in non-wheezers the inspiratory breath sound intensity decreased

significantly from baseline in 11 CAC+ patients (mean (SD) change -35 (24%)) but not in 16 CAC- patients (mean (SD) change 5 (24%)). In all non-wheezers a linear relationship was found between breath sound intensity and the squared inspiratory airflow (r = 0.53-0.92) which became looser after the inhalation of carbachol. CONCLUSION--When unertaking bronchial provocation testing the accurate identification of wheeze may prove useful in avoiding or shortening the test because of the presumed relationship between wheeze and airways hyperresponsiveness. Changes in breath sound intensity may also be useful, but further studies are required to define the threshold for significant changes in this index

545. Brooks, D. and J. Thomas. 1995. Interrater reliability of auscultation of breath sounds among physical therapists. *Phys.Ther.* 75:1082-1088.
Abstract: BACKGROUND AND PURPOSE: Although auscultation is routinely used in the assessment of respiratory status, the ability of the rater to accurately and consistently identify lung sounds has been questioned. The literature on this issue is sparse and has focused on reliability of auscultation of tape-recorded rather than in vivo lung sounds. The purposes of this study were to determine the interrater reliability of physical therapists in the direct auscultation of lung sounds based on their clinical experience in chest physical therapy and to determine whether the adoption of standardized nomenclature and education on proper technique and interpretation affects reliability. SUBJECTS AND METHODS: A group of 57 registered physical therapists were stratified by clinical experience into four groups. Sixteen therapists (ie, 4 in each stratum) were randomly chosen using a random number table. The following criteria were developed to delineate clinical experience. Group 1 subjects were senior chest physical therapists with at least 5 years of experience in this area of practice. Group 2 subjects were experienced therapists who had a minimum of 2 years of experience in chest physical therapy and were currently practicing in this area. Group 3 subjects were experienced physical therapists in other areas who were also practicing in chest physical therapy on occasional weekend service. Group 4 subjects were new graduates. Ten patients were evaluated by each group of 4 physical therapists using a teaching stethoscope with one diaphragm/bell and four pairs of earpieces. The education session consisted of discussion of the adoption of standardized nomenclature and education on proper technique and interpretation of auscultation. Interrater reliability was assessed before and after the education session using kappa (kappa) values. Comparisons were made between kappa values before and after the education session to determine the effect of education and between groups to determine the effect of clinical experience. RESULTS: The kappa values before the education session were low, indicating poor reliability in detecting specific abnormal sounds (kappa = -.02-.59). Group 1 (seniors in respiratory therapy) and group 4 (new graduates) demonstrated the greatest reliability levels. The lowest kappa values were observed for detecting and categorizing the quality of breath sounds (normal, absent, bronchial, or decreased) (kappa = -.02-.25). Following the education session, there was a general improvement in reliability (kappa = -.30-.77), especially for group 3 (specialists in other areas). The most improvement was noted for the detection of the quality of breath sounds (kappa = .08-.50). CONCLUSION AND DISCUSSION: Reliability of auscultation was poor to fair, in general, before the education session. There was a definite improvement in reliability after the education session. There was no clear effect of clinical experience on reliability, and the agreement among observers appeared to depend on the abnormal lung sound present. Limitations of this study and recommendations for future research are discussed. [Brooks D, Thomas J. Interrater reliability of auscultation of breath sounds among physical therapists

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Abstract: The quantitative analysis of expiratory wheezing may offer a new approach for study respiratory function in asthmatics. METHOD: The sound spectrum during expiration was analyzed in 9 asthmatics with wheezing and 5 normal subjects. Phonographic parameters were then correlated with spirometric results for baseline respiration and deep breathing. RESULTS: a) Expiratory wheezing is heard in a band of 210 to 280 Hz during deep breathing, and b) the volume in this band correlates positively with mean expiratory flow (VT/TE) and negatively with the slope of the volume/flow curve between 50 and 25% of FVC. CONCLUSIONS: The degree of air flow limitation in the peripheral airways correlates with the volume of pulmonary sound

547. Dalmay, F., M. T. Antonini, P. Marquet, and R. Menier. 1995. Acoustic properties of the normal chest. *Eur.Respir.J.* 8:1761-1769.
Abstract: Laennec invented the stethoscope in 1816 and published a treatise on auscultation in 1819. We then had to wait until the 1950s to observe development of modern devices and methods of recording and signal- processing, which allowed objective studies of lung sounds in time and frequency fields. Tracheobronchial sounds generated by ventilation originate in the upper airways, the frequency content of these sounds has led to extensive research. Consolidated lungs act as more efficient sound conductors to the chest wall (bronchial breathing murmur). Tracheobronchial sounds contain higher frequency components compared to vesicular lung sounds. The origin of vesicular lung sounds has been becoming progressively clear for about 10 yrs. It is at least partly produced locally, deep, and probably intralobular. Clearly, further studies need to be performed in order to elucidate the true mechanisms involved in generating vesicular lung sounds, the redistribution of intrapulmonary gas or vibrations caused by the stretching of lung tissue. The devices developed are already useful for monitoring the state of patients in intensive care. Sooner or later, real time analysis and automated diagnosis will become available

548. Fisher, E. W., C. R. Palmer, N. J. Daly, and V. J. Lund. 1995. Acoustic rhinometry in the pre-operative assessment of adenoidectomy candidates. *Acta Otolaryngol.* 115:815-822.
Abstract: Claims have been made for the potential of acoustic rhinometry (AR) in the evaluation of adenoidectomy patients. Little evidence has been presented to support such claims, and evidence is accumulating that AR is inaccurate in reflecting anatomical reality in the nasopharynx. We set out to establish whether acoustic rhinometry studies could predict operative decision-making sufficiently for it to be of assistance to the clinician, despite these theoretical and practical obstacles. A total of 101 patients aged 2-13 years were examined by AR using the impulse technique. Parameters were chosen from the area-distance function to indicate nasopharyngeal volumes and areas (decongested and non-decongested). This information was compared with findings at EUA (examination under anaesthesia-obstruction categories: A-'good airway' to D-'severe obstruction'), operative decision (2 categories- 'obstructive' = remove, versus 'non obstructive' = leave in situ) and parents' symptom scores. Twenty-one patients were also evaluated post- operatively. There was considerable overlap between the AR parameters in the groups classified at EUA as 'obstructive' or 'non obstructive', but this overlap diminished after decongestion. Logistic regression demonstrated that the decongested volume and area parameters were of significant predictive value with respect to operative decision (odds ratio for unit change in volume = 0.82; 95% C.I. = 0.70-0.97; p = 0.018). Parents' analogue scores for snoring and for [snoring+obstruction+ mouthbreathing] were also of significant predictive value. The presence of rhinitis diminishes the predictive value of AR. Acoustic rhinometry has potential as a pre-operative evaluation of the nasopharyngeal airway in adenoidectomy candidates, but the predictive value is low unless combined with clinical factors

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Abstract: Simple rhinohygrometry and passive rhinomanometry studies have suggested that the 'nasal cycle' in children is often different in pattern of that of adults and experimental animals. We aimed to establish whether this assertion was correct, using a reliable and sensitive method, acoustic rhinometry (AR), and to compare results with those of simple rhinohygrometry (RH). Healthy children with no evidence of nasal disease were examined (n = 15; age range three to 10 years; mean age six years). Simultaneous recordings using AR and RH were made on each child every 10-15 minutes over two to four hour periods. Six children underwent nine additional AR studies on separate occasions. 'Classical' reciprocal alternating patterns were evident in 80 per cent (12/15) AR and 53 per cent (8/15) RH studies, 'in concert' patterns in seven per cent (1/15) AR and 20 per cent (3/15) RH studies and 'irregular' patterns in 13 per cent (2/15) AR and 27 per cent (4/15) RH studies. The agreement between the two methods was 47 per cent, with a kappa (kappa) value of -0.17 (poor agreement compared to chance). Agreements between the acoustic rhinometry parameters were 'fair' for all data (kappa = 0.34) and excellent (kappa = 1.0) if irregular patterns were ignored. Repeated studies showed that the pattern of fluctuation varies within any particular individual. The nasal cycle is similar in pattern in children and adults, and acoustic rhinometry is currently the method of choice to further investigate and clarify this phenomenon

550. Gavriely, N., M. Nissan, A. H. Rubin, and D. W. Cugell. 1995. Spectral characteristics of chest wall breath sounds in normal subjects. *Thorax* 50:1292-1300.
Abstract: BACKGROUND--This study was carried out to establish a reliable bank of information on the spectral characteristics of chest wall breath sounds from healthy men and women, both non-smokers and smokers. METHODS-- Chest wall breath sounds from 272 men and 81 women were measured using contact acoustic sensors, amplifiers, and fast Fourier transform (FFT) based spectral analysis software. Inspiratory and expiratory sounds were picked up at three standard locations on the chest wall during breathing at flows of 1-2 l/s and analysed breath by breath in real time. RESULTS--The amplitude spectrum of normal chest wall breath sounds has two linear parts in the log-log plane--low and high frequency segments--that are best characterised by their corresponding regression lines. Four parameters are needed and are sufficient for complete quantitative representation of each of the spectra: the slopes of the two regression lines plus the amplitude and frequency coordinates of their intersection. The range of slopes of the high frequency lines was -12.7 to -15.2 dB/oct during inspiration and -13.4 to -20.3 dB/oct during expiration. The frequency at which this line crossed the zero dB level--that is, the amplitude resolution threshold of the system--was designated as the maximal frequency (Fmax) which varied from 736 to 999 Hz during inspiration and from 426 to 796 Hz during expiration with higher values in women than in men. The mean (SD) regression coefficient of the high frequency line was 0.89 (0.05). CONCLUSIONS--These data define the boundaries of normal chest wall breath sounds and may be used as reference for comparison with abnormal sounds

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Abstract: Screening for sleep-disordered breathing is often done in an interview and with a questionnaire. This method is indirect and it appears to underestimate the prevalence of sleep apnea syndrome. Recently, several devices such as the Medilog and Vitalog portable monitoring systems were developed. However, these devices are difficult for patients to operate by themselves, because they include EEG monitoring or measurement of chest and abdominal movement. Therefore, we developed a portable monitoring system that is easier to operate. This system can be used to assess three variables: oronasal airflow, tracheal sound, and electrical activity of the heart. It stores the time of the onset of apnea, apnea duration, and R-R intervals with a built-in

microcomputer. Apnea episodes, total apnea time, mean apnea time, and R- R interval are analyzed with a host computer. The sensitivity an specificity of this system are 92.5% and 87.5%, respectively, with an apnea index (AI) of less than 10 episodes/h. Using this device, we found that the prevalence of sleep apnea syndrome among Japanese industrial workers who had an AI of more than 10 episodes was 7.5%. Moreover, from 1984 to 1994 we used this device to monitor 1019 outpatients who complained of sleep disturbances such as snoring, abnormal breathing during sleep, and excessive daytime sleepiness, and found sleep apnea (AI > or = 10) in about 50% of these patients. This monitoring system is useful for screening of outpatients with sleep apnea and for epidemiological studies of sleep apnea. However, it may be necessary to include a non-invasive system for monitoring oxygen saturation in the portable sleep monitor, to detect hypoventilation during sleep

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Abstract: Distribution of resistance to respiratory airflow in the nasal cavities was determined by digitized pressure/flow measurements of consecutive 2- cm airway segments between nostril and nasopharynx. Healthy adult subjects seated in a head-out body plethysmograph breathed exclusively through a single nasal cavity while transnasal pressure and flow signals were transduced, digitized and processed by a programmed desk- top computer to provide resistance values. Mean total resistances of untreated and decongested single nasal cavities were 0.44 (n = 30; SD +/- 0.25) and 0.26 (n = 15; SD +/- 0.06) Pa/cm3/s, respectively. The proportion of total airway resistance of successive 2-cm segments from nostril to nasopharynx was 56%, 22%, 16%, and 6% in the untreated nose, and 88%, 5%, 2%, and 5% following decongestion. The findings from 45 nasal cavities are consistent with previous pressure/flow measurements from six nasal cavities and support recent acoustic reflection assessments of nasal cross-sectional areas of both untreated and decongested noses

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Abstract: The mechanism of human snoring caused by vibration of the soft palate and the characteristics of the noise are investigated. The soft palate becomes unstable and vibrates violently once the inspiratory flow exceeds a critical speed. The physiological phenomenon is modeled by studying flow over a flexible plate. In determining the stability of this flow, the trailing edge conditions are crucial. It is found that the noise generated in the simple experimental configuration has distinct characteristics found in human snores. For example, there is an antiphase relation between unsteady pressures from the oral and nasal channels and this provides a feature that distinguishes snoring by vibration of the soft palate from that caused by other parts of the human airway

554. Huang, L., S. J. Quinn, P. D. Ellis, and J. E. Williams. 1995. Biomechanics of snoring. *Endeavour* 19:96-100.
Abstract: A large proportion of the population either snores or suffers the snoring of others. Recent advances with the use of fibre-optic endoscopes have enabled surgeons to observe the inside of the pharynx while a patient is asleep and snoring. In this article we look at the underlying structure of the upper airway and explain, with the use of simple mechanical models, the aerodynamic events occurring inside the upper airway during snoring

555. Journee, H. L., A. C. van Bruggen, J. J. van der Meer, A. B. de Jonge, and J. J. Mooij. 1995. Design and application of sensor for recording sounds over human eye and nose. *Med.Biol.Eng Comput.* 33:140-144.
Abstract: The recording of sounds over the orbit of the eye has been found to be useful in the detection of intracranial aneurysms. A hydrophone for auscultation over the eye has been developed and is tested under controlled conditions. The tests consist of measurement over the eyes in three healthy volunteers at rest, during voluntary breathing, during eyeball movements and during sustained orbicular muscular contractions. Furthermore, measurements are performed at the side of the nose. Major features of the hydrophonic transducer are high sensitivity to physiological sounds and a high degree of insensitivity to environmental sounds propagated through the air. It can be concluded that the hydrophone may be useful for the early detection of intracranial aneurysms and also for apnoea detection

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Abstract: Crackles were recorded with one of two systems in a total of 58 cases and compared. In one system a stethoscope was attached to a microphone; in the other system no stethoscope was used (see reference 9). Coarse crackles were recorded with the stethoscope system in 11 patients, and with the microphone-only system in 12 patients. Most patients with coarse crackles had bronchiectasis. Fine crackles were recorded with the stethoscope system in 13 patients, and with the microphone-only system in 22 patients. Most patients with fine crackles had idiopathic pulmonary fibrosis. Each record was examined visually, and all crackles recorded during one inspiration were selected. Power spectra were estimated with the maximum entropy method and peak frequencies were determined with the damped least-squares method. Type-I crackles were defined as those with all peak frequencies below 800 Hz; these low- pitched sounds may correspond to coarse crackles. Type-II crackles were defined as those with peak frequencies over 800 Hz regardless of the existence of peaks below 800 Hz; these high-pitched sound may correspond

to fine crackles. The "%Type II" was defined as the percentage of the total crackles that were Type-II crackles. The %Type II value among coarse crackles was 10 +/- 16% with the stethoscope and 3 +/- 7% with the microphone. Among fine crackles, the values were 65 +/- 22% with the stethoscope and 79 +/- 23% with the microphone. For both kinds of equipment, the %Type II differed significantly between coarse and fine crackles ($p < 0.01$). The stethoscope-transmitted sound had components that could be used to differentiate fine crackles from coarse crackles. For clinical purposes, crackles recorded with a stethoscope are as useful as those recorded with a microphone only

557. Kraman, S. S., G. R. Wodicka, Y. Oh, and H. Pasterkamp. 1995. Measurement of respiratory acoustic signals. Effect of microphone air cavity width, shape, and venting. *Chest* 108:1004-1008.
Abstract: STUDY OBJECTIVE: We have previously investigated the effects of microphone type and coupler air chamber depth on lung sound characteristics. We now report the results of experiments exploring the effects of air chamber width, shape, and venting on lung sounds. DESIGN: We used a single electret microphone with a variety of plastic couplers. The couplers were identical except for the diameter and shape of the air chamber. We used cylindrical chambers of 5, 10, and 15 mm in diameter at the skin and conical chambers of 8, 10, and 15 mm in diameter. We compared the inspiratory lung sound spectra obtained using each of the couplers. We also examined the tendency of various needle vents to transmit ambient noise into the microphone chamber. SETTING: Anechoic chamber. MEASUREMENTS AND RESULTS: The shape and diameter had little important effect on the lung sound spectrum below 500 Hz. From approximately 500 to 1,500 Hz, the 5-mm diameter couplers showed slightly less sensitivity than the 10- and 15-mm diameter couplers. All conical couplers provided approximately 5 to 10 decibel more sensitivity than the cylindrical couplers. All vents allowed some ambient noise to enter the chamber but the amount was trivial using the narrowest, longest vent. CONCLUSIONS: These data suggest that the optimal electret microphone coupler chamber for lung sound acquisition should be conical in shape, between 10 and 15 mm in diameter at the skin, and either not vented or vented with a tube no wider than 23-g or shorter than 20 mm

558. Kulakov, I. V., A. A. Tagil'tsev, V. I. Korenbaum, and S. A. Kirichenko. 1995. [Device for examining the state of bronchial patency using the acoustic method]. *Med.Tekh.*20-23.
Abstract: An acoustic device was proposed to detect bronchial obstruction by analysing a noise process in the laryngotracheal region at the forced expiration. Clinical trials were under way, which revealed persistent diagnosis signs of bronchial patency impairments associated with changes in the duration and shape of the envelope of a recorded acoustic signal, as well as deviations of its spectral characteristic

559. Lu, S., P. C. Doerschuk, and G. R. Wodicka. 1995. Parametric phase-delay estimation of sound transmitted through intact human lung. *Med.Biol.Eng Comput.* 33:293-298.
Abstract: Sonic noise between 300 and 1600 Hz is introduced into the mouths of 11 healthy adult male subjects at resting lung volume and is detected over the anterior extrathoracic trachea and at three sites on the right posterior chest wall. To overcome the difficulties associated with non- parametric phase unwrapping due to thoracic anti-resonances, the phase delay tau(f) of propagation between the trachea and the chest wall is estimated using a linear parametric ARX-type statistical model with the non-parametric magnitude spectra as a guide. The resulting tau(f) estimates are unambiguous and reliable, and show a clear trend of decreasing tau(f) with increasing frequency, indicating that sound at higher frequencies reaches the chest wall faster than that at lower frequencies. This finding indicates that respiratory sound transmission is highly dispersive, most probably owing to frequency-dependent airway and parenchymal wavespeeds

560. Mahagnah, M. and N. Gavriely. 1995. Gas density does not affect pulmonary acoustic transmission in normal men. *J.Appl.Physiol* 78:928-937.
Abstract: Fremitus, the transmission of sound and vibration from the mouth to the chest wall, has long been used clinically to examine the pulmonary system. Recently, modern technology has become available to measure the acoustic transfer function (TF) and transit times (TT) of the pulmonary system. Because sound speed is inversely proportional to the square root of gas density in free gas, but not in porous media, we measured the effect of air and Heliox (80% He-20% O2) breathing on pulmonary sound transmission in six healthy subjects to investigate the mechanism of sound transmission. Wide-band noise (75-2,000 Hz) was "injected" into the mouth and picked up over the trachea and chest wall. The averaged power spectra, TF, phase, and coherence were calculated using a fast Fourier transform-based algorithm. The phase data were used to calculate TT as a function of frequency. TF was found to consist of a low-pass filter property with essentially flat transmitted energy to 300 Hz and exponential decline to 600 Hz at the anterior right upper lobe (CR) and flat transmission to 100 Hz with exponential decline to 150 Hz at the right posterior base (BR). TF was not affected by breathing Heliox. The average TT values, calculated from the slopes of the averaged phase, were 1.5 +/- 0.5 ms for trachea to CR and 5.2 +/- 0.5 ms for trachea to BR transmission during air breathing. During Heliox breathing, the values of TT were 1.5 +/- 0.5 ms and 4.9 +/- 0.5 ms from the trachea to CR and from the trachea to BR locations, respectively. These results suggest that sound transmission in the respiratory system is dominated by wave propagation through the parenchymal porous structure

561. Maitre, B., T. Similowski, and J. P. Derenne. 1995. Physical examination of the adult patient with respiratory diseases: inspection and palpation. *Eur.Respir.J.* 8:1584-1593.
Abstract: Inspection of the thorax identifies the breathing position adopted by the patient, the shape of the thorax, the dynamics of respiration (breathing pattern, symmetry of expansion, mechanics and synchrony of rib cage and abdominal movements). Inspection of the neck adds useful information, particularly with respect to the dynamics of breathing. Palpation ascertains the signs suggested by inspection with respect to the mechanics of breathing. It also assesses the state of the pleura and pulmonary parenchyma by studying the tactile fremitus. It integrates extrarespiratory signs, such as enlarged lymph nodes or breast abnormalities. Extrathoracic respiratory signs should also be systematically looked for, including cyanosis, finger deformation, pulsus paradoxus, and pursed lips breathing. Interobserver agreement about respiratory signs has repeatedly been studied, and generally found to be low, as are clinical-functional correlations. However, some data on chronic obstructive pulmonary disease (COPD), asthma or pulmonary embolism are available. From the description of some signs and the current knowledge about their operative values, it appears that much clinical research remains necessary to better define the precise diagnostic value of a given sign. The impact of training on diagnostic performance also has to be defined. Both of these aspects should allow clinicians to optimize the way in which they use their hands and eyes to conduct respiratory diagnosis, as well as the way they teach respiratory symptomatology

562. Malmberg, L. P., L. Pesu, and A. R. Sovijarvi. 1995. Significant differences in flow standardised breath sound spectra in patients with chronic obstructive pulmonary disease, stable asthma, and healthy lungs. *Thorax* 50:1285-1291.
Abstract: BACKGROUND--Spectral characteristics of breath sounds in asthma and chronic obstructive pulmonary disease (COPD) have not previously been compared, although the structural differences in these disorders might be reflected in breath sounds. METHODS--Flow standardised inspiratory breath sounds in patients with COPD (n = 17) and stable asthma (n = 10) with significant airways obstruction and in control patients without any respiratory disorders (n = 11) were compared in terms of estimates of the power spectrum. Breath sounds were recorded simultaneously at the chest and at the trachea. RESULTS--The median frequency (F50) of the mean (SD) breath sound spectra recorded at the chest was higher in asthmatics (239 (19) Hz) than in both the control patients (206 (14) Hz) and the patients with COPD (201 (21) Hz). The total spectral power of breath sounds recorded at the chest in terms of root mean square (RMS) was higher in asthmatics than in patients with COPD. In patients with COPD the spectral parameters were not statistically different from those of control patients. The F50 recorded at the trachea in the asthmatics was significantly related to forced expiratory volume in one second (FEV1) (r = -0.77), but this was not seen in the other groups. CONCLUSIONS--The observed differences in frequency content of breath sounds in patients with asthma and COPD may reflect altered sound generation or transmission due to structural changes of the bronchi and the surrounding lung tissue in these diseases. Spectral analysis of breath sounds may provide a new non-invasive method for differential diagnosis of obstructive pulmonary diseases

563. Marquet, P. 1995. [Respiratory sounds]. *Rev.Mal Respir.* 12:87-101.
Abstract: After having invented the stethoscope, Laennec published his treatise on auscultation in 1819, describing the acoustic events generated by ventilation and linking them with anatomopathological findings. The weak points of his semiology lay in its subjective and interpretative character, expressed by an imprecise and picturesque nomenclature. Technical studies of breath sounds began in the middle of the twentieth century, and this enabled the American Thoracic Society to elaborate a new classification of adventitious noises based on a few physical characteristics. This terminology replaced that of Laennec or his translators (except in France). The waveforms of the different normal and adventitious noises have been well described. However, only the study of the time evolution of their tone (frequency-amplitude-time relationship) will enable a complete analysis of these phenomena. This approach has been undertaken by a few teams but much remains to be done, in particular in relation to discontinuous noises (crackles). Technology development raises hope for the design, in near future, of automatic processes for respiratory noise detection and classification. Systematic research into the production mechanisms and sites of these noises has progressed equally. It should, in time, reinforce their semiological value and give to auscultation, either instrumental or using the stethoscope or instrumentally, an increased diagnostic power and the status of respiratory function test

564. Martin, S. E., I. Marshall, and N. J. Douglas. 1995. The effect of posture on airway caliber with the sleep-apnea/hypopnea syndrome. *Am J Respir Crit Care Med* 152:721-724.
Abstract: Snoring and sleep apnea are more common in the supine than seated position. We therefore studied the effect of posture on upper-airway caliber in normal subjects, snorers, and subjects with the sleep-apnea/hypopnea syndrome (SAHS). We measured upper-airway cross-sectional area by acoustic reflection in 110 SAHS patients (apnea/hypopnea index [AHI] > 15), 70 snorers without SAHS (AHI < 15), and 40 male controls matched for body-mass index (BMI) to the 40 SAHS patients. SAHS patients in the seated position had smaller upper-airway areas at the orophyngeal junction (OPJ) than either the snorers ($p < 0.01$) or the normal subjects ($p < 0.02$), but there were no differences between groups in airway cross-sectional areas in the supine or lateral recumbent positions. SAHS patients had significantly smaller decreases in OPJ area from the seated to either the supine ($p < 0.001$) or lateral recumbent ($p < 0.001$) positions than did the snorers. SAHS patients also had smaller ($p < 0.05$) decreases in

OPJ area upon lying down than did the BMI-matched normal subjects. These data are compatible with SAHS patients defending their upper airway more upon lying down than do snorers or normal subjects

565. McCombe, A. W., V. Kwok, and W. M. Hawke. 1995. An acoustic screening test for obstructive sleep apnoea. *Clin.Otolaryngol.* 20:348-351.
Abstract: Third-octave sound analysis was performed on the snoring sounds of nine subjects with obstructive sleep apnoea (OSA) and 18 with simple snoring. Both groups demonstrated a large low frequency peak in linear sound levels at around 80 Hz. However, the OSA group displayed a substantially larger high frequency sound component. We utilized this fact in the development of an acoustic index (Hawke Index: HI) which describes the ratio between the overall A-weighted and linear sound levels for the recorded snoring sound of each subject [HI = dB(A)/dB(SPL) for Lmax]. There was a significant positive correlation between the apnoea/hypopnoea index and the HI ($r = 0.73$, $t = 5.3$, 25df, $P < 0.001$). If a value of 0.90 or greater was taken as diagnostic of OSA, the HI exhibited 67% sensitivity, 100% specificity, 100% positive and 86% negative predictive accuracy. With further development, we believe this acoustic phenomena may have a role as a screening test in the diagnosis of OSA

566. McGee, S. R. 1995. Percussion and physical diagnosis: separating myth from science. *Dis.Mon.* 41:641-692.
Abstract: There are three percussion sounds, which are easily distinguishable by objective measures: tympany (heard with percussion over the intestines), resonance (heard over the normal lung), and dullness (heard over the liver or thigh). The percussion sound that is produced reflects the ease with which the body wall vibrates, which in turn is influenced by many variables, including the strength of the stroke, the condition and state of the body wall, and the underlying organs. Underlying organs or disease may cause dullness to occur at distant sites. There is good interobserver agreement among clinicians with regard to calling a particular percussion sound dull, resonant, or hyperresonant. In contrast, there is very poor interobserver agreement among clinicians using percussion to measure the span of a particular organ. The use of comparative percussion can detect most large pleural effusions, but this method is able to detect only a few pneumonias. Shifting dullness is a reliable and fairly accurate sign for the detection of ascites. Both of these techniques can still be recommended after a review of the literature. Topographic percussion (e.g., using percussion to locate the heart, liver, and spleen borders or dimensions) has poor reproducibility, is significantly inaccurate in many patients, and has little clinical utility; it should be abandoned. Its fundamental principle--that sound waves penetrate only several centimeters of tissue, resulting in a note reflecting abnormalities only in this layer of tissue--is incorrect. Auscultatory percussion offers no advantage over conventional percussion, with the possible exception of auscultatory percussion of the shoulder. Auscultatory percussion should be abandoned as a bedside diagnostic technique

567. Melbye, H. 1995. Bronchial airflow limitation and chest findings in adults with respiratory infection. *Scand.J.Prim.Health Care* 13:261-267.
Abstract: OBJECTIVE: To study the predictive value of clinical chest findings for bronchial airflow limitation in patients with respiratory tract infection. DESIGN: Associations were analysed between FEV1 (forced expiratory volume in one second) in % of predicted and physical chest findings. SETTING: The Municipal Emergency Clinic in Tromso, Norway. PARTICIPANTS: 398 adult patients with respiratory tract infection and 40 general practitioners. OUTCOME MEASURES: Mean FEV1% predicted and frequency of FEV1 < 80% predicted according to chest findings. Regression coefficients of the findings with FEV % predicted as outcome variable. RESULTS: Mean FEV1% predicted was 87 (range 25-129). Pathological chest findings were recorded in 127 patients (32%) and in 22 of the 24 patients (92%) with FEV1% predicted less than 60. The 78 patients with wheezes had a mean FEV1% predicted of 74 (range 29-120), significantly lower than those without wheezes ($p < 0.0001$), and 63% had FEV1% predicted less than 80. Prolonged expiration or strenuous respiration was recorded in 49 patients. The 29 patients with wheezes in this subgroup had a significantly lower mean FEV1% predicted, 65, than the 20 patients without wheezes ($p < 0.005$). By multiple regression wheezes and strenuous respiration were the most significant predictors of FEV1% predicted, together with patients' statement of very annoying dyspnoea. CONCLUSION: When predicting the degree of bronchial obstruction in a patient with respiratory infection, the doctor may take into account wheezes heard by auscultation, an impression of strenuous respiration, and the patient's statement about severe dyspnoea

568. Meslier, N., G. Charbonneau, and J. L. Racineux. 1995. Wheezes. *Eur.Respir.J.* 8:1942-1948.
Abstract: Wheezes are continuous adventitious lung sounds. The American Thoracic Society Committee on pulmonary nomenclature define wheezes as high- pitched continuous sounds with a dominant frequency of 400 Hz or more. Rhonchi are characterized as low-pitched continuous sounds with a dominant frequency of about 200 Hz or less. The large variability in the predominant frequency of wheezes is one of the difficulties encountered with automated analysis and quantification of wheezes. The large variations observed in automated wheeze characterization emphasize the need for standardization of breath sound analysis. This standardization would help determine diagnostic criteria for wheeze identification. The mechanism of wheeze production was first compared to a toy trumpet whose sound is produced by a vibrating reed. The pitch of the wheeze is dependent on the mass and elasticity of the airway walls and on the flow velocity. More recently, a model of wheeze production based on the mathematical analysis of the stability of airflow through a collapsible tube has been proposed. According to this model, wheezes

are produced by the fluttering of the airways walls and fluid together, induced by a critical airflow velocity. Many circumstances are suitable for the production of continuous adventitious lung sounds. Thus, wheezes can be heard in several diseases, not only asthma. Wheezes are usual clinical signs in patients with obstructive airway diseases and particularly during acute episodes of asthma. A relationship between the degree of bronchial obstruction and the presence and characteristics of wheezes has been demonstrated in several studies. The best result is observed when the degree of bronchial obstruction is compared to the proportion of the respiratory cycle occupied by wheeze (tw/ttot). However, the relationship is too scattered to predict forced expiratory volume in one second (FEV1) from wheeze duration. There is no relationship between the intensity or the pitch of wheezes and the pulmonary function. The presence or quantification of wheezes have also been evaluated for the assessment of bronchial hyperresponsiveness. Wheeze detection cannot fully replace spirometry during bronchial provocation testing but may add some interesting information. Continuous monitoring of wheezes might be a useful tool for evaluation of nocturnal asthma and its treatment

569. Min, Y. G., M. K. Kang, H. M. Park, and B. H. Song. 1995. Effects of adenotonsillar hypertrophy on snoring in children. *ORL J.Otorhinolaryngol.Relat Spec.* 57:214-219.
Abstract: A prospective study was performed to evaluate the effects of adenotonsillar hypertrophy on snoring in children. Thirty male patients were grouped with respect to the severity of snoring and were evaluated in terms of the noise level of the snoring sound, the lowest arterial oxygen saturation, degree of palatine tonsillar hypertrophy, body mass index and cephalometric findings that included the adenoidal- nasopharyngeal ratio, the angle between the lines sella turcica/nasion and most posterior point of anterior maxilla/nasion, the angle between the lines sella turcica/nasion and most posterior point of anterior mandible/nasion, the posterior airway space, the distance from the sella to the nasion, lower face height and the distance from the basion to the posterior nasal spine. The noise level of the snoring sound, the lowest arterial oxygen saturation and the adenoidal-nasopharyngeal ratio showed a significant correlation with the severity of snoring, but the degree of palatine tonsillar hypertrophy and the body mass index failed to disclose any significant relationship

570. Patel, S., S. Lu, P. C. Doerschuk, and G. R. Wodicka. 1995. Sonic phase delay from trachea to chest wall: spatial and inhaled gas dependency. *Med.Biol.Eng Comput.* 33:571-574.
Abstract: A parametric phase delay estimation technique is used to determine the spatial and inhaled gas composition dependencies of sound propagation time through an intact human lung at frequencies of 150-1200 Hz. Noise transmission measurements from the mouth to the extrathoracic trachea and six sites on the posterior chest wall are performed in 11 healthy adult subjects at resting lung volume after equilibration with air, an 80% helium-20% oxygen mixture, and an 80% sulfurhexafluoride-20% oxygen mixture. The phase delay, tau(f), exhibits a bilateral asymmetry with relatively decreased delays to the left posterior chest as compared with the right. The phase delay to lower lung sites is greater than to upper sites at frequencies below 300 Hz; yet the opposite is found at higher frequencies, indicating changing propagation pathways with frequency. There is no measurable effect of inhaled gas composition on tau(f) below 300 Hz. At higher frequencies, changes in tau(f) that reflect the relative sound speed of the particular inhaled gas are observed. These findings support and extend previous measurements and hypotheses concerning the strong frequency dependence of the acoustical properties of the intact respiratory system

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Ref Type: Thesis/Dissertation

572. Piirila, P. and A. R. Sovijarvi. 1995. Objective assessment of cough. *Eur.Respir.J.* 8:1949-1956.
Abstract: Cough is a primitive reflex typically consisting of an initiating deep inspiration, glottal closure, and an explosive expiration accompanied by a sound. The flow characteristics of cough have been shown to differ between different pulmonary diseases. Cough sounds are generated at the larynx and in the lungs. Modern analysing techniques have also been applied in cough sound studies, and differences in cough sound duration and spectra have been found in pulmonary diseases with different bronchopulmonary pathophysiology. Since the objective assessment of cough is clinically important, automatic cough detectors and counters have been constructed, e.g. to assess the efficacy of antitussive drugs. Also, ambulatory methods for assessment of cough have been reported. This review includes a brief history of cough research and present methods available for objective assessment of cough

573. Piirila, P. and A. R. Sovijarvi. 1995. Crackles: recording, analysis and clinical significance. *Eur.Respir.J.* 8:2139-2148.
Abstract: Crackles are short interrupted breath sounds usually associated with pulmonary disorders. According to present opinion, a crackle is generated when an abnormally closed airway opens during inspiration or closes at the end of expiration. The timing of crackles in breathing cycles can be assessed with phonopneumography, their duration with time- expanded waveform analysis, and their pitch with analysis of frequency spectra. The timing, pitch and waveform of crackles are different in pulmonary disorders

reflecting different pulmonary pathophysiology. This review deals with the genesis, auscultation, recording and analysis of crackles, with an emphasis on modern signal-processing methods

574. Poole, S. R., M. Chetham, and M. Anderson. 1995. Grunting respirations in infants and children. *Pediatr.Emerg.Care* 11:158-161.
Abstract: Grunting respirations are recognized as a sign of serious illness in infants and children, but have not been well studied beyond the newborn period. We present three illustrative cases and the results of a descriptive study which elucidates the causes of grunting in infants and children and suggests guidelines for assessing pediatric patients with this symptom. All patients between one month and 18 years of age who presented to the Emergency Department (ED) of The Children's Hospital of Denver during the last five months of 1992 with grunting respirations were prospectively identified, and their charts were retrospectively reviewed. The 51 pediatric patients with grunting respirations (0.3% of all patients seen in the ED) fell into three groups based upon mode of presentation: 1) 55% presented with predominantly respiratory signs and symptoms, and each one had a respiratory or cardiac condition; 2) 25% presented with high fever (greater than 38.5 degrees C) but without respiratory signs and symptoms, and all had an infectious cause (three fourths of them had an invasive bacterial disease); 3) 20% presented with neither fever nor respiratory signs or symptoms and had one of a variety of conditions which appeared to cause pain. Presenting symptoms can guide the selection of tests used to evaluate the infant or child with grunting respirations. Guidelines for evaluation are provided in this report

575. Prichard, A. J., A. J. Smithson, J. E. White, P. R. Close, M. J. Drinnan, C. J. Griffiths, H. F. Marshall, and G. J. Gibson. 1995. Objective measurement of the results of uvulopalatopharyngoplasty. *Clin.Otolaryngol.* 20:495-498.
Abstract: Thirty-two patients undergoing uvulopalatopharyngoplasty (UPPP) for snoring have been studied prospectively using objective measurement of snoring levels. A significant reduction was found, especially in the supine posture. The quantitative reduction was small and correlations between subjective and objective changes in snoring volume were weak

576. Rietveld, S., E. H. Dooijes, L. H. Rijssenbeek-Nouwens, F. Smit, P. J. Prins, A. M. Kolk, and W. A. Everaerd. 1995. Characteristics of wheeze during histamine-induced airways obstruction in children with asthma. *Thorax* 50:143-148.
Abstract: BACKGROUND--An automated system has been developed for the detection of sound patterns suggestive of airways obstruction in long term recordings. The first step, presented here, was tracheal sound recording during histamine-induced airways obstruction. METHODS--The tracheal sounds of 29 children aged 8-19 years with asthma were recorded during airways obstruction caused by histamine inhalation using a system for continuous respiratory telemetry and computer analysis. Sound patterns were analysed, classified, and related to airways obstruction measured by lung function tests based on the forced expiratory volume in one second (FEV1). RESULTS--Five sound patterns were identified, one dominant sensitive and four specific to a fall in FEV1 of > 20%. The presence of at least one of three specific sound patterns during unforced respiration predicted a fall in FEV1 of > 20% in 87.5% of the subjects. The inspiratory and expiratory sound patterns were almost equally informative of airways obstruction. CONCLUSIONS-- Wheezes can be differentiated with more precision than is currently accepted. Tracheal sound patterns are sensitive and specific predictors of histamine-induced airways obstruction. These patterns are neither invariably nor proportionally related to the results of lung function testing. However, they can be used for detection of airways obstruction on the basis of their presence or absence

577. Rosqvist, T., E. Paajanen, K. Kallio, H. M. Rajala, T. Katila, P. Piirila, P. Malmberg, and A. Sovijarvi. 1995. Toolkit for lung sound analysis. *Med.Biol.Eng Comput.* 33:190-195.

578. Sapira, J. D. 1995. About egophony. *Chest* 108:865-867.
Abstract: Egophony is a change in timbre (Ee to A) but not pitch or volume. It is due to a decrease in the amplitude and an increase in the frequency [corrected] of the second formant, produced by solid (including compressed lung) interposed between the resonator and the stethoscope head. This explains certain difficulties in learning this valuable but currently neglected sign as well as in understanding certain physiologic false-positive occurrences

579. Schreur, H. J., J. Vanderschoot, A. H. Zwinderman, J. H. Dijkman, and P. J. Sterk. 1995. The effect of methacholine-induced acute airway narrowing on lung sounds in normal and asthmatic subjects. *Eur.Respir.J.* 8:257-265.
Abstract: The association between lung sound alterations and airways obstruction has long been recognized in clinical practice, but the precise pathophysiological mechanisms of this relationship have not been determined. Therefore, we examined the changes in lung sounds at well- defined levels of methacholine-induced airway narrowing in eight normal and nine asthmatic subjects with normal baseline lung function. All subjects underwent phonopneumography at baseline condition and at > or = 20% fall in forced expiratory volume in one second (FEV1), and in asthmatic subjects also at > or = 40% fall in FEV1. Lung sounds were recorded at three locations on the chest wall during standardized quiet breathing, and during maximal forced breathing. Airflow-dependent power spectra were computed using fast Fourier transform. For each spectrum, we determined the intensity and frequency content of lung sounds, together with the extent of wheezing. The results were analysed using analysis of variance (ANOVA). During acute

airway narrowing, the intensity and frequency content of the recorded sounds, as well as the extent of wheezing, were higher than at baseline in both groups of subjects. At similar levels of obstruction, both the pitch and the change in sound intensity with airflow were higher in asthmatics than in normal subjects. Wheezing, being nondiscriminative between the subject groups at baseline, was more prominent in asthmatics than in normal subjects at 20% fall in FEV1. We conclude that, at given levels of acute airway narrowing, lung sounds differ between asthmatics and normal subjects. This suggests that airflow-standardized phonopneumography is a sensitive method for detecting abnormalities in airway dynamics in asthma.(ABSTRACT TRUNCATED AT 250 WORDS)

580. Sestini, P., E. Renzoni, M. Rossi, V. Beltrami, and M. Vagliasindi. 1995. Multimedia presentation of lung sounds as a learning aid for medical students. *Eur.Respir.J.* 8:783-788.
Abstract: New educational technologies might help to compensate for the decrease in time and emphasis dedicated to physical examination in medical training. This may, in particular, be applicable for improving the skills in auscultation of the chest. We investigated whether a multimedia presentation of acoustic and graphic characteristics of lung sounds could improve the learning of pulmonary auscultation by medical students, in comparison with conventional teaching methods. We studied 48 medical students without clinical experience, who had received conventional formal teaching on chest examination. Chest auscultation skills were evaluated using an inaccuracy score for the student's auscultation report on three patients, selected according to a standardized procedure. After a baseline evaluation, 27 students in groups of 5-10, participated in a multimedia seminar on lung sounds during which digitized lung sounds were played and the corresponding time-expanded waveform and frequency spectrum were commented on and displayed on a computer. The remaining 21 students received conventional bedside training, acting as control group. The following week, all the students underwent a second evaluation of chest auscultation skills. No differences in the inaccuracy score were observed between the two groups in the preliminary test. However, in the second postintervention assessment, the inaccuracy score of the students who had followed the seminar (11.2 +/- 1.3 points) was significantly lower than that of the controls (16.6 +/- 1.6 points). The answers to a feedback questionnaire confirmed that the great majority of the students found the association of the acoustic signals with their visual image to be useful for learning and understanding lung sounds.(ABSTRACT TRUNCATED AT 250 WORDS)

581. Sharma, O. P. 1995. Symptoms and signs in pulmonary medicine: old observations and new interpretations. *Dis.Mon.* 41:577-638.
Abstract: Andre Gide wrote, "Everything has been said before, but since nobody listens we have to keep going back and beginning all over again." To a certain extent, that statement applies to the importance of accurate and systematic history taking and physical examination in clinical practice. Although we are trained in habits of comprehension and accuracy in history taking and examination of patients, periodic reminders are required to develop a diagnostic framework based on observation (inspection), palpation, percussion, and auscultation. This monograph reemphasizes the method to be pursued in the treatment of a patient with pulmonary symptoms. It consists of three parts: (1) questioning the patient about his or her medical history; (2) performing the physical examination of the respiratory system; and (3) examining the extrapulmonary signs and symptoms. Once a strong clinical framework has been constructed, its further development and refinement depend on the clinician's experience, power of observation, and systematic reading of the medical literature. Good physicians must continue to learn throughout their careers; this is the most essential element of a physician's development. Be patient, however; as Cowper said, "Knowledge, to become wisdom, needs experience."

582. Smithson, A. J., J. E. White, C. J. Griffiths, A. J. Prichard, P. R. Close, M. J. Drinnan, H. F. Marshall, and G. J. Gibson. 1995. Comparison of methods for assessing snoring. *Clin.Otolaryngol.* 20:443-447.
Abstract: Objective measurements of several sound level indices were made on 32 subjects referred because of snoring and who subsequently underwent uvulopalatopharyngoplasty (UPPP). The measurements were repeated approximately 6 months post-UPPP. The indices were compared with the subjective assessment of snoring by both the subject and his/her bed partner. Correlations between objective and subjective assessments were generally weak and were strongest when the supine posture only was considered. The index which correlated best with subjective assessment was the level which 1% of the sound level samples exceeded

583. Suki, B., O. F. Pedersen, R. Habib, and A. C. Jackson. 1995. Wave speed during maximal expiratory flow and phase velocity from forced oscillations. *Respir.Physiol* 102:39-49.
Abstract: To test the hypothesis that pressure waves in the airways propagate at the speed obtained from maximal expiratory flow we compared wave speeds (WS) associated with flow limitation and phase velocities (PV) of oscillatory pressure waves in four excised calf tracheae for transmural pressures (Ptm) between 0 and -10 kPa. WS was calculated from static area-Ptm curves using the acoustic reflection technique. PV was determined by the forced oscillation method between 16 and 1024 Hz. WS ranged from 80 to 120 m/sec slightly increasing with decreasing Ptm. PV was relatively constant between 60 and 160 AZ with values between 170 and 310 m/sec. With decreasing Ptm, PV also increased, however, at 100 HZ it was 1.5-2.5 times higher than WS at all Ptm. In one additional trachea we found that PV decreased from approximately 200 m / sec at 7 Hz to approximately 130 m /

sec at 0.23 Hz approaching WS. We suggest that VP is larger than WS because of the differences in airway wall mechanics during small-amplitude oscillations and large amplitude oscillations and large amplitude unidirectional wall motion such as a forced expiration. These results may provide an additional explanation why expiratory flow during rapid breathing or expiratory transients can exceed the maximum expiratory flow-volume envelope

584. Suzuki, A., C. Sumi, K. Nakayama, and M. Mori. 1995. Real-time adaptive cancelling of ambient noise in lung sound measurement. *Med.Biol.Eng Comput.* 33:704-708.

585. Takahama, K. and T. Miyata. 1995. [Cough--diversity and the peripheral mechanisms of production]. *Nippon Yakurigaku Zasshi* 105:41-52.
Abstract: The physiology and pharmacology of the cough reflex were reviewed from the perspective that the cough response and its peripheral mechanisms have diversity, taking reported findings together with the results obtained from our own studies. It is clear that there was a remarkable difference in the magnitude of expiration and sound in coughing between the two types of coughs in guinea pigs: one is caused by mechanical irritation to the airway mucosa or citric acid inhalation and the other caused by inhalation of pharmacological agents such as capsaicin and substance P. Four types of stimulation, i.e., mechanical, physicochemical, chemical and pharmacological stimulation, were discussed with respect to the site and the mechanisms of action in the airway. Mechanical stimulants and chemical stimulants such as citric acid seem to act mainly on A delta-fibers. However, it is unclear whether pharmacological agents act on C-fibers to produce cough. As to the difference in distribution of cough receptors in the airway, pharmacological differences were found between coughs caused by mechanical irritation on the laryngeal sites and the site of bifurcation of the trachea. Furthermore, capsaicin, applied by a topical spraying method newly developed by us, produced cough-like forced expiration when it was sprayed around the site of the bifurcation of the trachea. This response was not depressed by codeine, but depressed by ophiopogonin, a Chinese herbal antitussive; mephenesine; and a neurokinin A antagonist. Mechanisms of cough augmentation in bronchitic guinea pigs were also described briefly. In conclusion, the site of action of cough stimulants and the mechanisms of cough production are still controversial. To solve these problems, we need to develop new methods and strategies for studying the cough reflex

586. Tomkinson, A. and R. Eccles. 1995. Errors arising in cross-sectional area estimation by acoustic rhinometry produced by breathing during measurement. *Rhinology* 33:138-140.
Abstract: Standardization of acoustic rhinometry is becoming increasingly important as the use of this technique becomes more widespread. The effects of breathing through the nose during acoustic rhinometry were investigated to determine if this affected the measurements of minimal cross-sectional area. During inspiration, and inspiration with the contralateral nasal airway obstructed, the minimal cross-sectional area decreased by 12.48% ($p < 0.05$) and 56.68% ($p < 0.01$), respectively, from the measurement made during a breathing pause. During expiration the reverse was observed, with increases in the minimal cross-sectional area of 13.95% ($p > 0.05$) and 40.20% ($p < 0.05$), respectively. In all but quiet expiration, the minimum cross-sectional area recorded during respiratory manoevres, differed significantly from those measured during a breathing pause. We recommend that in order to avoid changes in nasal measurements during breathing, acoustic rhinometry should be performed during a brief breathing pause

587. Van Brunt, D. L. Intensity pattern of sleep sounds as a predictor for obstructive sleep apnea. 1995. THE UNIVERSITY OF MEMPHIS.
Ref Type: Thesis/Dissertation

588. Vice, F. L., O. Bamford, J. M. Heinz, and J. F. Bosma. 1995. Correlation of cervical auscultation with physiological recording during suckle-feeding in newborn infants. *Dev.Med.Child Neurol.* 37:167-179.
Abstract: Pharyngeal swallows during infant suckle-feeding are associated with a characteristic sequence of sounds audible by stethoscope or by an accelerometer or microphone held over the larynx. In rhythmically feeding term-born neonates, the delineating acoustic elements are discrete sounds which precede and succeed pharyngeal swallows. Digital signal processing shows similarities in morphological detail between the discrete sounds preceding swallows and between those succeeding swallows; those succeeding swallows are more variable in temporal relation to swallows, amplitude and morphological detail. Variations in the pattern of interswallow respiration, including apnea, are correlated with variations in the discrete sounds. Specification of physiological correlates of these internal feeding sounds increases the utility of cervical auscultation as a method of investigation and of clinical observation of feeding

589. Wilson, N. M., P. Bridge, S. B. Phagoo, and M. Silverman. 1995. The measurement of methacholine responsiveness in 5 year old children: three methods compared. *Eur.Respir.J.* 8:364-370.
Abstract: The aim of this study was to compare the feasibility of three techniques for measuring the response to bronchial

challenge in young children: a direct airway measurement, the forced oscillation technique (FOT) for determining respiratory system resistance at 6 and 8 Hz (Rrs6 and Rrs8), and two indirect methods, the change in transcutaneous oxygen tension (PtcO2) and the detection of wheeze on auscultation of the chest. Thirty children aged 5 yrs, with a history of wheeze, and six asymptomatic controls, took part in a bronchial challenge test using methacholine administered by Wright nebulizer by the tidal-breathing method. The provocative concentration which produced a 35% increase in Rrs6 (PC35Rrs6) and a 15% decreases in PtcO2 (PC15PtcO2) were determined by interpolation, and the chest was ausculated after each dose of methacholine. The FOT was found to be unreliable in this age group: in seven children, the data were technically unsatisfactory in the presence of induced bronchoconstriction, whilst in three children, changes in Rrs were inconsistent after challenge. The use of Rrs8 did not improve the detection of positive responses. PC15PtcO2 was measurable in 29 of 30 children, and in 18 of these PC35Rrs6 was also measurable. In no subject did a significant, sustained increase in Rrs occur during challenge in the absence of a significant change in PtcO2. Wheeze was audible in only 4 of 25 (16%) of the positive and in no negative challenges. With this protocol, we found the FOT to be unreliable and the auscultation method valueless and potentially dangerous, since marked falls in PtcO2 of up to 33% sometimes occurred in the absence of wheeze.(ABSTRACT TRUNCATED AT 250 WORDS)

590. Yernault, J. C. and A. B. Bohadana. 1995. Chest percussion. *Eur.Respir.J.* 8:1756-1760.
Abstract: The direct method of chest percussion, first described by Auenbrugger but disseminated by Corvisart, has rapidly been replaced by the indirect or digitodigital method. Chest percussion has not been evaluated by modern acoustic means, so that our present knowledge of the method does not consistently differ from the 19th century approach. Auscultatory percussion is not superior to conventional percussion

591. Zhou, Y. Acoustic measurement of upper airway movement and inspiratory airflow modeling. 1995. DARTMOUTH COLLEGE.
Ref Type: Thesis/Dissertation

592. Zhou, Y. and J. A. Daubenspeck. 1995. Measurement of upper airway movement by acoustic reflection. *Ann.Biomed.Eng* 23:85-94.
Abstract: The acoustic reflection method provides a noninvasive way to determine the airway geometry. Based on a discrete upper airway model, an inverse scheme is developed to infer the upper airway area as a function of distance. We incorporate this scheme into a system that can generate multiple acoustic pulses to sample the upper airway geometry at a maximum frequency of 30 Hz, making possible determination of the airway area-distance relation as a function of time. Therefore, we can monitor the dynamic behavior of the upper airway during breathing. To validate the approach, we visualized vocal cord movements in three normal subjects via laryngoscopy; simultaneously acoustic measurements were made at 10 Hz. Video images of vocal cord movement were recorded and digitized. We compared the laryngeal area from analysis of the video images with the acoustic assessment at the level of the glottis. Linear regression analysis shows that the correlation coefficients are between 0.85 and 0.9 for all three subjects. We conclude that the acoustic reflection method is a useful tool for measuring vocal cord movement without the use of laryngoscopy, and the approach promises to be a useful one to measure the movement of the whole upper airway. This paper also discusses the limitations inherent in the algorithm and some useful procedures to ensure accurate and reliable area computation during implementation

593. al Jarad, N., S. W. Davies, R. Logan-Sinclair, and R. M. Rudd. 1994. Lung crackle characteristics in patients with asbestosis, asbestos- related pleural disease and left ventricular failure using a time- expanded waveform analysis--a comparative study. *Respir.Med.* 88:37-46.
Abstract: The aim of this study is to investigate lung crackle characteristics by time-expanded waveform (TEW) analysis in patients with asbestosis (AS), asbestos-related pleural disease (ARPD) and left ventricular failure (LVF). TEW was performed on a 33 s recording from each of 40 patients (12 AS, 17 ARPD and 11 LVF). They were 38 men and two women. Crackles on TEW were counted during inspiration and expiration, and the timing of clusters of crackles with respect to inspiration and expiration was noted. A total of 1117 crackles were identified. The initial deflection width (IDW) and the two cycle duration (2CD) were calculated for all crackles within one respiratory cycle for each patient (total of 298 crackles). Crackles were detected by TEW in all patients with AS, in seven patients with ARPD and in nine patients with LVF. Crackles in AS were mainly fine, mid- to late-inspiratory. Crackles in LVF took three patterns; in the first there were repetitive mid- to late inspiratory crackles similar to those seen in AS except that the crackles in LVF tended to be medium and coarse as well as fine (three patients); in the second crackles started early in inspiration followed by a crackle-free period then by another cluster of crackles lasting to the end of inspiration and to the early third of expiration (four patients) and in the third there were repetitive expiratory crackles with no or few inspiratory crackles (two patients). Crackles in ARPD generally took the configuration of fine crackles but another type of crackle preceded by a sharp deflection followed by an M-shape oscillation then by the largest oscillation was also found. IDW and 2CD for inspiratory crackles in ARPD were shorter than those in AS and LVF (for IDW $P < 0.009$ and $P < 0.003$ compared with AS and LVF respectively and for 2CD, $P < 0.006$ and $P < 0.003$ compared with AS and LVF respectively). IDW and 2CD in AS tended to be shorter than these for LVF but these results did not reach statistical significance. It is concluded that many differences exist between crackles in AS, LVF

and ARPD. Differences in nature and timing of crackles may reflect differences in the pathophysiology and mechanism giving rise to lung crackles in these conditions. TEW provides informations of diagnostic value

594. Andreassen, M. L., H. A. Leeper, D. L. MacRae, and I. R. Nicholson. 1994. Aerodynamic, acoustic, and perceptual changes following adenoidectomy. *Cleft Palate Craniofac.J.* 31:263-270.
Abstract: Fourteen children were seen prior to adenoidectomy and at 1 month, 3 months, and 6 months following surgery. On each visit, nasal airway resistance values, nasal cross-sectional area estimates, nasalance scores, and perceptual ratings of nasality were collected. These data were analyzed to identify changes that were related to the time of the test, and to the primary indication for surgery (nasal airway obstruction or recurrent infection). Results revealed significant reduction in nasal airway resistance and significant changes in nasalance following surgery. Perceptual changes were not significant. Clinical implications of these findings are discussed

595. Avital, A., S. Godfrey, J. Schachter, and C. Springer. 1994. Protective effect of albuterol delivered via a spacer device (Babyhaler) against methacholine induced bronchoconstriction in young wheezy children. *Pediatr.Pulmonol.* 17:281-284.
Abstract: Nine young asthmatic children aged 2-5 years underwent methacholine challenge after placebo or albuterol administered by metered dose inhaler through a spacer device (Babyhaler) with a face mask in a double-blind, cross-over, randomized study. The methacholine challenge was performed using chest auscultation to define the provocative concentration of methacholine that causes wheezing (PCW). The PCW increased from a geometric mean of 0.28 mg/mL after placebo to 3.59 mg/mL after albuterol ($P < 0.0001$). The protective effect of albuterol against methacholine-induced bronchospasm was 3.7 +/- 1.2 doubling doses. We conclude that administration of drugs from a metered dose inhaler through the Babyhaler with a face mask is effective. Albuterol causes a major reduction in the bronchial hyperreactivity in young wheezy children shortly after administration

596. Berezovskii, V. A. and M. I. Levashov. 1994. [A method for diagnosing a disturbance in bronchial patency]. *Lik.Sprava.*92.
Abstract: The authors elaborated the diagnostic method of bronchial disfunction by phonopulmography and gas mixtures with different density (two or three times lower than air). Using this method it is possible to do quantitative and qualitative estimation of initial bronchial disturbances. It may be used for express-diagnostic in ambulatory and clinical conditions

597. Bettencourt, P. E., E. A. Del Bono, D. Spiegelman, E. Hertzmark, and R. L. Murphy, Jr. 1994. Clinical utility of chest auscultation in common pulmonary diseases. *Am.J.Respir.Crit Care Med.* 150:1291-1297.
Abstract: In this investigation we applied the techniques of lung sound mapping and time-expanded wave-form analysis to four common diseases that involve the lung: interstitial pulmonary fibrosis (IPF), chronic obstructive pulmonary disease (COPD), congestive heart failure (CHF), and pneumonia (Pn). Twenty subjects were studied in each group. We also studied 15 subjects without evidence of lung disease. Differences in timing, character, and location were observed, which allowed separation among these groups. Multiple logistic regression models were created and tested by the bootstrap method. Regression models correctly classified 68 and 79% of subjects. Area under the receiver operating curve ranged from 0.96 for IPF and CHF to 0.80 for COPD. We conclude that auscultatory differences exist among common pulmonary conditions and that statistical models based on auscultatory data perform well in predicting diagnostic categories

598. Bohadana, A. B., N. Massin, D. Teculescu, and R. Peslin. 1994. Tracheal wheezes during methacholine airway challenge (MAC) in workers exposed to occupational hazards. *Respir.Med.* 88:581-587.
Abstract: Methacholine airway challenge (MAC) is a simple and useful means to assess bronchial hyperreactivity in workers exposed to various occupational hazards. Recently, wheeze detection by tracheal auscultation has been proposed as an indicator of bronchial responsiveness during bronchial provocation test in children. Our aim was to examine the relationship between the appearance of wheezes and the concurrent changes in forced expiratory volume in one second (FEV1) observed during MAC test in adults. Three cumulative doses of a methacholine solution (100 micrograms, 500 micrograms and 1500 micrograms) were inhaled by 45 workers with occupational exposure to flour dust. Spirometry was done using an electronic spirometer. Tracheal sounds were recorded with an electronic stethoscope placed over the anterior cervical triangle, 2 cm above the sternal notch. The amplified sounds were stored on magnetic tape, band-pass filtered (50- 2000 Hz), and digitized at a sampling rate of 4096 Hz into a GenRad Vibration Control System. Wheezes were detected by fast Fourier transform (FFT) analysis and their presence compared to a 20% fall in FEV1. A positive MAC test by spirometry was found in 12 subjects whereas wheezes were identified in 14 subjects. Among the wheezing subjects, nine had a positive MAC test (range of fall in FEV1 = 20.6 to 42.3%) and five had a negative one (range of fall in FEV1 = 3.6 to 16.9%). Moreover, no wheezes were found in the remaining three subjects with a positive MAC test (range of fall in FEV1 = 20.7 to 27.4%). Taking a 20% fall in FEV1 as reference, wheezes were 75% sensitive and 84.8% specific to detect airflow obstruction. In conclusion, since it carries a significant although small false-negative rate, the acoustic technique based upon wheeze detection cannot, at the present time, fully replace spirometry during airway challenge testing in subjects with suspected asthma

599. Bohadana, A. B., M. C. Kopferschmitt-Kubler, and G. Pauli. 1994. Breath sound intensity in patients with airway provocation challenge test positive by spirometry but negative for wheezing: a preliminary report. *Respiration* 61:274-279.
Abstract: Wheeze detection has been proposed as an indicator of bronchial responsiveness during airway provocation challenge (APC) test. However, there is evidence that wheeze may be occasionally absent in subjects whose APC is positive by spirometry. We tested the hypothesis that, in this case, inspiratory breath sound intensity (BSI) over the chest is noticeably decreased. Six patients (3 asthmatics and 3 patients with atopic rhinitis) were selected, whose forced expiratory volume in 1 s (FEV1) fell by 20% or more at the end point of the challenge in the absence of concurrent wheezing. Lung sounds were recorded at the right posterior lung base and analysed by computer. Inspiratory BSI at the end point of the challenge was markedly decreased in all patients, a change almost completely reverted by the inhalation of 200 micrograms of salbutamol in all of them but one. These results support the view that BSI monitoring is potentially useful as an indicator of bronchoconstriction during bronchial provocation testing. However, further studies are necessary to confirm this hypothesis

600. Collins, R. K. 1994. Hamman's crunch: an adventitious sound. *J.Fam.Pract.* 38:284-286.
Abstract: Hamman's crunch of pneumomediastinum is an unusual, adventitious sound heard on auscultation of the chest. Its rarity and dramatic nature frequently result in an expensive evaluation and hospitalization. Once recognized, it can be managed on an outpatient basis with serial chest radiographs to resolution of the pneumomediastinum or pneumothorax

601. Gavriely, N., M. Nissan, D. W. Cugell, and A. H. Rubin. 1994. Respiratory health screening using pulmonary function tests and lung sound analysis. *Eur.Respir.J.* 7:35-42.
Abstract: Lung sounds (LS) analysis is a potential source of additional objective, noninvasive and quantitative information on the status of the pulmonary system. We have examined the hypothesis that the addition of lung sounds analysis to spirometry increases the sensitivity of objective population screening, as compared to the use of spirometry alone. Questionnaires, spirometry and lung sounds were obtained in 493 active workers. Lung sounds analysis consisted of the averaged power spectra of breath sounds, measured separately during inspiration and expiration at four standard locations over the trachea and the chest- wall. Of the 493 subjects, 91 had an obstructive lung disease, including 27 with chronic bronchitis identified by a history of prolonged cough and sputum production but with normal spirometry. Twelve additional workers had a restrictive lung disease. Abnormal spirometric results were found in 74 of the patients. Abnormal lung sounds analyses were found in 54 patients, including 14 of the chronic bronchitis cases, so that the overall sensitivity of objective screening tests increased from 71% to 87% by combining the two tests. Thirty three of the subjects considered normal by evaluation of their questionnaire and spirometry had abnormal lung sounds. Of the twenty four who were re-evaluated 12-18 months after the first tests, three had developed a lung or heart disease. We conclude that the combination of spirometry and lung sounds analysis significantly increased the sensitivity of detection of pulmonary diseases by objective tests, and provided an early sign of lung disease that was not detected by spirometry alone

602. Guarino, J. R. and J. C. Guarino. 1994. Auscultatory percussion: a simple method to detect pleural effusion. *J.Gen.Intern.Med.* 9:71-74.
Abstract: OBJECTIVE: To assess a new technique for the detection of free pleural fluid. DESIGN: 118 consecutive inpatients with radiologic evidence of free pleural fluid and a control group of 175 randomly selected inpatients were examined over a three-year period in a prospective blind study by auscultatory percussion (AP) for evidence of pleural effusion. The cutoff in the percussion note by AP is strikingly loud and sharp at the fluid level and allows precise delineation of even minimal amounts of pleural fluid. The fluid level was measured in reference to the last rib. The criterion for detection of pleural effusion by AP was a demonstrable horizontal fluid level at the sound cutoff across the posterior hemithorax above the last rib that shifted with lateral tilt. SETTING: A general medical and surgical university- affiliated teaching Veterans Affairs hospital. PATIENTS/PARTICIPANTS: All inpatients were eligible. Ready availability of examiners was essential. Rotating third- and fourth-year medical students, residents, and senior staff members participated. INTERVENTIONS: None. MAJOR RESULTS: 113 of the 118 patients with radiologic evidence of pleural effusion had a distinct horizontal fluid level above the last rib that shifted with lateral tilt (sensitivity = 95.8%). None of the 175 control patients examined at random showed evidence of pleural effusion by AP examination, which was confirmed by chest radiography (specificity = 100%). Nine of the 175 patients without radiologic evidence of pleural effusion had elevated diaphragms that simulated a fluid level in the examination by AP. Each of the nine patients, however, had no shift in the level with lateral tilt. Subpulmonic effusions were readily displaced and identified by this method of AP. CONCLUSIONS: Examination by AP is highly sensitive and specific for the detection of free pleural fluid, even in the presence of obesity, thickened pleura, lung masses, pneumonia, and associated lung disease. The examination correlates closely with standard and lateral decubitus chest radiography. Pleural effusion unsuspected by conventional means of physical examination and undetectable by standard chest radiography can readily be detected by the method of AP. The examination is easy to do and is particularly suited to enhance detection of pleural effusion. As little as 50 mL of free pleural fluid can be detected

603. Habib, R. H. Airway geometry and wall mechanical properties from respiratory acoustic impedance (bronchoconstriction). 1994. BOSTON UNIVERSITY.
Ref Type: Thesis/Dissertation

604. Hamlet, S., D. G. Penney, and J. Formolo. 1994. Stethoscope acoustics and cervical auscultation of swallowing. *Dysphagia* 9:63-68.
Abstract: Frequency response characteristics of six popular stethoscopes are reported for the higher frequency range (to 3000 Hz) to supplement equivalent measurements for the lower frequencies (35-1000 Hz) published previously. Spectra of the sounds of swallowing from the throat, transduced with an accelerometer, demonstrate important frequency composition in this higher range. Two stethoscope models were found to have superior transmission characteristics for use in cervical auscultation of swallowing sounds

605. Hoffstein, V., S. Mateika, and D. Anderson. 1994. Snoring: is it in the ear of the beholder? *Sleep* 17:522-526.
Abstract: Complaint of snoring, which is usually voiced by a patient's bedpartner, frequently leads to investigations in the sleep laboratory that are designed to assess snoring objectively and determine whether it is a symptom of sleep apnea. How well this subjective complaint of the listener is confirmed by the objective measurement of snoring is not known. Consequently, we designed a study i) to test the validity of self-perception of snoring and ii) to compare subjective perception of snoring by the sleep technologist with objective measurement of its frequency and loudness. We studied 613 unselected patients referred to our sleep clinic because of snoring and suspicion of sleep apnea. They all had nocturnal polysomnography that included measurements of snoring, expressed as the number of snores per hour of sleep [snoring index (SI)] and mean (dBmean) and maximum (dBmax) nocturnal sound intensity. Following the sleep study, the technologist (and patient) independently rated a patient's snoring as none, mild, moderate or severe. Kruskall-Wallis test, Spearman rank correlations and Cohen's kappa statistics were used to compare the groups, examine the correlations between subjective and objective measurements, and check the agreement between them.(ABSTRACT TRUNCATED AT 250 WORDS)

606. Jan, M. A., I. Marshall, and N. J. Douglas. 1994. Effect of posture on upper airway dimensions in normal human. *Am J Respir Crit Care Med* 149:145-148.
Abstract: Posture has a major effect on breathing during sleep. Snoring, hypopneas, and apneas are all more common lying than sitting and more common supine than in a lateral lying position. Because the effect of the lateral lying position on upper airway caliber has not previously been studied, we examined this in 20 normal awake subjects and also determined the effect of neck position. The acoustic reflection technique was used. Pharyngeal cross-sectional areas (CSA) fell significantly from the sitting to supine position (oropharyngeal junction, from 1.65 +/- [SEM] 0.6 cm to 1.31 +/- 0.07 cm), but there was no difference in CSA between the supine and lateral positions for oropharyngeal junction (1.36 +/- 0.06 cm), mean pharyngeal area, maximal pharyngeal area, or pharyngeal volume. Neck hyper-extension significantly increased pharyngeal CSA (e.g., oropharyngeal junction null position 1.51 +/- 0.08, hyper-extension 1.94 +/- 0.11 cm), but there was no significant effect of neck flexion on airway CSA. These results confirm that in normal awake subjects, pharyngeal areas are smaller lying than sitting but also showed no significant difference between CSA in the supine and lateral lying positions. The study also demonstrates that the upper airway caliber increases with neck extension in conscious adults

607. Kase, Y., O. Hilberg, and O. F. Pedersen. 1994. Posture and nasal patency: evaluation by acoustic rhinometry. *Acta Otolaryngol.* 114:70-74.
Abstract: Nasal passage geometry was measured by acoustic rhinometry in 8 healthy medical students (5 males and 3 females, 21-29 years old; mean age 24 years) after 6 min in different postures of head and body. The minimum cross-sectional area (A-min) and volume between the nostril and 7 cm posteriorly were measured on both sides. When changing from sitting to horizontal the total airway dimension (i.e., the sum of A-min for the two sides) decreased by about 16% (Mean +/- SD = 0.19 +/- 0.14 cm2), and when standing up it increased by about 12% (0.14 +/- 0.13 cm2). A- min seemed more sensitive than volume to detecting postural changes. Including the variation between the cavities, the coefficient of variation (CV = SD/Mean) for area was 24.8 +/- 6.7 and for volume 22.4 +/- 6.4 for the 8 subjects. For the total nasal airway passage the corresponding figures were 12.9 +/- 3.9 and 10.9 +/- 5.5. These figures are considerably higher than for subjects measured only in the sitting position under comparable circumstances. In conclusion, our findings indicate a composite response of the nasal cavity mucosa to both systemic (hydrostatic) and local conditions, probably induced by vascular and cutaneous reflexes. These factors must be taken into account in studies of environmental, clinical, and pharmacological conditions

608. Louis, B., G. M. Glass, and J. J. Fredberg. 1994. Pulmonary airway area by the two-microphone acoustic reflection method. *J.Appl.Physiol* 76:2234-2240.
Abstract: We noninvasively assessed airway dimensions from acoustic reflection data measured at the mouth. We recently described a two-transducer system for measurement of the nasal airway. Here we apply this approach to the measurement of the

upper airway and trachea. We describe the theoretical implications of breathing on this kind of measurement and propose a new procedure that, unlike single- and dual-transducer systems used currently, does not require the use of He-O2 for inference of geometry of subglottic airways

609. Mahagnah, M. and N. Gavriely. 1994. Repeatability of measurements of normal lung sounds. *Am.J.Respir.Crit Care Med.* 149:477-481.
Abstract: The stability of lung sounds measurements over time may influence their clinical usefulness. In the present study we investigated the temporal variability of the spectral pattern of normal lung sounds. Breath sounds from five healthy men were recorded on the trachea and at four locations over the chest wall. Each subject was studied twice with a time interval of 1 wk. On each occasion, measurements were done in duplicate, with a 30-min interval between recordings. Sounds were amplified, band-pass filtered (75 to 2,000 Hz) and digitized into a computer, and the average spectra of the inspiratory, expiratory, and background sounds were calculated. The variability of corresponding spectra were calculated between the daily duplicate (same-day variability, SDV) and between the two recording sessions (between-day variability, BDV). SDV was 32.8 +/- 12.0% during inspiration and 40.8 +/- 12.6% during expiration ($p = 0.005$). BDV was 36.9 +/- 11.3% during inspiration and 42.7 +/- 12.7% during expiration. These values were not significantly different from SDV except for sounds recorded from the interscapular region (SR). At this location the SDV was 28.2 +/- 7.2% during inspiration and 40.8 +/- 14.2% during expiration, and the BDV was 48.2 +/- 18.7% during inspiration and 77.6 +/- 22.3% during expiration ($p < 0.05$). The increased BDV at SR was found to be a result of slight differences in microphone position from the first session to the next. Similar changes in microphone position at the other recording sites did not alter the variability of lung sounds.(ABSTRACT TRUNCATED AT 250 WORDS)

610. Malmberg, L. P., A. R. Sovijarvi, E. Paajanen, P. Piirila, T. Haahtela, and T. Katila. 1994. Changes in frequency spectra of breath sounds during histamine challenge test in adult asthmatics and healthy control subjects. *Chest* 105:122-131.
Abstract: Air-flow standardized breath sounds were recorded at the chest and at the trachea during histamine challenge test and after subsequent bronchodilation in 12 asthmatics and 6 healthy controls for spectral analysis, to be compared with simultaneous changes in spirometric variables. Of all the lung sound variables measured, the changes in median frequency of the power spectrum (F50) of tracheal expiratory sounds were found to correlate best ($r = 0.853$, $p < 0.0001$) with changes in FEV1. The increase of F50 during histamine challenge was significantly larger in asthmatics than in healthy control subjects ($p < 0.005$). The provocative dose of histamine inducing a decrease of 15 percent in FEV1 (PD15FEV1) and the provocative dose causing an increase of 30 percent in tracheal expiratory F50 (PD30F50) were significantly related ($r = 0.754$, $p = 0.012$). In asthmatics, the breath sound frequency distribution in terms of median frequency reflected acute changes in airways obstruction with high sensitivity and specificity. The present method for breath sound analysis can be applied for patients with limited cooperation during bronchial challenge tests

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Abstract: In order to study changes in respiratory sounds associated with acute bronchoconstriction and -dilatation, breath sounds of 11 children with asthma (age range, 10-14 years) were recorded at the chest and at the trachea during histamine challenge test and after subsequent bronchodilatation. The changes in frequency spectra of breath sounds were compared with simultaneous changes in forced expiratory volume in 1 second (FEV1). In seven children who responded to histamine with a decrease in FEV1 of more than 15%, there was a significant relationship between percentage change in FEV1 (delta FEV1) and percentage change in median frequency (delta F50) of expiratory breath sounds recorded at the chest ($r = 0.865$; beta = -0.706, $P = 0.0001$) and at the trachea ($r = 0.888$; beta = -1.12, $P = 0.0001$). The association between breath sound intensity and FEV1 was weaker. Based on ANOVA, the increase of F50 during the challenge test was significantly larger in children who responded to histamine than in those who were non-responsive ($P = 0.0016$). At the chest, a decrease of 15% in FEV1 corresponded to an increase of 8% in expiratory F50. The provocative dose of histamine inducing a decrease of 15% in FEV1 (PD15FEV1) and the provocative dose causing an increase of 8% in F50 (PD8F50) were significantly related ($r = 0.927$, $P = 0.003$). We conclude that spectral analysis of breath sounds can be used to indicate airway obstruction during bronchial challenge tests in children, and may be adapted for tests in pre-school children. The results suggest that the same mechanisms that induce airflow limitation due to inhaled histamine may generate an increase in frequency content of breath sounds in children with asthma

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Abstract: This study was designed to assess the subjective and objective effects of uvulopalatopharyngoplasty (UPPP) for treatment of snoring. We mailed a questionnaire dealing with snoring, quality of sleep, and interference with bed-partner's sleep to 100 unselected patients who were referred because of snoring. Replies were received from 69 patients. The answers were analyzed, and the subjective impressions were compared with preoperative and postoperative objective measurements of snoring and apnea. The average (+/- SD) length of follow-up was 45 +/- 20 mo. We found no significant differences in the apnea/hypopnea

index, snoring index, and mean and maximal nocturnal sound intensity before and after surgery in this group. However, despite this lack of objective improvement. 78% of patients reported reduction in snoring, and 79% reported improvement in the quality of sleep; 18 of 69 bed partners no longer complained of interference with their sleep compared with only one preoperatively. We conclude that if the purpose of UPPP is to reduce the reported health hazards associated with snoring, then comparison between objective preoperative and postoperative measurements of snoring does not indicate success; if, on the other hand, the purpose of surgery is to alleviate the social hazard, then UPPP partially achieves this goal

613. Mori, M. 1994. [Lung sound analysis and pulmonary function studies]. *Rinsho Byori* 42:396-400.
Abstract: Because of technical difficulties, the study of lung sounds has been neglected for the last 200 years since the age of Laennec. However, recent advances in signal processing and in technology have made it possible to record lung sounds routinely at the bedside or in clinical laboratories. Lung sound analysis has many advantages because it is safe, non-invasive, low-cost, and repeatable. Normal lung sounds can be classified into tracheal, bronchial, and alveolar (vesicular) sounds. They are all common in that the origin of the sound is the turbulence in the airways. The most important and convenient way of distinguishing them is the place where they are heard and the difference in intensity in relation to breathing cycle. Alveolar sounds are heard at the bases and are definitely larger during inspiration, while bronchial sounds are heard at the apex, over the sternum and inter-scapular area, and are equal or louder during expiration. The abnormal, or adventitious lung sounds are classified into continuous and discontinuous. Wheezes are most common continuous sounds. However, in patients with stenosis of trachea or major bronchus large continuous sounds often referred to as rhonchi are heard. They are easily heard over the neck and are important clinical signs which nurses and laboratory technicians must be aware of. By the use of adaptive digital filters we can reduce contaminating noises without the use of sound proof rooms. Because of many advantages, the lung sound analysis has a promising future as a method to supplement other pulmonary function studies

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Abstract: Regional ventilation and changes in airway caliber have been studied by analysis of breath sounds. The aim of this study was to find which frequency band is most suitable for such purposes. The subjects were 19 healthy men. Breath sounds at 6 sites on the chest wall, airflow rate at the mouth, and ECG were digitized and recorded for 30 seconds. Power spectra of breath sounds at various frequency bands (10-50 Hz, 50-100 Hz, 100-150 Hz, ..., 950-1000 Hz) were calculated with a fast-Fourier transform (FFT) for every block of 512 points (102.4 msec), and mean airflow rates for the blocks were calculated. Data recorded during inspiration when airflow ranged between 0.5 L/s and 3 L/s were analyzed. For frequency bands from 150 Hz to 850 Hz the logarithms of the power spectra were linearly correlated with the logarithms of the airflow rates, and the correlation coefficients exceeded 0.8, but for lower frequency bands the correlations were poor. When the data contaminated by heart sounds and those recorded late in inspiration were excluded the correlations at frequency bands below 150 Hz improved. The slope of log (power)/log (flow) was about 4 for the bands from 100 to 300 Hz, but it became steeper (4 to 6) for higher frequency bands. This means that the power spectra were proportional to the fourth power of the airflow rate for bands below 300 Hz, but the relation was from the fourth to the sixth power for higher frequency bands.(ABSTRACT TRUNCATED AT 250 WORDS)

615. Pasika, H. and D. Pengelly. 1994. Lung sound crackle analysis using generalised time-frequency representations. *Med.Biol.Eng Comput.* 32:688-690.

616. Peros-Golubicic, T. 1994. [Lung auscultation: an old skill with new interpretation and terminology]. *Lijec.Vjesn.* 116:308-314.
Abstract: The lung sound auscultation is a part of everyday practice of most physicians. This skill used to be in practice in antique times, but it did not gain any particular attention until the beginning of the 19th century when Laennec systematized his observations, so that the method became generally accepted as the means of examining the patient. Today the stethoscope has almost become the symbol of medical profession, and without it no worthy caricature on behalf of a physician is possible. In this article except short historical review of the lung auscultation, the new technical innovations, including the use of computers which have led to new insights into the characteristics of the lung sounds in health and disease have been shown. Indeed, the technical innovations have insured more accurate measurement of all characteristics of lung sounds, and in connection with this enabled the coining of new terms, especially for adventitious lung sounds. As the whole civilized world has agreed upon the terminology, in the radiance of the above mentioned we are also proposing new terminology for adventitious lung sounds

617. Poulton, T. J., D. W. Worthington, and T. R. Pasic. 1994. Physiologic chest sounds and helicopter engine noise. *Aviat.Space Environ.Med.* 65:338-340.
Abstract: To develop an amplification system for physiologic chest sounds during air medical transport in jet helicopters, we compared frequency spectra of physiologic chest sounds and Allison C-28 equipped jet helicopter noise. We found that the frequency spectrum of physiologic chest sounds is contained entirely within that of jet rotocraft noise. Attempts to amplify physiologic chest sounds or to filter jet rotorcraft noise will invariably fail to improve perception of chest sounds. Future research

must focus on assessment of actual movement of the chest and of each hemithorax, as well as an carbon dioxide production, as indicators of adequate ventilation and proper endotracheal tube position

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Abstract: Respiratory sounds of pathological and healthy subjects were analyzed via autoregressive (AR) models with a view to construct a diagnostic aid based on auscultation. Using the AR vectors, two reference libraries, pathological and healthy, were built. Two classifiers, k- nearest neighbour (k-NN) classifier and a quadratic classifier, were designed and compared. Performances of the classifiers were tested for different model orders. The best classification results were obtained for model order 6

619. Schreur, H. J., J. Vanderschoot, A. H. Zwinderman, J. H. Dijkman, and P. J. Sterk. 1994. Abnormal lung sounds in patients with asthma during episodes with normal lung function. *Chest* 106:91-99.
Abstract: Even in patients with clinically stable asthma with normal lung function, the airways are characterized by inflammatory changes, including mucosal swelling. In order to investigate whether lung sounds can distinguish these subjects from normal subjects, we compared lung sound characteristics between eight normal and nine symptom-free subjects with mild asthma. All subjects underwent simultaneous recordings of airflow, lung volume changes, and lung sounds during standardized quiet breathing, and during forced maneuvers. Flow- dependent power spectra were computed using fast Fourier transform. For each spectrum we determined lung sound intensity (LSI), frequencies (Q25%, Q50%, Q75%) wheezing (W), and W%. The results were analyzed by ANOVA. During expiration, LSI was lower in patients with asthma than in healthy controls, in particular at relatively low airflow values. During quiet expiration, Q25% to Q75% were higher in asthmatics than in healthy controls, while the change of Q25% to Q75% with flow was greater in asthmatic than in normal subjects. The W and W% were not different between the subject groups. The results indicate that at given airflows, lung sounds are lower in intensity and higher in pitch in asthmatics as compared with controls. This suggests that the generation and/or transmission of lung sounds in symptom-free patients with stable asthma differ from that in normal subjects, even when lung function is within the normal range. Therefore, airflow standardized phonopneumography might reflect morphologic changes in airways of patients with asthma

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621. Selley, W. G., R. E. Ellis, F. C. Flack, C. R. Bayliss, and V. R. Pearce. 1994. The synchronization of respiration and swallow sounds with videofluoroscopy during swallowing. *Dysphagia* 9:162-167.
Abstract: Simultaneous recording of adult subjects sipping small amounts of fluid from a cup have been obtained by videofluoroscopy together with feeding respiratory patterns and swallow sounds from the Exeter Dysphagia Assessment Technique (EDAT). These allowed visual representations of respiration and swallow sounds to be superimposed on a videofluoroscopy recording using a split-screen technique. Sequentially numbered, 1/50 sec, half-frame photographic prints were examined and schematic drawings of the relevant radiographs were made. These were superimposed on to the actual EDAT printed chart of the same swallow event, their exact time relationship with respiration and cervical swallow sounds being preserved. The results allow events in the barium videofluoroscopy to be related to events in the feeding respiratory pattern and swallow sounds recorded by EDAT

622. Tavel, M. E., D. D. Brown, and D. Shander. 1994. Enhanced auscultation with a new graphic display system. *Arch.Intern.Med.* 154:893-898.
Abstract: BACKGROUND: To provide an objective method to support and teach auscultation, a new portable system (graphic display system) was evaluated for graphic display and printing of heart sounds. METHODS: Ninety-one patients from three institutions, with a variety of heart sound abnormalities, were studied by two examiners. A graphic recording was made in each and compared with the auscultatory findings. RESULTS: The findings of the graphic system confirmed the auscultatory impressions of both examiners in 77 (85%) of the 91 cases. Brief sound transients, such as split second sounds and ejection sounds, third heart sounds, and prosthetic opening and closing sounds, were all regularly recorded with the graphic system, often allowing resolution when examiners were in disagreement. Graphic recordings commonly were at variance with examiners in detecting fourth sounds, possibly because of examiners' difficulty in distinguishing these from split first sounds as well as limitations of the graphic system itself. High- pitched murmurs of low intensity (< grade 2), as exemplified by those of aortic and mitral regurgitation, were occasionally missed by the graphic system, probably because of baseline interference by background noise. CONCLUSIONS: The graphic display system can often provide more information than can be obtained by standard auscultation alone, especially in the detection of low-frequency and multiple sounds, and in the accurate timing of intervals. It is often unable to detect soft high-frequency murmurs. Permanent records allow for more objective comparison of the auscultatory findings of various examiners at different times. This system provides an excellent means by which auscultation skills may be taught or enhanced, especially since its speed and portability allow immediate feedback for comparison with auditory perceptions

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Abstract: A problem in mechanical ventilation is the accumulation of mucus secretions in the endotracheal tube (ETT), which tends to reduce the patent cross-sectional area. Here we characterized the extent and locus of the ETT obstruction using an acoustic reflection method recently modified to be applied at bedside. Experiments were conducted both in vivo in 10 intubated patients and in vitro in ETT with or without known constrictions of 1 to 3 mm over 5 cm, located at various distances from the ETT entry: 5, 10, 15, and 20 cm. Acoustic results were compared with the results obtained by an hydraulic reference method, which was the only method available to measure ETT obstruction in mechanically ventilated patients. In vivo acoustic results showed that area reductions were maximal near the tracheal extremity of the ETT, with a range from 2 to 36% (mean value 13 +/- 10%), when estimated relative to the area measured in an unused ETT of the same inner diameter (7 to 9 mm). Statistical analysis of the differences between acoustic reflection data and hydraulic data showed that the two methods did not differ significantly. In vitro acoustic results obtained in constricted ETT showed a highly significant correlation with the actual area ($r = 0.97$, $p = 0.0001$). Thus, reductions in ETT area may be detected, quantified, and located by the present acoustic reflection method, which therefore provides a means to avoid emergency extubation because of ETT obstruction

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Abstract: A model for the dependence of normal lung sounds upon airflow and air volume recorded at the mouth, is proposed and investigated. Data from 8 healthy subjects and 2 sessions have been analysed. Test statistics give very strong support for the adequacy of the model. This opens possibilities for diagnostic application of the model to normal lung sounds. Several suggestions are given for still further improvement of the model

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Abstract: It is desirable to screen snoring patients for obstructive sleep apnoea (OSA) prior to surgical treatment. We postulated that the addition of a sound profile would increase the value of overnight oxygen saturation (SaO_2) as a screening method. Thirty-nine polysomnographic studies including sound level measured by calibrated meter were performed on snorers being considered for uvulopalato-pharyngoplasty (UPPP). Polysomnography showed an apnoea/hypopnoea index (AHI) > or = 15 per hour of sleep in seven subjects. Two experienced observers independently, without knowledge of other data, classified paper records of SaO_2 alone and SaO_2 plus sound level obtained during polysomnography as OSA 'unlikely', 'equivocal' or 'definite'. The addition of sound to SaO_2 reduced the number of equivocal results from 14 to six and increased the number classified as 'definite' or 'unlikely'. The sensitivity of oximetry +/- sound increased as the threshold AHI used in the definition of OSA increased; addition of sound improved recognition of mild OSA without impairing specificity

626. Wodicka, G. R., S. S. Kraman, G. M. Zenk, and H. Pasterkamp. 1994. Measurement of respiratory acoustic signals. Effect of microphone air cavity depth. *Chest* 106:1140-1144.
Abstract: The use of electret microphones to measure lung sounds is widespread because of their small size, high fidelity, and low cost. Typically, an air cavity is placed between the skin surface and the microphone to convert the chest wall vibrations into a measurable sound pressure. The importance of air cavity depth on this transduction process was investigated in this study. An acoustic model of chest wall--air cavity- -microphone interface was developed and the predicted effects of depth were compared with measurements performed using an artificial chest wall and lung sounds from a healthy subject. Model predictions are in general agreement with both in vitro and in situ measurements and indicate that the overall high-frequency response of the transduction diminishes with increasing cavity depth. This finding suggests that smaller cavity depths are more appropriate for detection of lung sounds over a wide band width and stresses the importance of coupler size on microphone measurements

627. Wodicka, G. R., P. D. DeFrain, and S. S. Kraman. 1994. Bilateral asymmetry of respiratory acoustic transmission. *Med.Biol.Eng Comput.* 32:489-494.
Abstract: Sonic noise transmission from the mouth to six sites on the posterior chest wall is measured in 11 healthy adult male subjects at resting lung volume. The measurement sites are over the upper, middle and lower lung fields and are symmetric about the spine. The ratios of transmitted sound power to analogous sites over the right (R) and left (L) lung fields are estimated over three frequency bands: 100-600 Hz (low), 600-1100 Hz (mid) and 1100-1600 Hz (high). A R-L dominance in transmission is measured at low frequencies, with a statistically significant difference observed at the upper site. No significant asymmetry is observed in any measurement site at mid or high frequencies. A theoretical model of sound transmission that includes the asymmetrical anatomy of the mediastinal structures is in agreement with the observed asymmetry at low frequencies. These findings suggest that the pathway of the majority of sound transmission from the trachea to the chest wall changes from a more radial to airway-borne route over the measured frequency range

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Abstract: BACKGROUND--Crackles are a prominent clinical feature of asbestosis and may be an early sign of the condition. Auscultation, however, is subjective and interexaminer disagreement is a problem. Computerised lung sound analysis can visualise, store, and analyse lung sounds and disagreement on the presence of crackles is minimal. High resolution computed tomography (HRCT) is superior to chest radiography in detecting early signs of asbestosis. The aim of this study was to compare clinical auscultation, time expanded wave form analysis (TEW), chest radiography, and HRCT in detecting signs of asbestosis in asbestos workers. METHODS--Fifty three asbestos workers (51 men and two women) were investigated. Chest radiography and HRCT were assessed by two independent readers for detection of interstitial opacities. HRCT was performed in the supine position with additional sections at the bases in the prone position. Auscultation for persistent fine inspiratory crackles was performed by two independent examiners unacquainted with the diagnosis. TEW analysis was obtained from a 33 second recording of lung sounds over the lung bases. TEW and auscultation were performed in a control group of 13 subjects who had a normal chest radiograph. There were 10 current smokers and three previous smokers. In asbestos workers the extent of pulmonary opacities on the chest radiograph was scored according to the International Labour Office (ILO) scale. Patients were divided into two groups: 21 patients in whom the chest radiograph was > 1/0 (group 1) and 32 patients in whom the chest radiograph was scored < or = 1/0 (group 2) on the ILO scale. RESULTS--In patients with an ILO score of < or = 1/0 repetitive mid to late inspiratory crackles were detected by auscultation in seven (22%) patients and by TEW in 14 (44%). HRCT detected definite interstitial opacities in 11 (34%) and gravity dependent subpleural lines in two (6%) patients. All but two patients with evidence of interstitial disease or gravity dependent subpleural lines on HRCT had crackles detected by TEW. In patients with an ILO score of > 1/0 auscultation and TEW revealed mid to late inspiratory crackles in all patients, whereas HRCT revealed gravity dependent subpleural lines in one patient and signs of definite interstitial fibrosis in the rest. In normal subjects crackles different from those detected in asbestosis were detected by TEW in three subjects but only in one subject by auscultation. These were early, fine inspiratory crackles. CONCLUSION--Mid to late inspiratory crackles in asbestos workers are detected by TEW more frequently than by auscultation. Signs of early asbestosis not apparent on the plain radiograph are detected by TEW and HRCT with similar frequency. off

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Abstract: Prior studies have shown that laryngotracheal sounds are vectors of objective information which indicate the origins and mechanisms of sound production. The first objective of this study is to confirm these earlier findings on a larger scale. The second objective is to develop a simple apparatus which permits the rapid acquisition and analysis of information for a prompt diagnosis. This study will be carried out in infants referred to the Department of otolaryngology of the Kremblin- Bicetre Hospital over the next two years. The material and methods used are described

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Abstract: This study investigated the accuracy and inter-rater reliability of 'specialized' physical therapists in the auscultation of tape-recorded lung sounds. In addition, a correlation was investigated between accuracy of interpretation and the number of years of specialization in the field of cardiorespiratory physical therapy. This research follows an earlier study which investigated the accuracy and inter-rater reliability of auscultating tape-recorded lung sounds in a 'non- specialized' cohort of physical therapists. The subjects were 26 'specialized' cardiorespiratory physical therapists working in acute urban teaching hospitals. These individuals were required to have been practising currently and exclusively for at least one year in the area of cardiorespiratory physical therapy. Participants listened with a stethoscope to five different sounds and identified them from a standardized list of terms. One of three tapes with the same lung sounds in different order was randomly selected for each physical therapist. The percentage of correct answers for all subjects was calculated. An accurate response in the detection of lung sounds was arbitrarily defined as a percentage of correct answers of 70% or greater. The difference between the pooled correct response rate of 50% and the arbitrarily set value of 70% was statistically significant ($z = 2.23$, $p < 0.05$), indicating that the 'specialized' physical therapists were not accurate in identifying lung sounds. There was no relationship evident between the accuracy and the number of years of cardiorespiratory 'specialization' ($r = 0.08$). Analysis of inter-rater reliability revealed 'fair agreement' (kappa = 0.26) among subjects. These results were similar to those found in the previous study.(ABSTRACT TRUNCATED AT 250 WORDS)

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Abstract: Heart sounds provide clinicians with valuable diagnostic and prognostic information. They are repetitive in nature, but reflect complex mechano-acoustical events which have been inadequately described by traditional digital signal processing methods. In this study, left ventricular and aortic intravascular phonocardiograms were obtained from six patients by catheter-mounted piezoelectric transducers. Phonocardiograms (PCGs) were bandpass filtered (50-500 Hz), digitized at 4kHz and analyzed by three separate techniques: (1) Short-Time Fourier Transform (STFT), (2) Fast Wavelet Transform (FWT), and (3) a pulse-counting time-domain method based on an Order Statistic (OS) filter. The resulting time-frequency distributions were

employed to examine intra-patient and inter-patient acoustic variability. Results suggest that STFT and FWT provide comparable temporal and frequency resolution of cardiac acoustical events. However, the time-varying and multicomponent nature of heart sounds was poorly characterized by the OS technique employed in this study. This study suggests that improved localization of acoustic events during the cardiac cycle may prove useful in the development of automated auscultation devices

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Abstract: We found that on pulmonary auscultation, fine crackles could be induced by changing the posture from sitting to supine and/or from supine to supine with passive leg elevation in patients without obvious congestive heart failure. We named these crackles "posturally induced crackles (PIC)." To investigate the relationship between PIC and long-term prognosis after myocardial infarction, we followed up 262 patients who recovered from acute myocardial infarction for a mean period of six years. Cardiac death occurred in three of 78 PIC-negative patients and in 28 of 143 PIC-positive patients. PIC-negative patients had a significantly better long-term prognosis than PIC-positive patients according to the Kaplan-Meier survival curves for cardiac death ($p < 0.01$). In a multilogistic model based on 70 appropriate cases, PIC was the third most important prognosticator after recovery from myocardial infarction and the number of diseased coronary vessels and the pulmonary capillary wedge pressure ranked first and second, respectively

634. Gavriely, N. and O. Jensen. 1993. Theory and measurements of snores. *J.Appl.Physiol* 74:2828-2837.
Abstract: Upper airway narrowing, collapsibility, and resistance are recognized predisposing factors for snoring and obstructive sleep apnea, but the mechanisms of their action and interaction are not known. We studied a simple theoretical model of the upper airways, consisting of a movable wall in a channel segment that connects to the airway opening via a conduit with a resistance. Inspiratory flow (V) through the channel segment causes local pressure changes due to viscous losses and the Bernoulli force that may overcome the elastic forces acting on the movable wall. The model predicts instability leading to upper airway closure over a wide range of parameter values. Increasing inspiratory V above a boundary, determined by values of upper airway resistance, segment compliance, length, width, and diameter, as well as gas density, leads to a dynamic airway closure. The mathematical model establishes the power relationships between parameters and provides physiologically realistic quantitative simulation of upper airway closure when values are adapted from literature and from radiographic measurements of upper airway motion induced by negative pressure. The rate of appearance of repetitive sound structures during snoring was favorably compared with the model's prediction of the time course of wall motion during collapse. V measurements during simulated snores revealed an asymmetric oscillatory pattern compatible with repetitive upper airway closure. We conclude that snoring may be modeled as a series of dynamic closure events of the upper airways. The model predicts that the width and length of the movable portion of the upper airways and the gas density are likely to affect the onset of snoring, in addition to other, previously recognized, parameters

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Abstract: To evaluate the accuracy of the acoustic reflection (AR) technique for determination of nasal cavity cross-sectional areas, the area-distance function of both sides of the nose was determined in 10 subjects and compared with magnetic resonance imaging (MRI). Interindividual variation for the correlation between MRI and AR was seen, but in general the areas from 1 to 6 cm into the nasal cavity measured by AR were larger than areas measured by MRI, especially where the surface was most convoluted. The total volume for this region was 6.47 +/- 1.83 (SD) cm3 for AR and 5.65 +/- 1.34 cm3 for MRI. It was demonstrated that this could be due to errors in calculation of the areas on the basis of MRI and AR. In the posterior part of the nasal cavity and the epipharynx, there was a convincingly higher correlation between acoustic measurements and a scan perpendicular to the assumed geometrical axis of the epipharynx than between acoustic measurements and coronal scanning. This indicates that the sound axis roughly follows the geometrical axis. In a model of two tubes (nasal cavities) joined in a larger tube (the epipharynx), closure of the posterior part of the latter revealed that the contralateral nasal cavity is likely to cause overestimation of the posterior part of the epipharynx during AR compared with MRI

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637. Hoffstein, V., S. Mateika, and A. Metes. 1993. Effect of nasal dilation on snoring and apneas during different stages of sleep [see comments]. *Sleep* 16:360-365.
Abstract: This study was designed to test the hypothesis that nasal dilation reduces snoring. To achieve this we performed nocturnal polysomnography, including measurement of snoring, in 15 patients without nasal pathology before and after insertion of

a nasal dilator (NOZOVENT). Snoring was quantified for each sleep stage by recording the number of snores per minute of sleep, number of snores per minute of snoring time and nocturnal sound intensities (maximum, average and minimum). We found that nasal dilation had no effect on the number of apneas, hypopneas or oxygen saturation. Snoring parameters were unaffected by NOZOVENT during stages I, II and REM sleep, but were all significantly reduced during slow wave sleep. We conclude that dilation of the anterior nares in patients without nasal pathology has a relatively weak effect on snoring, and routine use of nasal dilating appliances is not recommended for treatment of snoring

638. Issa, F. G., D. Morrison, E. Hadjuk, A. Iyer, T. Feroah, and J. E. Remmers. 1993. Digital monitoring of sleep-disordered breathing using snoring sound and arterial oxygen saturation. *Am.Rev.Respir.Dis.* 148:1023-1029.
Abstract: A new portable digital recorder (SNORESAT) that uses the sound of snoring and arterial oxygen saturation (SaO2) to monitor breathing abnormalities during sleep was constructed and compared in the laboratory with standard overnight polysomnography (PSG). The device digitally records sound from a transducer applied to the chest and SaO2 from a commercially available ear oximeter. A snore is identified when the moving time average of the sound exceeds a threshold voltage level longer than 0.26 s. The stored data are transferred to a personal computer for poststudy analysis. An analysis algorithm identifies a respiratory disturbance event when a quiet period of 10 to 120 s separates two snores and is associated with a fall in SaO2 exceeding 3%. The respiratory disturbance index (RDI), mean apnea duration, mean lowest SaO2, and number of desaturations > 3% are computed. A total of 129 referrals to the sleep apnea outpatient clinic underwent simultaneous all-night recording of PSG and SNORESAT. Using the computed RDI recorded by the SNORESAT, the sensitivity and specificity of the monitor in detecting sleep apnea syndrome (SAS) ranged between 84 and 90% and 95 and 98%, respectively, depending on the PSG value of RDI used to define SAS (range, > or = 7 to > or = 20 events/h). Using a PSG value of RDI > or = 10, or > or = 20 RD/h as the definition for SAS, the prevalence of SAS in the referral population was 45 and 31%, respectively.(ABSTRACT TRUNCATED AT 250 WORDS)

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640. Korpas, J., J. G. Widdicombe, and M. Vrabec. 1993. Influence of simulated mucus on cough sounds in cats. *Respir.Med.* 87:49-54.
Abstract: Although in the clinic the presence of mucus in the airways is known to be an important factor influencing the sound of coughing in pathological conditions, this observation has not been established experimentally. We have substituted mucus in the airways of anaesthetized cats with 0.5 ml of natural undiluted egg albumin (EA) from hens' eggs, or with 1 ml of 10% pig gastric mucin (PGM) in saline. There were obvious changes in the character of cough sounds and significant increases in the intensity of the sounds (+76% with EA, +36% with PGM). The intensity of cough efforts significantly increased but only in the cats with addition of PGM (mean 30%). Removal of EA or PGM caused the opposite effects, a decrease in cough sounds (-41%) and intensity of cough effort (-52%), with simultaneous changes in the character of the cough sounds. There were no clear-cut patterns of cough sounds as has been described for humans. The cough sounds were often present not only during the expiratory phase of cough but also during the inspiratory phase. The results establish an important role of mucus in the airways in the creation of cough sounds

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Abstract: We have assessed the importance of changes in lung structure on the pattern of cough sound and its creation with 13 anaesthetized cats. Acute lung injury with oedema was induced by i.v. administration of a mixture of fatty acids. Cough was elicited by mechanical stimulation of the mucous membranes of the airways and was evaluated by its intensities of effort and sound before and up to 2 h after administration of the fatty acids. Changes of cough sound pattern were not definitive, there being no typical alterations. The cough effort and sound intensities, induced from the trachea, consistently decreased (by 70-80% in both cases). The cough efforts immediately after induction of oedema were transiently abolished in some cats. The cough values induced from the larynx similarly decreased at 5 min (51-57%) but subsequently gradually returned to control values. There were significant correlations, both for coughs induced from the trachea and from the larynx, and for changes in intensity of efforts compared with sounds. Thus, pathological changes in the lungs modify the intensities both of cough efforts and their associated sounds

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643. Loudon, R. G. 1993. Clinical application of wheeze analysis. *Monaldi Arch.Chest Dis.* 48:583-585.

644. Louis, B., G. Glass, B. Kresen, and J. Fredberg. 1993. Airway area by acoustic reflection: the two-microphone method. *J.Biomech.Eng* 115:278-285.
Abstract: This report deals with noninvasive imaging of airway geometry based upon information contained in acoustic reflections measured at the mouth. Here we describe a new theoretical approach that enables development of a new miniaturized apparatus. Unlike the single- transducer systems used currently, this new strategy is based upon a two-transducer system that is a variant of that suggested originally by Shroeder (1967). We have developed, implemented, and tested computational algorithms necessary to reconstruct airway dimensions from acoustic reflection data using this two-transducer strategy

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Abstract: The review compares five methods that utilise electronic/computer acoustic processing techniques for the analysis of infantile stridor sounds. The first method uses traditional spectrographic techniques to produce time/frequency/intensity three-dimensional representation of the waveform. The second method is computer-based and uses the fast Fourier transformation (FFT) to show the frequency composition of the waveform. The third uses linear prediction coefficients (LPCs) to produce a power spectrum and inverse filtering to estimate the cross-sectional area of the human upper airway. The fourth technique employs a proprietary digital filterbank to analyse normal infant vocalisations, which may be used as a control by subsequent researchers. In the fifth method, a physiologically based digital filterbank, designed to closely model the human ear response, is proposed. It is envisaged that this approach will offer the flexibility of all the previous techniques and also closely model the analysis procedure carried out using subjective auscultation. It is concluded that none of the above techniques are sufficiently robust to provide unambiguous diagnosis of stridor type and that a reappraisal is required in terms of feature extraction so that relevant features can be identified. To this end, the authors propose that a physiologically based model of the human airway, including the vocal cords, be developed as an aid to the assessment of acoustic features

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Abstract: A prototype instrument to guide the placement and continuously monitor the position of an endotracheal tube (ETT) was developed. An incident audible sound pulse is introduced into the proximal ETT and detected as it travels down the ETT via a miniature microphone located in the wall. This pulse is then emitted from the tube tip into the airways and the reflected signal from the airways is detected by the microphone. A well defined reflection arises from the point where the total cross sectional area of the airways increases rapidly, and the difference in timing between detection of the incident pulse and this reflection is used to determine ETT position or movement. This reflection is not observed if the ETT is erroneously placed in the esophagus. The amplitude and polarity of an additional reflection that occurs at the ETT tip is used to estimate the cross-sectional area of the airway in which the ETT is placed. This combined information allows discrimination between tracheal and bronchial intubation and can be used to insure an adequate fit between the ETT and trachea. The instrument has proven extremely reliable in multiple intubations in eight canines and offers the potential to noninvasively and inexpensively monitor ETT position in a continuous manner

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Abstract: A practical implementation of acoustic reflectometry for determining airway areas in routine clinical use is described. Advances over previous systems include portability, free breathing during measurements, no need to equilibrate with helium/oxygen, and real-time display of airway areas. Validation of the reflectometer with an airway model gave accuracies and reproducibilities (coefficient of variation (CV)) in the range 5-10%. With human volunteers, the within-run CV was typically 10%, and the day-to-day CV was 20%. The effect of breathing pattern on airway areas is demonstrated. In ten normal volunteers, acoustic and magnetic resonance imaging (MRI) methods of assessing pharyngeal and glottal areas were compared. The results (mean +/- SD) for the oropharynx were 1.0 +/- 0.3 cm2 acoustically and 0.9 +/- 0.5 cm2 by MRI (p = 0.77). The corresponding figures for glottal areas were 1.3 +/- 0.3 cm2 and 1.1 +/- 0.4 cm2 (p = 0.09)

648. Miljeteig, H., P. Savard, S. Mateika, P. Cole, J. S. Haight, and V. Hoffstein. 1993. Snoring and nasal resistance during sleep. *Laryngoscope* 103:918-923.
Abstract: Although it is widely accepted that nasal obstruction leads to snoring and sleep apnea, the relationship between these variables is not clear, mainly because of the lack of studies in which nasal resistance (Rna) and snoring were measured concurrently. The authors studied eight nonapneic snoring men with healthy noses by nocturnal polysomnography that included quantitative assessment of snoring and concomitant nasal resistance. In six of these eight patients nasal resistance increased during sleep, but there was no significant change for the group as a whole between wakefulness (0.209 +/- 0.224 Pa/cm3 per second) and sleep (0.292 +/- 0.203 Pa/cm3 per second). Linear regression analysis showed no significant correlation between sleeping nasal resistance and snoring index (partial R2 = .44, P = .071). We used each subject as his own control and compared

the snoring profile at a time during sleep when nasal resistance was at its highest (0.550 +/- 0.375 Pa/cm3 per second) and lowest (0.146 +/- 0.090 Pa/cm3 per second) levels. Despite the significant (P < .01) differences in nasal resistance, they were not reflected in the number of snores or their sound intensity. It is concluded that nasal obstruction during sleep is not correlated significantly to frequency or intensity of snoring during exclusively nasal breathing

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650. Nissan, M. and N. Gavriely. 1993. A microcomputer based lung sounds analysis. *Comput.Methods Programs Biomed.* 40:7-13.
Abstract: The use of a microcomputer in lung sound-analysis is described. The system was used experimentally in order to evaluate automated auscultation as a mean for improving the sensitivity of pulmonary health mass screening. The sound signals from four custom-made piezoelectric transducers, affixed at specific locations on the chest wall, and the breathing flow signal produced by a pneumotachograph were amplified, filtered and digitized simultaneously at 4000 Hz per channel for 512 ms. The acoustic data were transformed to the frequency domain to enable the calculation of the power spectra. Those were averaged over successive runs and displayed as log power vs. frequency. The operator could assess the convergence of the spectral pattern using the on-line graphics and calculated parameters, and store the data once the noise level had reached a preset level. This procedure was repeated during expiration, inspiration and on breath arrest. The results of the off-line analysis of the lung sounds, combined with pulmonary function tests and a questionnaire, were used to identify lung pathology

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Abstract: The influence of posture on nasal cavity geometry was studied by acoustic rhinometry in 14 normal adult subjects. On adopting a supine position from sitting the volume of the initially more patulous nasal cavity decreased and the volume of the less patulous side increased. These changes in volume are statistically significant (p = less than 0.01)

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Abstract: We assessed the performance of three air-coupled and four contact sensors under standardized conditions of lung sound recording. Recordings were obtained from three of the investigators at the best site on the posterior lower chest as determined by auscultation. Lung sounds were band-pass filtered between 100 and 2,000 Hz and sampled simultaneously with calibrated airflow at a rate of 10 kHz. Fourier techniques were used for power spectral analysis. Average spectra for inspiratory sounds at flows of 2 +/- 0.5 L/s were referenced against background noise at zero flow. Air-coupled and contact sensors had comparable maximum signal-to-noise ratios and gave similar values for most spectral parameters. Unexpectedly, less sensitivity (lower signal- to-noise ratio) at high frequencies was observed in the air-coupled devices. Sensor performance needs to be characterized in studies of lung sounds. We suggest that lung sound spectra should be averaged at known airflows over several breaths and that all measurements should be reported relative to sounds recorded at zero flow

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Abstract: We analyzed snoring noise from 10 nonapneic heavy snorers and nine patients with obstructive sleep apnea (OSA). Sound was recorded simultaneously through two microphones, one attached to the manubrium sterni and one suspended in the air 15 cm from the patient's head. Signals were stored on magnetic tape, digitized, and displayed in the time and frequency domains. Most of the power of snoring noise was below 2,000 Hz, and the peak power was usually below 500 Hz. When snores were generated during nose-only breathing (nasal snores), the sound spectrum was made up of a series of discrete, sharp peaks, with a fundamental note and harmonics similar to the spectrum of voiced sounds. When snores were generated during breathing through nose and mouth (oronasal snores), the spectra showed a mixture of sharp peaks and broad-band white noise. Patients with apnea showed a sequence of snores with spectral characteristics that varied markedly through an apnea-respiration cycle. The first postapneic snore consisted mainly of broad-band white noise with relatively more power at higher frequencies, so that the ratio of power above 800 Hz to power below 800 Hz could be used to separate snorers from patients with OSA. Other breaths in the cycle resembled oronasal or nasal snores in nonapneic subjects. Characteristics of the noise give information about the possible mechanism of sound generation and thus about the behavior of the pharynx during snoring. Quality of snoring sound may help to separate patients with obstructive apnea from those with simple snoring

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Abstract: In 23 subjects with chronic obstructive pulmonary disease (COPD) who wheezed when changing their position from sitting to dorsal decubitus (DD), we recorded lung volumes and flow volume loops in sitting (S1), DD and immediately after resuming sitting (S2). We found three main patterns of ventilatory changes associated with wheezing in DD: (1) acute obstruction (AO) in 14 subjects characterized by FEV1 > or = -10% and %FEV1/FVC > or = -3%; functional residual capacity or residual

volume was increased, decreased or unchanged; (2) acute restriction (AR) in 7 subjects characterized by absence of obstruction spirographically and FVC and/or FRC > -10%; (3) indeterminate response (IR) in 2 subjects. Except for 3 subjects, the changes recorded in DD returned to baseline in S2. Both AO and AR responses in DD and their rapid resolution in S2 were reproducible (11 subjects). In conclusion: (1) in COPD, DD may trigger wheezing; (2) the physiologic changes during DD wheezing are reproducible, rapidly reversible when the sitting position is resumed and unlike those recorded during bronchoprovocation, heterogeneous

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656. Rossi, M., G. Pasquali, R. Barnabe, P. Rottoli, S. Ottomano, S. Solitro, and M. Vagliasindi. 1993. Phonopneumographic findings in patients with sarcoidosis and lung fibrosis. *Sarcoidosis.* 10:156-157.

657. Rotger, M., R. Farre, D. Navajas, and R. Peslin. 1993. Respiratory input impedance up to 256 Hz in healthy humans breathing foreign gases. *J.Appl.Physiol* 75:307-320.
Abstract: Currently available data concerning respiratory input impedance (Zrs) at frequencies up to 300 Hz indicate that Zrs is determined mainly by the airways and, in particular, the gas compressibility in the airways and the airway wall compliance. Hence, measurements of Zrs when breathing gases with different physical properties would be useful in investigating airway mechanics and the role of acoustic propagation. Zrs measured with a standard generator (Zst) and corrected for the upper airway shunt (Zrs*) were measured in nine healthy subjects breathing air or a gas mixture consisting of 20% O2 and 80% He or SF6. The frequency band was extended up to 256 Hz for air and He-O2 and up to 128 Hz for SF6-O2. Zrs exhibited a similar pattern for the three gases, with a shift toward low frequencies as the gas density increased. Moreover, the resonance peaks tended to be narrower and higher as the gas density increased. The second frequency of resonance for He-O2, air, and SF6-O2 were 220, 180, and 50 Hz, respectively, for Zrs* and were systematically higher for Zst. Zrs* and Zst data were interpreted in terms of a tricompartmental model that partitioned the airways into two segments: a central one featuring the acoustic propagation in the airways and a peripheral one that included bronchial wall elasticity (Farre et al. J. Appl. Physiol. 67: 1973-1981, 1989). The model was able to interpret the gas dependence of Zrs* but not that of Zst. The influence of the gas physical properties on both Zrs* and Zst confirms that total Zrs at high frequencies is basically that of the airways and that the second resonance is related mainly to the gas compressibility in the airways

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659. Sanchez, I., A. Avital, I. Wong, A. Tal, and H. Pasterkamp. 1993. Acoustic vs. spirometric assessment of bronchial responsiveness to methacholine in children. *Pediatr.Pulmonol.* 15:28-35.
Abstract: To study wheezing as an indicator of bronchial responsiveness during methacholine challenge (MC) in children, we used computer analysis of respiratory sounds and compared wheeze measurements to routine spirometry. MC was performed in 30 symptomatic subjects (sympt), age 11 +/- 3.1 years (mean +/- SD), with suspected asthma and in 12 controls (contr), age 10 +/- 3.4 years. Respiratory rate (RR), spirometry, arterial oxygen saturation (SaO2), and cough were registered until the concentration provoking a > or = 20% fall in forced expiratory flow in 1 second (FEV1;PC20), or the end point (8 mg/mL) was reached. For 1 min after each inhalation, sounds over the trachea and posterior right lower lobe were recorded together with calibrated airflow. Computer analysis of respiratory sounds was used for objective wheeze quantification. Wheezing was measured as its duration relative to inspiration (Tw/Ti) and expiration (Tw/Te). Seventeen of the sympt group developed wheezing (sympt/W) with > or = 5% Tw/Ti or > or = 5% Tw/Te. Thirteen of the sympt did not wheeze (sympt/no W). Three contr developed wheeze (contr/W) while 9 did not (contr/no W). In sympt/W, RR increased from 20 +/- 6.2 per min at baseline to 25 +/- 9.2 ($P < 0.05$) at the MC concentration provoking wheeze (PCw), and SaO2 decreased from 97.4 +/- 1.2% to 95.3 +/- 2.4 ($P < 0.05$). In contr/W, RR did not change, but SaO2 decreased from 97.3 +/- 1.5% to 95.7% +/- 1.2% ($P < 0.05$). Wheezing occurred at both recording sites and was as common during inspiration as during expiration.(ABSTRACT TRUNCATED AT 250 WORDS)

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Abstract: To study wheeze as an indicator of bronchial responses during standardized methacholine challenge (MCH), we used computerized analysis of respiratory sounds in children with cystic fibrosis (CF) and in healthy control subjects. We recorded tracheal and lung sounds from 10 young CF = yCF patients, mean age 5.7 yr (range 4 to 7 yr), 13 older CF = oCF, age 10.5 yr (8 to 18 yr), 7 young normal subjects = yNO, age 5.3 yr (4 to 7 yr), and 11 older normal subjects = oNO, age 11 yr (8 to 16 yr). Spirometry was obtained after each doubling concentration of methacholine until the concentration provoking a > or = 20% fall in FEV1 (PC20) or the end point (8 mg/ml) was reached. Sound and calibrated flow signals were recorded on tape and later analyzed by respirosonography. The concentration of methacholine associated with wheeze (PCw) was noted. Wheezing was quantified by

its duration during inspiration (Tw/TI) and expiration (TW/TE). We found a positive response to MCH in 11 of 13 oCF (PC20 0.75 mg/ml, range 0.08 to 3.0) and in 3 of 11 oNO (PC20 4.2 mg/ml, range 2.5 to 6.5). Wheezing occurred in 6 oCF (PC20 < 8 mg/ml). In 7 yCF PC20 or PCW developed (1.51 mg/ml, range 0.125 to 4.0) versus 4 yNO (4.0 mg/ml, range 2.0 to 8.0). In 10 oCF subjects who performed MCH on three occasions within a 2-wk period, both positive and negative wheeze responses were reproducible. Patients who wheezed had a lower FRC compared with patients who did not (109 versus 147% of predicted, p < 0.05).(ABSTRACT TRUNCATED AT 250 WORDS)

661. Sanchez, I. and H. Pasterkamp. 1993. Tracheal sound spectra depend on body height. *Am.Rev.Respir.Dis.* 148:1083-1087.
Abstract: Tracheal sounds originate from turbulent flow in upper and central airways. Turbulent flow characteristics are influenced by conduit dimensions. Because tracheal dimensions are a function of body height, we hypothesized that there should be a correlation between sound spectra and body length. We recorded tracheal sounds at standardized airflows in 21 healthy children 9.1 +/- 0.6 yr of age (mean +/- SE) and in 24 healthy adults 30.2 +/- 0.8 yr of age. A contact sensor was attached at the suprasternal notch of the sitting subject, and airflow was measured at the mouth with a calibrated pneumotachograph. Tracheal sounds were low-pass-filtered at 2.4 kHz and digitized at 10 kHz. A 2048 point FFT was applied at a successive 100-ms intervals, using a Hanning data window. Resulting spectra were normalized to a reference power of 0.1 (mV)2/5 Hz. We applied a gating algorithm to extract sounds at inspiratory flows of 1 L/s (+/- 10% tolerance), and we computed average power spectra from the collected samples. We calculated the average spectral power (Pavg), the quartile frequencies below which 25% (Q1), 50% (Q2), and 75% (Q3) of the power in the range of 50 to 2,000 Hz was contained, the spectral edge frequency (SE95) below which 95% of the power was found, and the frequency where spectral power rolled off sharply (Fcut).(ABSTRACT TRUNCATED AT 250 WORDS)

662. Series, F., I. Marc, and L. Atton. 1993. Comparison of snoring measured at home and during polysomnographic studies. *Chest* 103:1769-1773.
Abstract: Snoring characteristics depend on several factors (sleep position, sleep architecture, breathing route) that can be influenced by changes in sleep habits and by the presence of the different probes and electrodes during polysomnographic studies. Our objective in this study was to compare the characteristics of snoring in the home environment with those of the sleep laboratory where most conventional studies are carried out. Fourteen nonapneic snorers were subjected to three night recording sessions within a two-week period, two at home and one in the sleep laboratory. To eliminate any sleep interference by the apparatus, breathing sounds were recorded with two microphones symmetrically placed on either side of the bed, the signal being preamplified and stored on a VHS hi-fi video recorder. The recorded signal was analyzed by using a spectrum analyzer (real time analyzer) and an equalizer to correct for acoustic resonances of the bedrooms. A snoring event was defined as a breathing sound with a sound pressure level (SPL) greater than 60 dB SPL. The snoring index (number/sleep hour) and the sound intensity of each event were automatically determined. The total sleep time (TST) was similar for the two home recordings (6.8 +/- 0.2 and 7.0 +/- 0.2 h, respectively, mean +/- SEM), but it was significantly shorter during the hospital study (6.0 +/- 0.3 h). The snoring indices obtained at home were 141.4 +/- 33.3 and 144.1 +/- 41.2/h and not statistically different from those obtained during the hospital recording (209.1 +/- 41.5/h). The percentage of TST spent above 60 dB SPL was significantly greater during the polysomnographic study (4.3 +/- 1.2 percent) than during the home recordings (2.5 +/- 0.7 and 2.9 +/- 1.0 percent, respectively). We conclude that the severity of snoring may be overestimated during polysomnographic recordings

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Abstract: We evaluated the effects of protriptyline on snoring characteristics in 14 nonapneic snorers (age range, 23 to 54 years; body mass index, 27.4 +/- 0.9 kg/m2, mean +/- SEM). The study design was a double-blind placebo-controlled crossover trial. Patients were evaluated during a polysomnographic study after each 2 weeks of treatment. Breathing sounds were recorded with two microphones symmetrically placed on each side of the bed, the signal being preamplified, equalized, and analyzed by using a real time analyzer. A snoring event was defined as a breathing sound with a sound pressure level (SPL) greater than 60 dB SPL. The snoring index (number/sleep hour) and the sound intensity of each event were automatically determined. Mild side effects were observed in ten subjects, but no subject interrupted the study because of them. The REM sleep time decreased with protriptyline with a parallel increase in stages 1 to 2. There was no difference in body position during sleep between the placebo and protriptyline trials. The snoring index decreased from 335 +/- 40 with placebo to 238 +/- 41 with protriptyline (p < 0.05) with important individual differences. Among the different sleep stages, the highest values of the snoring index were observed in slow-wave sleep with placebo. The snoring index decreased in each sleep stage with protriptyline, the highest decrease occurring in slow-wave sleep. The percentage of total sleep time (TST) spent above 60 dB SPL was significantly lower with protriptyline (6.1 +/- 1.2 percent TST) than with placebo (8.6 +/- 1.2 percent TST). Changes in snoring characteristics were not correlated with snoring severity, the drug blood level, the body mass index, or the drug-induced modifications in sleep architecture. We conclude that protriptyline can improve both snoring frequency and loudness in some nonapneic snorers, and that this improvement occurs mostly in the sleep stages where snoring is worst

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Abstract: It is reported that obstructive sleep apnea syndrome (OSAS) has a marked elderly male predominance and that patients with OSAS have reduced pharyngeal cross-sectional area and increased pharyngeal collapsibility. These reports suggest that the size and mechanical properties of the pharynx have sex- and age-related differences even in normal subjects. However, there are only a few reports on normal values of pharyngeal cross-sectional area and compliance. The purpose of this study was to determine the normal values of the pharyngeal cross- sectional area and compliance in Japanese healthy subjects and to determine sex-related differences and the effect of age, body size, and body posture on these parameters. We examined 181 subjects with an age range spanning 21-69 years, with normal range of body mass index and without enlarged tonsils or jaw retrusion. No subject complained of symptoms suggestive of OSAS. We measured the pharyngeal cross-sectional area in three body positions (sitting, lateral and supine) using the acoustic reflection technique (AAAR). Fifty airway area versus distance functions with a rate of 3 times per second were measured and averaged in each body position during normal breathing of room air. After identifying the fauces and the glottis on the averaged area versus distance function, we defined a region between 2 cm distal to the fauces and 2 cm proximal to the glottis as a pharyngeal segment and computed the mean area of that segment (mean pharyngeal cross-sectional area).(ABSTRACT TRUNCATED AT 250 WORDS)

665. Slawinski, E. B. and E. Dubanowicz-Kossowska. 1993. The assessment of hypertrophy of nasopharyngeal tonsil by acoustical methods. *Int.J.Pediatr.Otorhinolaryngol.* 27:229-244.
Abstract: The possibilities for using acoustical analysis as a noninvasive measure of the degree of obstruction created by an enlarged pharyngeal tonsil (adenoid) are discussed. The method capitalizes on the relationship which exists between a specific obstruction of the respiratory tract and the resulting respiratory sound. Results indicate that as the adenoid increases in size relative to the size of the nasopharynx, the dominant components of the respiratory sound spectrum shift towards a higher frequency range. Furthermore, the correlation found between the assessments of the obstruction due to various sizes of the adenoid by radiological methods and acoustical analyses supports the theoretical prediction that information on the size of the constriction is carried by the respiratory sound. Therefore, careful analyses of the acoustic patterns in the respiratory sound can assist in identifying constrictions and monitoring the constriction changes in the upper respiratory tract

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667. Stoohs, R., A. Skrobal, and C. Guilleminault. 1993. Does snoring intensity predict flow limitation or respiratory effort during sleep? *Respir.Physiol* 92:27-38.
Abstract: We tested whether snoring sound intensity could be an accurate predictor of the degree of respiratory effort or the decrease of inspiratory volume during partially obstructed breathing in sleep. Six snorers were investigated with nocturnal polygraphic monitoring including measurement of esophageal pressure (Pes), airflow (pneumotachometer and face mask, indicating tidal volume [VT]), and snoring sound intensity (SSI) measured in decibels. SSI was a poor predictor of flow limitation during snoring. Considerable between- and within-subject variance did not allow establishment of models for the interdependence between VT and SSI. The increase in peak-negative inspiratory efforts was better predicted by SSI. Individual multiple correlation analyses of Pes on SSI indicated a positive interdependence in all subjects. Calculation of ecological correlations with subject means of Pes and SSI was performed. SSI significantly predicted the level of peak-negative inspiratory effort during obstructed, noisy breathing for a given subject. Monitoring of snoring sound intensity may be a useful indicator identifying subjects performing high peak negative inspiratory efforts with obstructed, noisy breathing during sleep

668. Suki, B., R. H. Habib, and A. C. Jackson. 1993. Wave propagation, input impedance, and wall mechanics of the calf trachea from 16 to 1,600 Hz. *J Appl Physiol* 75:2755-2766.
Abstract: Propagation of waves in the airways is important in flow limitation as well as in oscillation mechanics. In five excised calf tracheae, we measured phase propagation velocity (c) and input impedance with open (Zop) or closed end (Zcl) for frequencies (f) between 16 and 1,600 Hz at two axial tensions [nonstretched (TN) and stretched (TS); TS > TN]. From 16 to 64 Hz, c slightly increased because of the viscoelastic properties of the wall tissues. Between 64 and 200 Hz, c was relatively constant and less than the free-field speed of sound (c0 = 340 m/s), with values smaller at TS (140 +/- 39 m/s) than at TN (172 +/- 35 m/s). Above 200 Hz, c exceeded c0 and displayed two maxima at approximately 300 and approximately 700 Hz, with values of approximately 360 and approximately 550 m/s, respectively. For f > 1,400 Hz, c approached c0. We provide evidence that the two maxima in c were the result of the two-compartment behavior of the wall tissues, i.e., the separate cartilaginous and soft tissues. A nonrigid tube model with its wall impedance composed of two series resistance, compliance, and inertance pathways in parallel simultaneously fits c, Zop, and Zcl well and hence provides a link among these data. By use of the relationship between volumetric wall parameters and the tracheal geometry, separate material properties such as viscosity and Young's modulus of both the soft tissue (approximately 1 cmH2O.s and approximately 0.26 x 10(4) cmH2O, respectively) and the cartilage (approximately 3.7 cmH2O.s and approximately 2 x 10(4) cmH2O, respectively) were estimated. These results indicate that measures of c and Zop or

Zcl data over these frequencies provide information about the dynamic mechanical properties of both the soft tissue and cartilage in the airway walls

669. Yonemaru, M., K. Kikuchi, M. Mori, A. Kawai, T. Abe, T. Kawashiro, T. Ishihara, and T. Yokoyama. 1993. Detection of tracheal stenosis by frequency analysis of tracheal sounds. *J.Appl.Physiol* 75:605-612.
Abstract: To develop a simple noninvasive method for detecting tracheal stenosis, tracheal sounds were analyzed using fast-Fourier transform. The subjects were all female and included 5 normal volunteers and 13 patients with tracheal stenosis mostly secondary to thyroid cancer (11 extrathoracic and 2 intrathoracic lesions). Tracheal sounds were recorded during spontaneous breathing and were digitized with an analog- to-digital converter. Pulmonary functions, including forced expiratory volume in 1 s (FEV1) expressed as percentage of vital capacity, peak expiratory flow rate (PEFR), the ratio of FEV1 to PEFR (Empey's index), and the ratio of expiratory to inspiratory flow rates at 50% vital capacity, were measured. A computed tomography scan was used to obtain the tracheal minimum cross-sectional area. Whereas PEFR demonstrated a weak correlation with the stenotic area, FEV1%, Empey's index, and the ratio of expiratory to inspiratory flow rates at 50% vital capacity did not. The power of the fast-Fourier transform spectrum of normal tracheal sounds decreased as the frequency increased up to 500 Hz. A small spectral peak was observed at approximately 1 kHz. Patients with significant tracheal stenosis demonstrated an increase in the peak spectral power at approximately 1 kHz and in the mean spectral power from 600 to 1,300 Hz in their tracheal sounds. In patients with extrathoracic lesions, the peak and mean spectral powers correlated well with the area of the stenosis as defined by computed tomography scan. In patients with intrathoracic lesions, abnormalities in the pulmonary functions as well as tracheal sound spectra appeared more evident despite milder stenoses.(ABSTRACT TRUNCATED AT 250 WORDS)

670. Abella, M., J. Formolo, and D. G. Penney. 1992. Comparison of the acoustic properties of six popular stethoscopes. *J.Acoust.Soc.Am.* 91:2224-2228.
Abstract: This study evaluated stethoscope acoustics by using a sound frequency generator and an active artificial ear. Six popular, currently available stethoscopes were compared in their various modes involving bells, diaphragms, etc.: Littmann Classic II, Littmann Cardiology II, Littmann Master Cardiology, Hewlett-Packard Rappaport-Sprague, Tycos Harvey Triple Head, and Allen Medical Series 5A RPS Binaural. The transfer function was measured from 37.5-1000 Hz, the range where nearly all heart and lung sounds are found. Sound in the low-frequency range (37.5-112.5 Hz) was in most cases amplified by the bells and attenuated by the diaphragms; however, there were no significant differences. Both bells and diaphragms attenuated sound transmission in the high range, and this increased with frequency. The Tycos Harvey Triple Head ribbed diaphragm attenuated sound transmission to a significantly greater extent than the other diaphragms (P less than 0.01). The results show that the bell and diaphragm for a given stethoscope usually have different transmission characteristics, particularly at low frequencies. The Littmann Classic II is an exception. The Hewlett-Packard and Tycos Harvey stethoscopes showed the greatest differences in low frequency response between the bell and the diaphragm. While the differences found in sound transmission between stethoscopes were in most cases small, the Littmann Cardiology II, bell and diaphragm, appears to possess the best overall performance by this study design

671. Beck, R., U. Dickson, M. D. Montgomery, and I. Mitchell. 1992. Histamine challenge in young children using computerized lung sounds analysis. *Chest* 102:759-763.
Abstract: The use of the histamine challenge test (HCT) for the diagnosis of asthma has so far been limited to older children who can perform spirometry consistently. Recently, wheeze detection by tracheal auscultation with analog recording into a tape recorder has been utilized in young children in place of spirometry. Wheezing can also be identified using computerized lung sounds analysis (LSA) by a typical pattern on spectral analysis. Our aim was to develop a practical computerized system in which the response to histamine could be identified in an objective manner and documented on hard copy. Lung sounds were recorded with a Hewlett-Packard HP 21050A contact sensor placed over the right upper anterior chest. Sounds were amplified, band-filtered (50 to 2,000 Hz), and digitized at a sampling rate of 5.5 kHz into a Macintosh SE computer, and spectral LSA was performed. To validate our method, six older children (ages 9 to 16 years) with mild or moderate asthma underwent HCT. The identification of typical wheezing pattern (discrete, high-amplitude power peaks) on LSA was compared to 20 percent fall in FEV1 (PC20) and symptoms (cough, wheeze, chest tightness). In five children, the histamine concentration required to produce the characteristic wheezing pattern on LSA was half that required to produce a 20 percent fall in FEV1. In the sixth patient, wheezing on LSA and PC20 occurred at the same histamine concentration. To determine the technique's applicability to young children, we then studied six young asthmatic children (age 2 to 5 years). All children showed the wheezing pattern at a histamine concentration of 25 percent or 50 percent (one or two steps prior) to that producing symptoms (cough, wheeze, chest tightness) or wheezing on tracheal auscultation. Six age- and sex-matched nonasthmatic children (control subjects) did not show this pattern on LSA and had no symptoms or tracheal wheeze with HCT. We describe a sensitive method enabling application of HCT to young children who are unable to perform spirometry. This method is as sensitive as, and often more sensitive than, conventional PC20 with spirometry or tracheal auscultation

672. Bohadana, A. B. and S. S. Kraman. 1992. Consistency of sternal percussion performed manually and with mechanical thumper. *Eur.Respir.J.* 5:1004-1008.
Abstract: Auscultatory percussion is a technique that is potentially useful to study the acoustic behaviour of the chest. However, finger percussion, as used in this technique, has not been previously assessed for consistency. We calculated the intrasubject variability and short-term reproducibility of this technique in 10 healthy subjects. We examined several indices of the output sound of two series of sternal percussion manoeuvres performed one hour apart by the same examiner. The results were compared to those obtained during sternal percussion performed by a mechanical thumper. Consistency for both finger and thumper percussion varied from 4.8-20.6 (coefficients of variation) for various acoustic indices. For thumper percussion, the average results were not significantly different from those of finger percussion. We conclude that finger percussion of the sternum is sufficiently consistent to be used as a tool to investigate the acoustic behaviour of the chest

673. Brooks, L. J. and K. P. Strohl. 1992. Size and mechanical properties of the pharynx in healthy men and women. *Am.Rev.Respir.Dis.* 146:1394-1397.
Abstract: Obstructive sleep apnea (OSA) has a marked male predominance. To determine whether there are differences in the mechanical properties of the pharynx of men and women that may contribute to the gender difference in disease incidence, we measured pharyngeal cross-sectional area during quiet breathing in 77 normal men and 98 normal women using the acoustic pulse technique. Standard pulmonary function tests were also performed. Pharyngeal mechanics were studied in 23 men and 34 women by measuring the change in pharyngeal area during a slow vital capacity maneuver. Gender was found to be the most important independent factor contributing to pharyngeal size. The men had a significantly larger pharynx than the women (3.63 +/- 0.10 versus 3.20 +/- 0.09 cm2, mean +/- SEM; $p < 0.01$). Pharyngeal mechanics were also different between men and women. The men had a larger change in pharyngeal area with changing lung volume than the women (0.60 +/- 0.14 versus 0.12 +/- 0.12 cm2, mean +/- SEM; $p < 0.02$). This difference persisted even after normalizing the data for pharyngeal size. We found that there are gender-related differences in the size and mechanical properties of the pharynx and speculate that the larger pharynx of men may be more than offset by greater changes in pharyngeal size with changing lung volume, contributing to the greater incidence of OSA in men

674. Chalker, R. B., B. R. Celli, R. H. Habib, and A. C. Jackson. 1992. Respiratory input impedance from 4 to 256 Hz in normals and chronic airflow obstruction: comparisons and correlations with spirometry. *Am.Rev.Respir.Dis.* 146:570-576.
Abstract: Measurement of respiratory system input impedance (Zrs) by forced oscillation (FO) has generally been limited to frequencies less than or equal to 50 Hz, and correlations with spirometry have been variable. Using FO from 4 to 256 Hz in normals, Jackson and colleagues recently described a first acoustic antiresonance frequency (Far,1) at approximately 170 Hz. Using the same frequency range, we compared several Zrs spectral characteristics with spirometry in 12 chronic airflow obstruction (CAO) patients (range FEV1 0.8 to 2.0 L) and 10 matched controls. Compared with controls, patients had a higher first resonance frequency (Fr,1) (mean +/- SD = 15 +/- 5 versus 10 +/- 2 Hz, p less than 0.02) and a higher Far,1 (196 +/- 11 versus 172 +/- 13 Hz, p less than 0.0002). Good correlations occurred between % predicted FVC and the Far,1 ($r = -0.81$, p less than 0.0000), between FEV1/FVC and the reactance at 20 Hz ($r = -0.6$, p less than 0.003), between FEV1 and Far,1 ($r = -0.74$, p less than 0.0001). Because Far,1 may be affected by airway wall mechanical properties, the shift in Far,1 seen in these patients may be due to airway wall properties in CAO. We conclude that measurement of Zrs up to 256 Hz requires little patient cooperation and may be clinically useful. It can differentiate CAO patients from controls and correlates well with spirometry. The first acoustic antiresonance frequency may reflect airway mechanical properties and provide information not available from Zrs measured at lower frequencies

675. Chandler, C. A. Development of an acoustic two microphone transfer function method to study guinea-pig airways: experiments and data analysis. 1992. WEST VIRGINIA UNIVERSITY.
Ref Type: Thesis/Dissertation

676. Connolly, M. J., J. J. Crowley, and R. E. Vestal. 1992. Clinical significance of crepitations in elderly patients following acute hospital admission: a prospective study. *Age Ageing* 21:43-48.
Abstract: Because of a clinical impression that lung crepitations are a common, non-specific sign in acutely ill elderly people, two investigators, blinded to each other's findings and to subject case notes, prospectively examined 207 consecutive elderly [aged 70-98 (mean 77) years] and 75 young patients [24-50 (41) years] acutely admitted to hospital. Crepitations and persistent crepitations (PCs) were commoner in the elderly patients (p less than 0.001) but agreement over their presence/absence was reduced (p less than 0.05). Both investigators agreed PCs were absent in 35% of elderly subjects suffering from conditions classically associated with their presence, and, conversely, were present in 29 elderly subjects in whom no cause for their presence was discovered (14% of the total elderly group or 42% of those with PCs). PCs without obvious cause were unrelated to smoking history and did not predict outcome, length of stay or development of cardiorespiratory complications. In view of poor

sensitivity and specificity of crepitations in elderly patients undergoing acute hospital admission we caution against over-reliance on this sign in isolation in these circumstances

677. Dalston, R. M. 1992. Acoustic assessment of the nasal airway. *Cleft Palate Craniofac.J.* 29:520-526.
Abstract: Instrumental assessment techniques are needed to acquire quantitative information concerning the form and function of the nasal cavity. Until recently, aerodynamic methods were virtually the only source of such information. Two additional instruments are now available that purport to provide information useful to clinicians interested in assessing nasal form and function. This paper describes both the Nasometer and the acoustic rhinometer. In addition, a more traditional measure involving acoustic analysis of nasal consonants is discussed. Both the known and potential benefits and limitations of each technique are discussed

678. Earis, J. 1992. Lung sounds [editorial]. *Thorax* 47:671-672.

679. Gavriely, N. and M. Herzberg. 1992. Parametric representation of normal breath sounds. *J.Appl.Physiol* 73:1776-1784.
Abstract: The spectral content of normal tracheal and chest wall breath sounds has been calculated using the fast Fourier transform (FFT) (J. Appl. Physiol. 50: 307-314, 1981). Parameter estimation methods, in particular autoregressive (AR) modeling, are alternative techniques for measuring lung sounds. The outcome of AR modeling of 38 complete breaths picked up simultaneously over the chest walls and tracheae of five normal males was evaluated. The sounds were treated as noise, bounded by a quasi-periodic envelope generated by the cyclic action of breathing, thus causing the sounds to become inherently nonstationary. Normalization of the sounds to their corresponding variance envelopes eliminated the nonstationarity, an important requirement for most signal-processing methods. Subsequently, the AR model order was sought using formal criteria. Orders 6-8 were found to be suitable for normal chest wall sounds, whereas tracheal sounds required at least orders 12- 16. Using orders 6 and 12, we compared the prominent spectral features of chest wall and tracheal sounds calculated by AR with those found in the spectra calculated by FFT. The polar representation of the AR roots, calculated from the AR coefficients, showed that normal lung sounds from a group of individuals are characterized by a low variability, suggesting that this method may provide an alternative representation of the sounds. The data presented here show that normal lung sounds, when measured in the frequency domain by either FFT or AR modeling, have a characteristic pattern that is independent of the analysis method

680. Henneberg, S., B. Hok, L. Wiklund, and G. Sjodin. 1992. Remote auscultatory patient monitoring during magnetic resonance imaging. *J.Clin.Monit.* 8:37-43.
Abstract: A system for patient monitoring during magnetic resonance imaging (MRI) is described. The system is based on remote auscultation of heart sounds and respiratory sounds using specially developed pickup heads that are positioned on the precordium or at the nostrils and connected to microphones via polymer tubing. The microphones operate in a differential mode outside the strong magnetic field to reduce various sources of interference from the MRI equipment. After amplification, the signal is transmitted as infrared light to a small, battery-operated receiver and a headphone set. Thus, the patient can be simultaneously auscultated both inside and outside the shielded MRI room by infrared transmission through a metal mesh window. Bench tests of the system show that common mode acoustic noise is suppressed by approximately 30 dB in the frequency region of interest (100-1,000 Hz), and that polymer tubing having a diameter of approximately 2 mm can be used for efficient sound transmission. Recordings in situ show satisfactory detection of both heart sounds and respiratory sounds, although the signal is somewhat masked by noise during imaging. A clinical test incorporating 17 sedated or anesthetized patients was also performed. In all but four cases, the quality of the breath and heart sounds was regarded as acceptable or better

681. Kudoh, S. 1992. [Wave form of intrabronchial spark sound on the chest wall and sound transmission in the lung-thoracic system]. *Nippon Ika Daigaku Zasshi* 59:323-334.
Abstract: A spark sound was generated in the canine bronchus and sound waves were observed on the surface (skin) and on each layer (pectoralis major muscle, intercostal muscle and parietal pleura) of the chest wall. The sound wave observed on the surface of the chest wall was 5-10 ms in duration, 400-500 Hz in dominant frequency and 0.6-1.2 ms in the duration of the initial deflection. Reverse dispersion of the waves, i.e., the later components of the wave having longer periods, was also recognized. These characteristics of the wave were similar to those of time-expanded wave-form of crackle, i.e., discontinuous adventitious lung sounds, in clinical cases. Both the spark sound and the sound wave observed on the visceral pleura were of short duration, being 0.7 ms and 1 ms, respectively. therefore, the main component of the sound wave observed on the chest surface was considered to reflect the physical properties of the chest wall itself. The analysis of place relationship within the chest wall suggested that transmission of the sound across the chest occurred not as a surface wave but as a longitudinal wave, therewith traversing the chest wall directly from the sound source. The arrival time of the sound was well correlated with the distance between the sound source and the positions of the pick-ups on the surface of the chest wall. Assuming that the medium between the source and the lung and in the chest wall were 71.5 and 29.6 m/sec, respectively. Further studies will be necessary to clarify the theory of the sound transmission through the living tissue as a viscoelastic body

682. Mangione, S. and S. Dennis. 1992. CompuLung: a multimedia CBL on pulmonary auscultation. *Proc.Annu.Symp.Comput.Appl.Med.Care*820-821.
Abstract: Cardio-pulmonary auscultation, a time honored art, is suffering a declining interest caused by competing diagnostic technology and inadequate training of physicians. Overreliance on diagnostic technology is expensive, not cost-effective and bound to lead to loss of our clinical heritage. We need novel methods to teach and revive this art. Computer-Based Learning (CBL), particularly multimedia supporting graphics plus sound-and-motion pictures, appears to be ideally suited for teaching and sharpening this skill. We present in this paper a multimedia CBL ("CompuLung"), that provides the user with a comprehensive and interactive tutorial on pulmonary auscultation

683. Mangione, S., L. Z. Nieman, and E. J. Gracely. 1992. Comparison of computer-based learning and seminar teaching of pulmonary auscultation to first-year medical students. *Acad.Med.* 67:S63-S65.

684. Marchetti, M., F. Felici, M. Bernardi, P. Minasi, and L. Di Filippo. 1992. Can evoked phonomyography be used to recognize fast and slow muscle in man? *Int.J.Sports Med.* 13:65-68.
Abstract: The present study is aimed at ascertaining if muscle sound might be used as a detector of the contractile properties of individual human muscles "in vivo". In order to test this hypothesis, Soleus muscle (slow) and Vastus Lateralis Femoris muscle (fast) were investigated in three healthy subjects during electrically elicited contractions. Evoked phonomyograms were obtained from isometric single twitch contractions using a microphonic apparatus. Time and frequency domain analysis were performed. Evoked phonomyogram rising time values obtained from the two muscles are significantly different (p less than .01) and this difference is clearly due to their different mechanical properties. The power spectrum of all signals was obtained by means of harmonic analysis routine and mean frequency thus obtained was taken into account. Power spectrum values are approximately 1.5 times greater in fast muscle than in slow muscle (p less than .01). These findings lead us to the conclusion that evoked phonomyography can be considered a useful technique for the assessment of mechanical properties of individual human muscles

685. Molfino, N. A., A. S. Slutsky, V. Hoffstein, P. A. McClean, A. S. Rebuck, J. M. Drazen, and N. Zamel. 1992. Changes in cross-sectional airway areas induced by methacholine, histamine, and LTC4 in asthmatic subjects. *Am.Rev.Respir.Dis.* 146:577-580.
Abstract: To examine whether leukotrienes, histamine, and methacholine have different sites of bronchoconstrictor action, we studied 8 stable asthmatic subjects (mean age +/- SD, 26 +/- 5 yr) on 3 different days. On each day, a randomized challenge with LTC4, methacholine, or histamine was performed until the dose that provoked a fall of 20% in FEV1 (PC20) was obtained. Complete and partial flow-volume curves as well as area-distance profiles generated by the acoustic reflection technique (ART) at a fixed lung volume were obtained in all subjects before and after each inhalation challenge. No significant differences were found in pulmonary function or baseline cross-sectional airway areas for the different study days. The three agonists provoked significant (p less than 0.05) bronchoconstriction at the level of the main bronchi when identical falls of FEV1 were achieved. Similarly, equal reductions of V30p were elicited by the three agonists. However, LTC4 and methacholine induced additional tracheal constriction but histamine inhalation did not. These differences in the degree of tracheal constriction were statistically significant (p less than 0.05; ANOVA). These results may be explained by distinct pharmacologic properties of the agents used and may have relevance in the understanding of the pathophysiology of asthma

686. Mussell, M. J. 1992. The need for standards in recording and analysing respiratory sounds. *Med.Biol.Eng Comput.* 30:129-139.
Abstract: Respiratory sounds (RSs) recorded from the chest and trachea are nowadays being electronically analysed by many investigators with a view to (i) determining the mechanisms of their production, and (ii) to develop automated diagnostic systems based on RS analysis, that objectively categorise RS as being associated with health or respiratory diseases. However, one problem that hampers this type of research is that almost every RS investigation team uses different equipment, protocols and analysis methods which, to varying degrees, makes inter-investigator results difficult to compare. The review first discusses the many variables involved in RS recording and analysis, and the different approaches used by different investigators, to highlight this problem and its consequences. Secondly, although the review cannot propose immediately acceptable guidelines and standards for RS analysis, it proposes a 'seed' set of guidelines that are 'up for discussion' between investigators in the field, the final goal being to inject a degree of standardisation in equipment and methods that are acceptable to all involved

687. Mussell, M. J. and Y. Miyamoto. 1992. Comparison of normal respiratory sounds recorded from the chest and trachea at various respiratory air flow levels. *Front Med.Biol.Eng* 4:73-85.
Abstract: Respiratory sounds (RS)s were recorded from the trachea and chest of 10 normal adult subjects at respiratory air flow levels of 1.6, 2.1 and 2.6 l/s using an oral flow transducer, and at approximately 2.1 l/s without the flow transducer. Tracheal RS (TRS) and chest RS (CRS) frequency spectra were generated using Fast Fourier Transform, and the peak, mean and maximum frequency parameters were derived from each spectra. Parametric analysis showed: (i) all three parameters for TRS spectra are significantly higher than those for CRS spectra; (ii) TRSs are on average eight times louder than CRSs; (iii) both TRSs and CRSs

are air-flow independent over the flow range, though TRSs are significantly modified by the flow transducer while CRSs are not; and (iv) though of similar loudness, inspired and expired RSs (both TRSs and CRSs) have some significant spectral differences. To compare the complex shapes of RS spectra, each spectra was divided into narrow frequency bands (to create a feature set) and principal component analysis was performed on all spectral feature sets. TRSs and CRSs were shown to be independent biological signals with little overlap in their respective spectral characteristics

688. Nekvasil, R., J. Stejskal, and M. Nevrtal. 1992. [Acoustic frequency analysis of auscultation findings in neonates]. *Cesk.Pediatr.* 47:204-209.
Abstract: The authors analyzed 280 auscultation findings of 35 neonates with birth weights of 1800-4500 g and 65 pathological neonates with birth weights of 1150-3600 g. For recording of the auscultation findings an electronic phonendoscope EST 40 (Bosch) was used and the finding was recorded on a microtape recorder (Olympus). The frequency analysis was made on a Sonagraf analyzer (Kay Elemetric), using a 45 Hz filter a time range of 2.4 sec. From the results of the work ensues that in physiological neonates two basis types of sonagrams can be detected: 1. the record presenting itself as a continuous zone of noise with maximal cumulation of acoustic energy up to 500 Hz where the ratio of acoustic energy is equal in both stages of the respiratory cycle. The clinical correlate is "alveolar respiration". 2. a record with a discontinuous zone of noise with a more expressive ratio of acoustic energy up to 2500 Hz during inspiration. The clinical correlate is "sharper bronchoalveolar respiration". In the group of pathological neonates with different pneumopathies further sonagraphic phenomena were detected: a) "rales" as discontinuous acoustic phenomena persisting for 7-35 msec with a frequency range up to 3000 Hz, without a harmonious structure, present during inspiration as well as expiration, b) "transmitted phenomena"--discontinuous acoustic phenomena persisting for 75-150 msec with a frequency range up to 6000 Hz, without a harmonious structure, c) "wheezing"--continuous acoustic phenomena with a clearly marked harmonious acoustic structure lasting 540 +/- 240 msec with a frequency of the basic sound of 500 +/- 240 msec.(ABSTRACT TRUNCATED AT 250 WORDS)

689. Pasterkamp, H. and I. Sanchez. 1992. Tracheal sounds in upper airway obstruction. *Chest* 102:963-965.
Abstract: A boy with subglottic narrowing secondary to laryngotracheitis presented with noisy breathing. Acoustic measurements of tracheal sounds at standardized air flows correlated well with the clinical course and with spirometric assessments. This indicates the potential value of respiratory sound characterization in patients with upper airway obstruction

690. Pasterkamp, H. 1992. [New developments and knowledge in research of respiratory sounds]. *Pneumologie* 46:602-611.

691. Petitjean, M., B. Maton, and J. C. Cnockaert. 1992. Evaluation of human dynamic contraction by phonomyography. *J.Appl.Physiol* 73:2567-2573.
Abstract: Phonomyogram (PMG, or acoustic myogram) is known to increase with force in isometric contractions. We investigated this relationship for dynamic contractions against different inertias. PMG and surface electromyogram (EMG) from biceps brachii and brachioradialis muscles were simultaneously recorded with the angular acceleration of elbow flexions. These were self-initiated movements (30 degrees) toward a fixed target and performed against two different inertias. PMG and EMG were integrated from the onset of the signal to the end of the acceleration phase. Phono- and electromechanical delays were also measured. For integrated EMG (iEMG), there was a linear relationship between integrated PMG (iPMG) and force, the slope of which did not depend on inertia. There was also a linear relationship between iPMG or iEMG and angular acceleration, with a higher slope for the highest inertia condition. There was also a family of linear relationships between iPMG or iEMG and angular acceleration, and their slopes depended on inertia. Measurements of the phono- and electromechanical delays showed that onset of PMG followed that of EMG but preceded onset of acceleration. It is suggested that PMG expresses tension of the underlying muscle contractile elements. Given the simplicity of the PMG method, we conclude that PMG allows convenient evaluation of muscle tension during human dynamic contraction

692. Piirila, P. 1992. Changes in crackle characteristics during the clinical course of pneumonia. *Chest* 102:176-183.
Abstract: Recorded crackling lung sounds of 11 patients with pneumonia were studied with phonopneumography, FFT spectrography and time-expanded waveform display. The sounds were recorded on average six days after the onset of pneumonia and the recording was repeated two to four days later. In the first recording the crackles were coarse and midinspiratory. The patients with unilateral pneumonia had a significant difference in the upper frequency limit of inspiratory sound of the FFT spectrum between the healthy and diseased lung (p less than 0.01). In the second recording, the beginning of crackling had shifted later (p less than 0.01) and the end point of crackling also became later (p less than 0.05). The largest deflection width of the individual crackles became shorter (p less than 0.05). The results indicate that the pneumonic crackles vary markedly during the clinical course of pneumonia. The duration of the individual crackles became shorter and the timing of the crackles shifted toward the end of inspiration

693. Piirila, P. L. Acoustic properties of cough and crackling lung sounds in patients with pulmonary diseases. 1992. HELSINGIN YLIOPISTO (FINLAND).
Ref Type: Thesis/Dissertation

694. Schreur, H. J., P. J. Sterk, J. Vanderschoot, H. C. van Klink, E. van Vollenhoven, and J. H. Dijkman. 1992. Lung sound intensity in patients with emphysema and in normal subjects at standardised airflows. *Thorax* 47:674-679.
Abstract: BACKGROUND: A common auscultatory finding in pulmonary emphysema is a reduction of lung sounds. This might be due to a reduction in the generation of sounds due to the accompanying airflow limitation or to poor transmission of sounds due to destruction of parenchyma. Lung sound intensity was investigated in normal and emphysematous subjects in relation to airflow. METHODS: Eight normal men (45-63 years, FEV1 79- 126% predicted) and nine men with severe emphysema (50-70 years, FEV1 14-63% predicted) participated in the study. Emphysema was diagnosed according to pulmonary history, results of lung function tests, and radiographic criteria. All subjects underwent phonopneumography during standardised breathing manoeuvres between 0.5 and 2 1 below total lung capacity with inspiratory and expiratory target airflows of 2 and 1 l/s respectively during 50 seconds. The synchronous measurements included airflow at the mouth and lung volume changes, and lung sounds at four locations on the right chest wall. For each microphone airflow dependent power spectra were computed by using fast Fourier transformation. Lung sound intensity was expressed as log power (in dB) at 200 Hz at inspiratory flow rates of 1 and 2 l/s and at an expiratory flow rate of 1 l/s. RESULTS: Lung sound intensity was well repeatable on two separate days, the intraclass correlation coefficient ranging from 0.77 to 0.94 between the four microphones. The intensity was strongly influenced by microphone location and airflow. There was, however, no significant difference in lung sound intensity at any flow rate between the normal and the emphysema group. CONCLUSION: Airflow standardised lung sound intensity does not differ between normal and emphysematous subjects. This suggests that the auscultatory finding of diminished breath sounds during the regular physical examination in patients with emphysema is due predominantly to airflow limitation

695. Shabtai-Musih, Y., J. B. Grotberg, and N. Gavriely. 1992. Spectral content of forced expiratory wheezes during air, He, and SF6 breathing in normal humans. *J.Appl.Physiol* 72:629-635.
Abstract: The effect of gas density on the spectral content of forced expiratory wheezes was studied in the search for additional information on the mechanism of generation of respiratory wheezes. Five normal adults performed forced vital capacity maneuvers through four or five orifice resistors (0.4-1.92 cm ID) after breathing air, 80% He-20% O2, or 80% SF6-20% O2. Tracheal lung sounds, flow, volume, and airway opening (Pao) and esophageal (Pes) pressures were measured during duplicate runs for each orifice and gas. Wheezes were detected in running spectra of lung sounds by use of a frequency domain peak detection algorithm. The wheeze spectrograms were presented along side expiratory flow rate and transpulmonary pressure (Ptp = Pao - Pes) as function of volume. The frequencies and patterns of wheeze spectrograms were evaluated for gas density effects. We found that air, He, and SF6 had similar wheeze spectrograms. Both wheeze frequency and patterns (as function of volume) did not exhibit consistent changes with gas density. Speech tone, however, was substantially affected in the usual pattern. These observations support the hypothesis that airway wall vibratory motion, rather than gas phase oscillations, is the source of acoustic energy of wheezes

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Abstract: The frequency spectrum of stridor was studied by the computer program in the patients with upper airway obstruction. The results showed that the peak frequency of respiratory sound increased significantly, the frequency spectrum got wider and removed to the high frequency area above 200Hz, the E ratio was smaller than 1. These changes were more apparent during inspiration than those during expiration. It is concluded that the stridorous sound could be determined exactly and quantitatively, and differentiated from wheezing by the spectral analysis

697. Spence, D. P., S. Bentley, D. H. Evans, and M. D. Morgan. 1992. Effect of methacholine induced bronchoconstriction on the spectral characteristics of breath sounds in asthma. *Thorax* 47:680-683.
Abstract: BACKGROUND: Analysis of breath sounds by digital techniques offers an attractive non-invasive method of monitoring changes in airway calibre. Asthmatic breath sounds have been analysed and related to changes in forced expiratory volume in one second (FEV1). METHODS: Bronchoconstriction was induced with methacholine in six asthmatic subjects on two occasions and changes in FEV1 and breath sound spectra were measured. RESULTS: Audible wheeze appeared after a mean (SE) fall in FEV1 of 35% (6.3%) but the level was not reproducible within patients. The mean and median frequency of the spectra of breath sounds correlated with the percentage of predicted FEV1 ($r = -0.5$ and -0.6 respectively; $p < 0.001$). Inclusion of the quartile frequencies in a stepwise multiple regression reduced the residual variance by a further 9%. CONCLUSION: Detecting changes in airway calibre by this method of sound analysis so far produces qualitative data only and will not yield quantitative data in individual patients

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Abstract: This study describes a method of quantitatively characterizing cough sounds using digital signal processing techniques. Differences between asthmatic and non-asthmatic cough sounds are presented. Coughs from 12 asthmatic and 5 non-asthmatic subjects were analysed. Cough sounds and flows were digitized, at a sampling rate of 5 kHz, before and after a free-running exercise test. Individual coughs were divided into two or three phases, corresponding to the initial glottal opening burst, the quieter middle phase, and (sometimes) the final closing burst. Standard signal processing techniques were then invoked to characterize the spectral and temporal shapes of the first two phases. Factor analysis indicated that the spectral shapes of the two phases are independent, with each being largely described by the degree of "peakedness" in the spectrum, and by the balance of energy between low and high frequencies. Both the duration of the initial burst and zero-crossing rates of the cough waveform (which indicates the "spectral balance") during each of the first two phases were smaller for asthmatic than for non-asthmatic coughs. Fewer asthmatic coughs contained a final burst. Discriminant analysis between the two groups gave classification error rates of 20-30%. The peak flow recorded during the cough was significantly smaller for asthmatics, and correlated very well with the peak flow recorded during forced expiration. Thus, significant differences exist between asthmatic and non-asthmatic cough sounds. An effective representation of the temporal structure of the cough sound is required to successfully characterize the cough

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Abstract: The frequency-dependent propagation time, or phase delay tau (f), of sonic noise transmission from the trachea to the chest wall was estimated over the 100-600 Hz frequency range using a phase estimation technique from measurements performed on eight healthy subjects. Since tau (f) can be greater than one period of the input signal at frequencies greater than 100 Hz, the unambiguous phase estimate at 100 Hz was used as a starting-point to determine the phase angle H(f) and tau (f) at higher frequencies under the constraint that the spectra did not exhibit large point-to-point discontinuities. The resulting tau (f) range of 0.9-4.1 ms is consistent with sound propagation to the chest wall through both airways and surrounding parenchyma. The frequency and spatial dependence of tau (f) indicates that with increasing frequency more sonic energy travels further into the branching airway structure before coupling into the parenchyma. These results suggest that information concerning distinct regional lung structures may be obtained by probing the system acoustically over selected frequency bands

700. Arakawa, K., H. Harashima, M. Ono, and M. Mori. 1991. Non-linear digital filters for extracting crackles from lung sounds. *Front Med.Biol.Eng* 3:245-257.
Abstract: A non-linear digital filter system is proposed for automatic extraction of crackles which are discontinuous paroxysmal sounds in lung sounds. This system is composed of two filters: one is a stationary-non- stationary separating filter and the other is a width separating filter. The former separates non-stationary signals from stationary ones, using the prediction error for the input. This filter can roughly separate the crackles as non-stationary signals. The latter, the width- separating filter, performs signal extraction on the basis of the interval between the zero-crossing points of the non-stationary signals, simply realized by logical algebra. This filter extracts a small-width impulsive signal and its succeeding waves; such a waveform is typical of crackles. Crackles can be more precisely extracted from the non-stationary signals by this filter. Both of the filters are realized quite simply. The high performance of this system is shown in processing actual lung sound data

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Abstract: STUDY OBJECTIVE: Determine why crackles on chest auscultation are characteristic of most interstitial lung diseases, but may not be heard in sarcoidosis. DESIGN: All patients with sarcoidosis or cryptogenic fibrosing alveolitis seen during a four-week period were studied. In a second study to relate ausculatory findings to anatomy, patients with fibrotic changes on their chest roentgenogram were studied. SETTING: Patients were recruited from outpatient clinics. PATIENTS: In the first part, all patients seen over the course of one month were studied. In the second study, patients with pulmonary fibrosis seen on chest roentgenograms were studied. INTERVENTIONS: For the first study, two independent observers performed auscultation on five sites for crackles and reviewed four roentgenogram quadrants for changes. For the second study, patients underwent VC measurements, auscultation, and high resolution computer tomography scans. MEASUREMENTS AND RESULTS: For the first study, crackles were noted at greater than 2 sites in all 11 CFA patients, but only one of 17 SARC patients (p less than 0.001). Roentgenogram changes were seen in greater than 2 quadrants in nine of 11 CFA patients and eight of 17 SARC patients (p = ns). In the second study, the VC was similar in the two groups: SARC: 1.96 +/- .90 L (means +/- SD), 58 +/- 20.4 percent predicted; CFA: 1.81 +/- .33 L, 59 +/- 9.2 percent predicted). Only two of 14 SARC patients had crackles in greater than 1 area, while all 14 CFA patients had crackles at greater than 2 sites. The HRCT studies were read by a radiologist unaware of the diagnosis. The presence and degree (0 to 3 scale) of subpleural and peribronchial fibrosis were scored. Twelve SARC patients had peribronchial changes (mean score 1.9 +/- 1.08), while only eight had subpleural fibrosis (mean score .6 +/- .52). There was a significantly different pattern in the CFA patients, where eight had peribronchial fibrosis (mean score = .9 +/- .78, p less than 0.05) and all 14 had subpleural fibrosis (mean score = 1.6 +/- .73, p less than 0.01). CONCLUSIONS: We conclude that crackles are more frequent in fibrosing alveolitis than in sarcoidosis; this difference may be due to the distribution of parenchymal fibrosis

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Abstract: The method of phonopulmographic topography of the lung developed by the authors is presented which permits determining elevation of apices, width of the Kronig fields topography of inferior borders and mobility of inferior border of the lung. The method of phonopulmography applied to study local and regional pulmonary ventilation is used as a basis. Examinations of practically healthy people and those with pulmonary pathology have shown that this method has high resolution, it is safe and informative

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Abstract: An acoustic-electric analog and transmission line theory have been used to examine acoustic wave propagation in a tube with a compliant wall. The input impedance (i.e., input pressure-flow) has been simulated using a distributed element model. A relative minimum and maximum, denoted by fr and f2, respectively, that are independent of tube length have been identified theoretically and confirmed experimentally from input impedance measurements on a compliant tube. A method has been devised which uses measured values of fr and f2 to deduce the tube wall properties from the theoretical model. This method has been validated on a tube with known wall properties determined using standard methods. In practice, the input impedance is measured through a short section of rigid connecting pipe. In this case fr remains constant while f2 is reduced. This reduction can be accounted for by the volume compliance of the gas within the lumen of the rigid pipe. The theory could have useful applications such as estimating the wall properties of the airways from noninvasive measurements made through the mouth

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Abstract: We studied the acoustic features of continuous adventitious lung sounds in asthmatic patients, and analyzed the characteristics of transmission by comparing the continuous sounds in asthmatic patients with those due to bronchial stenosis. The results were as follows. 1) Continuous adventitious lung sounds in patients with bronchial stenosis confirmed by bronchoscopy were well transmitted to the neck over the trachea. Therefore, it was demonstrated that continuous adventitious lung sounds generated in the lung are able to be transmitted to the tracheal region. 2) Continuous adventitious lung sounds in asthmatic patients were divided into monophonic tones and polyphonic tones, according to sound spectrographic findings. From the results of the coherence analysis, the monophonic tones were considered to be generated in the right or left lung, and were well transmitted to the neck over the trachea. The origin of the polyphonic tones was unknown, but they were also relatively well transmitted to the neck over the trachea. It was confirmed that the tracheal region is a very important location for auscultating and monitoring asthmatic patients

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Abstract: Two methods for the analysis of the acoustic transmission of the respiratory system are presented. Continuous speech utterance is used as acoustic stimulation. The transmitted acoustic signal is recorded from various sites over the chest wall. The AR method analyzes the power spectral density function of the transmitted sound, which heavily depends on the microphone assembly and the utterance. The method was applied to a screening problem and was tested on a small database that consisted of 19 normal and five abnormal patients. Using the first five AR coefficients and the prediction error of an AR(10) model, as discriminating features, the system screened all abnormals. An ARMA method is suggested, which eliminates the dependence on microphone and utterance. In this method, the generalized least squares identification algorithm is used to estimate the ARMA transfer function of the respiratory system. The normal transfer function demonstrates a peak at the range of 130-250 Hz and sharp decrease in gain for higher frequencies. A pulmonary fibrotic patient demonstrated a peak at the same frequency range, a much higher gain in the high frequency range with an additional peak at about 700 Hz

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Abstract: Listening to a human airway to determine obstruction is a highly subjective art and an important clinical tool. Sophisticated acoustic monitoring techniques should be developed and tested in the laboratory before they are applied in the clinic. We describe construction of an acoustic tube model to study the mechanism of noise generation in a simulated obstructed human airway. Spectral differences were demonstrated between different amounts and locations of obstruction and changes resulting from variations in airflow using Fast-Fourier transform techniques. With this analog model, systematic research can be conducted to define expected patterns in obstructed human airways for use in the clinical setting

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709. Griffiths, C. J., B. G. Cooper, and G. J. Gibson. 1991. A video system for investigating breathing disorders during sleep. *Thorax* 46:136-140.
Abstract: A system has been developed for investigating breathing during sleep that superimposes physiological signals on a video image of the patient, with the combined image plus sound recorded on video tape for later analysis. Signals normally displayed include oxygen saturation, airflow, chest wall motion, electroencephalogram, and electrooculogram; but others can be recorded if desired. The information is displayed on a timebase appropriate for the recognition and analysis of respiratory events during sleep. In addition, use is made of normally invisible video lines to record the analogue voltage waveforms so that on replay this information can be displayed on a fast timebase for analysing the more rapidly changing waveforms of electrophysiological signals. The system allows detailed polysomnography to be performed in the normal ward setting with the subject monitored overnight by the nursing staff. Subsequent analysis of the synchronised video, audio, and analogue signals allows measurement of the conventional indices obtained by polysomnography and aids their interpretation

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Abstract: The nose with normal feeling of nasal patency, and no gross structural changes has been described in 82 individuals by acoustic rhinometry. Curves for one and both sides of the nasal cavity and before and after decongestion have been recorded. We have found that the minimal cross- sectional area (MCA) is located anteriorly in the nasal cavity; in some subjects it is localized at the head of the inferior turbinate and in other subjects more anteriorly at the nasal valve. After decongestion MCA moves even more anteriorly. Beyond the MCA the dimension of the nasal cavity increases, with maximal effect of decongestion at 4 cm from nostrils. Decongestion increases the total volume of the nasal cavity by 35%

711. Hidalgo, H. A., M. J. Wegmann, and W. W. Waring. 1991. Frequency spectra of normal breath sounds in childhood. *Chest* 100:999-1002.
Abstract: Clinicians who auscultate the chest of normal children note that the frequency content of their breath sounds appears to vary with age. Because these changes have not been systematically documented before, we recorded and analyzed inspiratory breath sounds in 35 children (0 to 13 years) and five adults (34 to 43 years). Our objective was to determine if the frequency content of normal breath sounds differed with age. Using a Fast Fourier Transform program, we calculated an average amplitude frequency spectrum from the inspiratory portion of the breath sounds of each subject (n = 10 breaths), and we compared the shape of the AFS and the values of selected frequency parameters. We found that the shape of the AFS of the youngest children differed most from the AFS of adults. Three of four selected frequency parameters (F25, F50, F95) differed significantly between children and adults (p less than 0.05), and one parameter (F75) did not (p = 0.11). The F25, F50, and F75 parameters of children (but not F95) were correlated (p less than 0.001) with increasing height and age. These results suggest that differences in the frequency content of the normal breath sounds of children and adults contribute to the differences that clinicians detect during clinical auscultation

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Abstract: Non-invasive assessment of upper airway area by acoustic reflections has been developed in the last 12 yrs. The technique is based on the analysis of sound waves reflected from the airways. Measurement of the amplitudes of the reflections and their times of arrival at the sensing microphone permits construction of a plot of airway area vs distance from the microphone. We describe the theoretical foundations of the method and review the underlying assumptions. This is followed by a summary of the results of in vitro and in vivo validation studies, with particular attention to the reproducibility, accuracy and variability of the technique. The description of clinical and physiological applications of this technique includes detection of tracheal stenosis, demonstration of structural and functional abnormalities of the pharynx and glottis in patients with sleep apnoea, dichotomous response of the airway area to exercise, and airway vs parenchymal hysteresis. Finally, we comment on the future directions that might be investigated using this technique

713. Hoffstein, V., S. Wright, N. Zamel, and T. D. Bradley. 1991. Pharyngeal function and snoring characteristics in apneic and nonapneic snorers. *Am.Rev.Respir.Dis.* 143:1294-1299.
Abstract: Abnormalities in pharyngeal function, manifested even when the patients are awake, are thought to play an important role in the pathogenesis of sleep apnea. Tests of awake pharyngeal function continue to stimulate interest because it is hoped that they may allow physicians to distinguish patients with sleep apnea from those without it, and therefore reduce the number of unnecessary sleep studies. We elected to study two measures of pharyngeal function: changes in pharyngeal area with lung volume (PLVD) and changes in pharyngeal area in response to externally applied positive pressure, i.e., pharyngeal distensibility

(Cph). Both measurements have been employed for assessment of pharyngeal function, and both are thought to reflect pharyngeal "floppiness." Measurement of PLVD is technically very simple, whereas the measurement of Cph is technically more complex. If the two measurements are highly correlated, it might be possible to replace the technically more difficult one by the simpler one. Consequently, the purpose of this study was two-fold: first, to examine the relationship between pharyngeal distensibility and lung volume dependence of pharyngeal area, and second, to compare these parameters in a large group of confirmed snorers with and without obstructive sleep apnea (OSA). We studied 75 unselected patients referred for the investigation of snoring and suspected sleep apnea. All patients had nocturnal polysomnography, pulmonary function tests, and measurement of pharyngeal areas at TLC, FRC, and residual volume (RV) employing the acoustic reflection technique. The area measurement at FRC was performed at zero and at 4.1 cm H2O positive airway pressure to calculate pharyngeal distensibility.(ABSTRACT TRUNCATED AT 250 WORDS)

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Abstract: This study assessed the capabilities of a traditional and an amplified stethoscope used by flight nurses to assess breath sound during air medical transport in an MBB BO-105 helicopter. We developed a normal breath sound model using a prerecorded tape of breath sounds interspersed with segments without breath sounds; the recorder had been placed in the chest wall of a resuscitation training manikin. Flight nurses completed control listening sessions in a quiet environment and experimental sessions during flight using a traditional stethoscope for half of the sessions and an amplified stethoscope for the remaining half. In the quiet environment, flight nurses accurately reported the presence or absence of breath sounds in 110 (92%) of 120 trials. During helicopter flight, none of the flight nurses heard breath sounds during any of the recorded segments with either the traditional stethoscope or the amplified stethoscope. We conclude that flight nurses are unable to hear normal breath sounds using a traditional or amplified stethoscope during flight in a medically configured MBB BO-105 helicopter. Improved stethoscopes, innovative methods of listening, and reduction of aircraft noise are potential solutions to the problems of breath sound assessment during air medical transport

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Abstract: The lumped six-element model of the respiratory system proposed by DuBois et al. (J. Appl. Physiol. 8: 587-594, 1956) has often been used to analyze respiratory system impedance (Zrs) data. This model predicts a resonance (relative minimum in Zrs) at fr between 6 and 10 Hz and an antiresonance (relative maximum in Zrs) at far at higher frequencies (greater than 64 Hz). The far is due to the lumped tissue inertance (Iti) and the alveolar gas compression compliance (Cg). An fr and far have been recently reported in humans, but the far was shown to be not related to Iti and Cg, but instead it is the first acoustic antiresonance of the airways due to their axial dimensions). Zrs data to frequencies high enough to include the far have not been reported in dogs. In this study, we measured Zrs in dogs for frequencies between 5 and 320 Hz and found an fr at 7.5 +/- 1.6 Hz and two far at 97 +/- 13 and 231 +/- 27 Hz (far,1 and far,2, respectively). When breathing 80% He-20% O2, the fr shifted to 14 +/- 2 Hz, far,1 did not change (98 +/- 9 Hz), and far,2 increased to greater than 320 Hz. The behavior of fr and far,1 is consistent with the structure-function implied by the six- element model. However, the presence of an far,2 is not consistent with this model, because it is the airway acoustic antiresonance not represented in the model. These results indicate that, for frequencies that include the fr and far,1, the six-element model can be used to analyze Zrs data and reliable estimates of the model's parameters can be extracted by fitting the model to the data. However, more complex models must be used to analyze Zrs data that include far,2

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Abstract: Crackling lung sounds are associated with many pulmonary diseases. Their occurrence reflects the quality and the severity of the disease. An automatic method for crackle detection is developed, based on analysing the spectral stationarity of the lung sound. The method is validated by studying the crackles of 20 adult patients; 10 with fibrosing alveolitis (FA) and 10 with bronchiectasis (BE). The number of crackles detected by the automatic method in inspiratory cycles is compared to the number of crackles counted from time-expanded waveforms by two expert observers. The total number of inspiratory cycles studied is 117 and that of crackles 1064. The method has a sensitivity of 89 per cent and a positive predictivity of 88 per cent for patients with FA, and 80 per cent and 83 per cent respectively, for patients with BE. The linear correlation coefficients between the numbers of crackles counted by the automatic method and by the observers is 0.86 (p less than 0.001) for the patients with FA and 0.93 (p less than 0.001) for the patients with BE. The values refer to whole inspiratory cycles. The new automatic method seems reliable enough for clinical and scientific purposes. It enables a rapid and objective analysis of large materials with crackling lung sounds

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Abstract: In lung sound research, low-frequency noise usually disturbs the sound signal being recorded. Some researchers therefore use high-pass filtration before the final analysis. In this study, the effect of digital and analog high-pass filtration on the morphology of the lung sound crackles is evaluated. The original nonprefiltered crackle waveform is presented, and the effect of the high-pass filtration on the crackle waveform characteristics is elucidated in one patient with silicoasbestosis

719. Kerem, E., G. Canny, R. Tibshirani, J. Reisman, L. Bentur, S. Schuh, and H. Levison. 1991. Clinical-physiologic correlations in acute asthma of childhood. *Pediatrics* 87:481-486.
Abstract: Seventy-one patients who presented to the emergency room with acute asthma were evaluated to determine the relationship between common clinical signs and spirometric and transcutaneous arterial oxygen saturation (SaO2) measurements. Prior to treatment, a physical examination was performed, a clinical score assigned, and pulmonary function and SaO2 were measured. Although forced expiratory volume in 1 second (FEV1) and SaO2 had strong correlation with the overall clinical score (r2 = .47, .49 respectively), many patients with low clinical scores and apparent mild clinical disease had low FEV1 values (as low as 20% predicted). Of the individual components of the clinical score (ie, heart rate, respiratory rate, pulsus paradoxus, accessory muscle use, dyspnea, and wheezing), the degree of accessory muscle use correlated most closely with lung function followed by the degree of dyspnea and wheezing. Similarly, the degree of accessory muscle use correlated most closely with SaO2 followed by dyspnea and respiratory rate. Significant correlation (r2 = .59) was found between SaO2 and FEV1, although the range of SaO2 value for a given FEV1 was wide and some patients with low FEV1 values had normal SaO2 values. These results show that although clinically apparent severe disease and hypoxemia were always associated with low FEV1, their absence does not exclude the presence of airflow obstruction. It is concluded that for the optimal evaluation of acute asthma in children in the emergency room, clinical evaluation should be used in conjunction with objective laboratory measurements

720. Kern, D. G. and S. R. Patel. 1991. Auscultated forced expiratory time as a clinical and epidemiologic test of airway obstruction. *Chest* 100:636-639.
Abstract: OBJECTIVE: Seeking an inexpensive, readily available, clinical, screening, and field surveillance test of airway obstruction, we determined the validity of current dogma that forced expiratory time (FET) is a good clinical test of airway obstruction yet is of no epidemiologic use given excessive intrasubject variability. SUBJECTS AND METHODS: Two hundred twenty-nine white male plumbers and pipefitters were evaluated by spirometry, chest roentgenography, and a standardized respiratory questionnaire during a union-sponsored asbestos screening program. Subjects were classified as having large airway obstruction (LAO), small airway obstruction (SAO) alone, or no obstruction, on the basis of standard spirometric prediction equations. Two physicians, blinded to clinical and spirometric data, independently measured FET while auscultating the trachea with a stethoscope. The FET was defined as the time taken for an individual to forcefully exhale through an open mouth from total lung capacity until airflow became inaudible. Five such times were recorded for each subject. The mean of the three times having the narrowest range was deemed the FET for calculating test sensitivity and specificity. Based on previous literature, an FET greater than or equal to 6 s was considered abnormally prolonged. RESULTS: Two hundred five subjects completed both spirometry and FET testing; 67 had LAO, 5 SAO, and 133 no obstruction. A total of 83 percent had three FETs reproducible within a range of less than or equal to 1 s. The sensitivity and specificity of FET for LAO were 92 and 43 percent, respectively, while for SAO alone, 60 and 44 percent, respectively. Overall, FET misclassified 56 percent of nonobstructed subjects. Adjusting the normal-abnormal cutoff points for both FET and SAO minimally improved the performance of FET. CONCLUSION: Although FET is a simple, inexpensive, sensitive, and fairly reproducible clinical test of LAO, it cannot be recommended as a clinical or an epidemiologic tool because of its extremely low specificity

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Abstract: A new explanation of improved oxygenation during high-frequency jet ventilation has been suggested. The mechanism is based on resonance oscillations generated by oscillation and injection high-frequency jet ventilation and promoting gas penetration into the alveoli, PaO2 elevation in perimembrane layer and O2 concentration gradient increase between the alveolar and convection zones. Alveolar and bronchial fluctuations facilitate their drainage and decrease pulmonary shunting. The suggested mechanism is explained, using facts known from the practical application of high frequency jet ventilation. The advantages of combined volumic-oscillation high-frequency jet ventilation over the jet one are established, except cases of lung ventilation in patients with open bronchus and in patients transmitted to spontaneous respiration after prolonged controlled lung ventilation

722. Liistro, G., D. C. Stanescu, C. Veriter, D. O. Rodenstein, and G. ubert-Tulkens. 1991. Pattern of snoring in obstructive sleep apnea patients and in heavy snorers. *Sleep* 14:517-525.
Abstract: We measured respiratory mechanical characteristics during sleep in five heavy, nonapneic snorers (HS) and in five obstructive sleep apnea (OSA) patients. In two HS and in two OSA patients we obtained lateral pharyngeal cineradiographic

images during sleep while snoring. Flow limitation preceded all snores in both HS and OSA. Pattern of snoring, hysteresis and temporal relationship between supraglottic pressure (Psg) and flow rate were different in HS and OSA. Maximal flow during snoring was less (p less than 0.05) in OSA (0.18 +/- 0.07 liter/second) than in HS (0.36 +/- 0.06 liter/second). Linear supraglottic resistance during inspiratory snoring was higher, though not significantly, in OSA patients (7.11 +/- 3.01 cm H2O/liter/second) than in HS (4.80 +/- 2.83 cm H2O/liter/second). We conclude that: 1) Snoring is characterized by high frequency oscillations of the soft palate, pharyngeal walls, epiglottis and tongue. 2) Flow limitation appears to be a sine qua non for snoring during sleep. 3) The pattern of snoring is different in OSA and HS. 4) Pharyngeal size during snoring is probably larger in HS than in OSA patients

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Abstract: Cineradiography of the pharynx during simulated snoring was done in 6 healthy volunteers, and supraglottic pressure and flow rate were recorded in 12 others. We observed, immediately before snoring, a decrease in the sagittal diameter of the oropharynx followed, during snoring, by high-frequency oscillations of soft palate and pharyngeal walls. The pattern of soft palate oscillations was different while snoring through the nose or mouth. During inspiratory snoring through the nose, the soft palate remained in close contact with the back of the tongue and only the uvula presented high-frequency oscillations. Snoring through the mouth resulted in ample high-frequency oscillations of the whole soft palate. Frequency of airflow and supraglottic pressure oscillations was less (P less than 0.05) during mouth (28.2 +/- 7.5 Hz) than during nasal snoring (77.8 +/- 36.7 Hz). This difference may be related to the smaller oscillating mass (i.e., uvula) during nasal snoring. At variance with our previous data, which showed that snoring during sleep, in both heavy (nonapneic) snorers and obstructive sleep apnea patients, was systematically preceded by flow limitation, this was not true during simulated snoring

724. Marshall, I., M. Rogers, and G. Drummond. 1991. Acoustic reflectometry for airway measurement. Principles, limitations and previous work. *Clin.Phys.Physiol Meas.* 12:131-141.
Abstract: Acoustic pulse reflectometry is a relatively recent technique which allows the non-invasive measurement of human airways. The technique consists of guiding an acoustic impulse through the subject's mouth and into the airway. Suitable analysis of the resulting reflection (the 'echo') allows a reconstruction of the area-distance function. The non- invasive nature of the technique offers significant advantages over the established methods of x-ray cephalometry and CT scanning, and makes it very attractive for the investigation of ENT problems and sleep apnoea, and in the anaesthetic management of patients. This paper describes the theory and limitations of acoustic reflectometry, discusses previous work, and suggests some modifications: it is currently being implemented clinically

725. Metes, A., M. Ohki, P. Cole, J. S. Haight, and V. Hoffstein. 1991. Snoring, apnea and nasal resistance in men and women. *J.Otolaryngol.* 20:57-61.
Abstract: To examine if gender and airway resistance (nasal and pulmonary) influence the loudness and intensity of snoring, we prospectively studied 370 unselected patients referred to our sleep clinic because of heavy snoring and a possibility of sleep apnea. All patients had full nocturnal polysomnography, including measurements of snoring using a calibrated microphone-sound meter system, and determination of pulmonary (Raw) and nasal resistance (Rna). Snoring was quantified by reporting the number of snores per hour of sleep (snoring index--SI) and the maximum nocturnal sound intensity (dBmax). The patient population comprised 77 females and 293 males, ranging in age from 12 to 80 years. Based on the apnea/hypopnea index (AHI) we separated all patients into the apneic and non-apneic groups. There were 201 non- apneic snorers (AHI less than or equal to 10) and 160 apneic snorers (AHI greater than 10). There was no significant difference in snoring frequency, maximum nocturnal sound intensity, nasal and pulmonary resistance between men and women or between apneic and non-apneic snorers. Stepwise, forward, multiple linear regression analysis showed that body mass index and nasal resistance correlate significantly with the snoring index (R2 = 0.29, p less than 0.005), while age and body mass index correlate only weakly, but significantly, with the maximum nocturnal sound intensity. We conclude that (1) men snore similarly to women, and (2) obesity and nasal resistance are important determinants of the frequency of snoring. It follows that measures taken to reduce weight and decrease nasal resistance may be of benefit in reducing snoring

726. Munakata, M., H. Ukita, I. Doi, Y. Ohtsuka, Y. Masaki, Y. Homma, and Y. Kawakami. 1991. Spectral and waveform characteristics of fine and coarse crackles. *Thorax* 46:651-657.
Abstract: Two acoustically different types of lung crackles, fine and coarse, occur in different pathophysiological conditions. To differentiate these crackles from objective characteristics of frequency information, crackles were recorded from 16 patients with pulmonary fibrosis judged clinically to have "fine" crackles and from 10 with chronic bronchitis who had mainly "coarse" crackles. Time expanded waveforms (1/4 cycle duration, initial deflection width, two cycle duration, and 9/4 cycle duration; duration of the first 1/4, 2/4, 8/4, and 9/4 cycles of crackle waveforms) were examined and fast Fourier transform analysis (peak and maximum frequencies) was performed. All waveform measurements for fine crackles were significantly smaller than those for coarse crackles. Peak and maximum frequencies for fine crackles were significantly higher than those for coarse crackles. Although there

was some overlap in these values for individual crackles between the two groups when average values of these measurements were calculated for each patient, there was no overlap between fine and coarse crackles and the two groups could be clearly separated. Log peak frequency and log maximum frequency correlated better with 9/4 cycle duration (r = 0.85, 0.84) and two cycle duration (r = 0.87, 0.86) than with 1/4 cycle duration (r = 0.66, 0.77) or initial deflection width (r = 0.67, 0.79). Early and late segments of crackles have different characteristics, probably related to the origin of the sound and the resonance of the lung respectively. These results suggest that spectral and waveform characteristics may help to improve the accuracy of pulmonary auscultation and increase knowledge of how crackles are generated

727. Nekvasil, R., J. Stejskal, M. Nevrtal, and M. Muchova. 1991. [Sonographic analysis of postextubation stridor in neonates and children with low birth weight after long-term artificial ventilation]. *Cesk.Pediatr.* 46:259-261.
Abstract: In a group of 23 neonates with mean birth weights of 1470 g (range 1200-3980 g) who had orotracheal intubation for an average period of 12.6 days (range 5-96 days) sonagraphic frequency analysis of 86 stridors 1-3 hours after intubation was performed. According to the results of the frequency analysis more than 97.6% of the stridors are supraglottic (84 of 86 analyzed stridors). The laryngeal and tracheal type of stridor was recorded only in two children. The finding is surprising and does not confirm the widely accepted view that neonates after extubation are threatened with oedema of the larynx or stricture at this or a distal level. As elective postextubation laryngoscopy is controversial, acoustic frequency analysis of stridor after extubation is a suitable alternate method in investigations of the clinical condition of the infant and serves the clinician as an indication on the level of stenosis of the airways

728. Noviski, N., L. Cohen, C. Springer, E. Bar-Yishay, A. Avital, and S. Godfrey. 1991. Bronchial provocation determined by breath sounds compared with lung function. *Arch.Dis.Child* 66:952-955.
Abstract: Bronchial provocation testing with methacholine was undertaken in 15 children aged 5 to 8 years with obstructive lung disease, mostly asthma (13/15). The methacholine was inhaled during two minutes of tidal breathing in increasing concentrations. After each inhalation, lung function was measured and clinical signs recorded independently by two observers unaware of each other's results. The logarithm of the concentration of methacholine which caused wheezing over the trachea correlated closely with the logarithm of the concentration of methacholine causing a 20% fall in the forced expiratory volume in one second (FEV1) but was 52% greater on average. At the end of the test there was a mean (SD) fall in FEV1 of 33.3 (7.4)% and a fall in oxygen saturation of 5.2 (3.1)%. Bronchial provocation testing by listening for wheeze over the trachea is a safe technique, which correlates with objective measures of lung function in young children

729. Piirila, P., A. R. Sovijarvi, T. Kaisla, H. M. Rajala, and T. Katila. 1991. Crackles in patients with fibrosing alveolitis, bronchiectasis, COPD, and heart failure. *Chest* 99:1076-1083.
Abstract: We have studied the crackling lung sounds of ten patients with cryptogenic fibrosing alveolitis, ten with bronchiectasis, ten with chronic obstructive pulmonary disease, and ten with heart failure by analyzing frequency, waveform, and timing of crackles. The upper frequency limit of inspiratory sounds was higher in CFA than in COPD or in HF. The period of crackling was shorter in COPD than in CFA or BE. Inspiratory crackling terminated significantly earlier in COPD than in CFA, BE, or HF. The initial deflection width and the two-cycle duration of the expanded waveforms of crackles were smaller in CFA than in BE, COPD, or HF. The largest deflection width was smaller in CFA than in BE, HF, or COPD and smaller in BE than in HF. The results indicate that crackling lung sounds in different diseases have distinctive features and that their analysis can be of diagnostic value

730. Ploysongsang, Y., V. K. Iyer, and P. A. Ramamoorthy. 1991. Reproducibility of the vesicular breath sounds in normal subjects. *Respiration* 58:158-162.
Abstract: Nonfiltered (NF) lung sounds from the apical area of the heart along with lung volumes and ECG signals were recorded from 5 normal subjects. The signals were digitized and subjected to three methods of heart sound cancellation: 75-Hz high-pass filtering (75 HF), ECG-triggered blanking (BL) and adaptive noise cancelling (AF) [IEEE Trans. Biomed. Engng 33: 1141-1148, 1986]. The sound signals were then subjected to the fast Fourier transform algorithm to obtain power spectra. Five breaths from each subject were analyzed, and their spectra were similar and slightly skewed to the right. The average values of mean, median and mode frequencies of the whole breath of 5 subjects, respectively, were for NF: 64.62 +/- 3.74, 44.57 +/- 2.06 and 36.75 +/- 1.79 Hz; for 75 HF: 150.42 +/- 17.49, 114.02 +/- 6.43 and 86.16 +/- 3.13 Hz; for BL: 81.76 +/- 6.02, 52.36 +/- 2.79, 41.10 +/- 3.15 Hz; for AF: 96.87 +/- 11.58, 68.23 +/- 10.44 and 52.25 +/- 8.97 Hz. These values showed no differences between subjects. The F values obtained by the two-way analysis of variance of all breaths of all subjects (mean, median, mode) were: NF: 0.161, 0.341, 0.089; 75 HF: 0.455, 0.042, 0.085; BL: 0.108, 0.082, 0.057; AF: 0.130, 0.204, 0.113 (all p greater than 0.1). The data revealed a remarkable lack of variation within and between subjects, suggesting similar sites and mechanisms of production and transmission

731. Rasche, H., R. Koster, and H. J. Schultz-Coulon. 1991. [Differential diagnosis of rhonchopathy using the MESAM system]. *HNO* 39:451-459.
Abstract: A programme for the differential diagnosis of rhonchopathy is reported, based upon the MESAM system developed at the

University of Marburg. With this biparametric long-term monitor the snoring noise and the heart beat frequency (a beat-by-beat analysis) were recorded in 94 patients with a history of snoring. Other investigations included tape recordings of the snoring noise, nasoendoscopy, pulsed cineradiography of the pharynx and the recording of the character of the snoring. This programme is much cheaper than a sleep laboratory, but it can distinguish between obstructive sleep apnoea syndrome, habitual rhonchopathy and non-snorers, mainly by means of the characteristic patterns of MESAM recordings. A sleep apnoea syndrome was diagnosed in 19 patients and habitual rhonchopathy in 38 patients, whereas 33 patients were regarded as non-snorers. Ten of our 19 patients with sleep apnoea were re-examined by a sleep laboratory and the diagnosis was proved in all of these cases. In the 38 patients with habitual rhonchopathy auditory analysis of the snoring noise classified 23 patients as velar and 10 as pharyngeal snorers; 5 patients showed a mixed type of rhonchopathy. The questionnaire accompanying the MESAM system, nasal endoscopy and cine films support the individual diagnosis by revealing typical complaints and characteristic organic findings and thus contribute to the differential diagnostic screening. However, the three groups do overlap quite markedly with respect to symptoms und organic findings. In summary, the MESAM system provides an economically viable examination programme that can be used routinely by the otorhinolaryngologist for the differential diagnosis of rhonchopathy

732. Shen, H., J. Huang, K. Yamanouchi, S. Sakurai, S. Kitagawa, Y. Nagasaka, N. Ohya, and T. Fukunaga. 1991. [Effect of posture on pharyngeal area measured by acoustic reflection technique]. *Nihon Kyobu Shikkan Gakkai Zasshi* 29:554-559.
Abstract: Patients with obstructive sleep apnea (OSA) have a smaller pharyngeal area (PA) and higher compliance than normal subjects. The apnea- hypopnea index (AHI) in OSA patients determined by polysomnographic study was greater in the supine than lateral position. Recently there have been reports of reduction in the PA by the acoustic reflection technique (ART) in the supine position. However, there has been no report on the PA measured by ART in the lateral position which is important in the treatment of OSA. To evaluate differences in the PA with posture changes, we measured the PA in 41 normal subjects (11 males and 30 females) in the sitting, lateral and supine positions by ART. The average PA in the sitting position in the males and females was 3.8 +/- 0.6 cm2, and 3.3 +/- 0.5 cm2, respectively. The average PA in the lateral position in the males and females was 3.5 +/- 0.6 cm2, and 3.1 +/- 0.5 cm2, respectively. The average PA in the supine position in the males and females was 2.9 +/- 0.5 cm2, and 2.7 +/- 0.4 cm2, respectively. PA in the sitting position correlated well with body surface area (BSA). The average PA in both the males and females was significantly smaller in the supine than in the sitting position. The average PA in the lateral position in both males and females was significantly smaller than that in the sitting position and was significantly larger than that in the supine position. Decrease in PA with posture (from sitting to lateral) in the males (9.2 +/- 5.5%) was similar to that in the female (5.7 +/- 5.4%). Decrease in PA with posture (from sitting to supine) was significantly larger in male (24.4 +/- 9.5%) than in female (16.6 +/- 6.8%). We conclude that the decrease of PA in the supine position is ameliorated in the lateral position in normal subjects. Lateral position may be the preferred sleeping position in snoring or OSA patients

733. Slegel, D. E. and H. P. Roffwarg. 1991. A sensitive air pressure-measuring transducer for indirect middle ear muscle recording in humans. *Sleep* 14:65-68.
Abstract: In the past, the recording of middle ear muscle activity (MEMA) during sleep was accomplished with the use of the acoustic impedance bridge (AIB). However, two major concerns with this technique are: 1. augmentation of MEMA (and possible impairment of the auditory apparatus), as a consequence of the 85-95 dB probe tone, which is necessary for acoustic tympanometry; 2. the AIB recording method is susceptible to snoring artifact so that determination of true MEMA events is difficult. By utilizing a highly sensitive air-pressure measuring transducer (AMPT), we were able to record MEMA accurately without artifactual stimulation of this endogenously occurring REM sleep phasic activity. Possible damage to inner ear structures is precluded because no sound input is required with the AMPT

734. Tal, A., I. Sanchez, and H. Pasterkamp. 1991. Respirosonography in infants with acute bronchiolitis. *Am.J.Dis.Child* 145:1405-1410.
Abstract: Respirosonography was used to analyze lung sounds and breathing patterns in 16 infants with acute bronchiolitis who were treated with nebulized salbutamol (albuterol). Wheezing was measured as a proportion of respiratory time (time spent wheezing [Tw]/total time [Ttot]). A decrease of 10% or greater in Tw/Ttot or a reduction in Tw/Ttot to less than 2% was considered a positive response to salbutamol. Seven infants responded to the salbutamol, and nine did not. In responders, Tw/Ttot decreased from 47% +/- 26% to 20% +/- 25% (mean +/- SD), and the respiratory rate decreased from 65 +/- 8 to 57 +/- 7 breaths per minute. In nonresponders, mean Tw/Ttot either did not change or increased, and there was no significant change in respiratory rate (53 +/- 10 breaths per minute before salbutamol inhalation and 56 +/- 9 breaths per minute after salbutamol inhalation). Complex repetitive waveforms, different from the sinusoidal waveforms of typical wheezing, were observed in 14 of 16 infants. Our findings add supportive evidence to the clinical impression that some infants with bronchiolitis respond to salbutamol. Respirosonography provides a noninvasive method for objective clinical assessment of young, wheezy children

735. Thorpe, C. W., W. R. Fright, L. J. Toop, and K. P. Dawson. 1991. A microcomputer-based interactive cough sound analysis system. *Comput.Methods Programs Biomed.* 36:33-43.

Abstract: The occurrence and nature of cough sounds, especially those occurring in asthma in young children, is of considerable interest to workers in paediatrics and general practice. To facilitate our research into the characteristics of such sounds, we have developed a microcomputer-based analysis system, which we call COFF. In this paper we discuss the design and implementation of the system, emphasising its user-friendly, interactive features, and the manner in which it efficiently manages the large amounts of data that research into sounds incurs. We illustrate the operation of the system with examples of spectrograms computed from cough sounds recorded simultaneously at the mouth and through the chest wall

736. Tian, X. Nonlinear dynamics and chaos in flow through a collapsed tube. 1991. UNIVERSITY OF NEW SOUTH WALES (AUSTRALIA).
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737. Tinkelman, D. G., C. Lutz, and B. Conner. 1991. Methacholine challenges in the management of young children. *Ann.Allergy* 66:225-230.
Abstract: Methacholine bronchial challenges (MBCs) have been used as an important diagnostic and management tool for physicians who treat children with chronic asthma. Despite this, children less than 5 years of age present significant diagnostic and management questions that can not easily be answered because of their inability to perform standard spirometry, and thus methacholine bronchial challenges. The present study was designed to evaluate with methacholine bronchial challenge small children (between 2 and 6 years of age) with the diagnosis of or a suspected diagnosis of asthma, utilizing a new method of evaluating airflow in small children through sound analysis, Computer Digitized Airway Phonopneumography (CDAP). There were 23 children in the study between the ages of 2 and 6 years with suspected asthma who could not perform pulmonary function tests. A control group consisting of 12 subjects between the ages of 8 and 38 years of age with a history of chronic cough and/or wheezing who could perform pulmonary function tests was also studied. Of the 12 patients over the age of 8 who had MBC, 11 of them had positive challenges with a fall in FEV1 of 19% or greater. The percent change in sound intensity levels from baseline range from 232% to 396% of baseline. There was greater than 200% change in mean intensity levels with a concentration of methacholine that produced a 19% fall in FEV1 in all of the eleven patients. For one individual who had a negative MBC there was only a 16% change in pulmonary function at 25 mg of methacholine with essentially no change in sound intensity level from baseline.(ABSTRACT TRUNCATED AT 250 WORDS)

738. Tinkelman, D. G., C. Lutz, and B. Conner. 1991. Utilizing lung sounds analysis for the evaluation of acute asthma in small children. *Ann.Allergy* 67:339-344.
Abstract: One of the most difficult aspects of management of acute asthma in the small child is the clinician's inability to quantitate the response or lack of response to bronchodilator agents because of the inability of a child this age to perform objective lung measurements in the acute state. The present study was designed to evaluate bronchodilator responsiveness in children between 2 and 6 years of age with wheezing by means of a computerized lung sound analysis, computer digitized airway phonopneumonography. Children between ages 2 and 6 who were experiencing acute exacerbations of asthma were included in this study population. The 43 children were evaluated by physical examination, pulmonary function testing, if possible, by use of (spirometry or peak flow meter) and transmission of lung sounds to a computer using an electronic stethoscope to obtain a phonopneumograph with sound intensity level determinations during tidal breathing. A control group of 20 known asthmatic patients between the ages of 8 and 52 years who also presented to the office with acute asthma were evaluated similarly. In each of these individuals, a physical examination was followed by complete spirometry as well as computer digitized airway phonopneumonography recordings. Following initial measurements, all patients were treated with nebulized albuterol (0.25 mL in 2 mL of saline). Five minutes after completion of the nebulization all patients were reexamined and repeat pulmonary function tests were performed followed by CDAP recordings. In the study group of children, the mean pretreatment sound intensity level was 1,694 (range 557 to 4,950 SD +/- 745).(ABSTRACT TRUNCATED AT 250 WORDS)

739. Tinkelman, D. G., C. Lutz, and B. Conner. 1991. Analysis of breath sounds in normal and asthmatic children and adults using computer digitized airway phonopneumography (CDAP). *Respir.Med.* 85:125-131.
Abstract: Analysis of breath sounds using the stethoscope is a major part of physicians evaluation of their patients. However, the use of a stethoscope is often inadequate to give quantitative measurements of the clinical state of the individual. In this study a modification of a previously described computer analysis of breath sounds was used to measure sound intensity levels in both normal and asthmatic children who, in most cases, were unable to perform pulmonary function. The intensity levels were derived using a microcomputer-based program that digitizes audio signals and calculates energy values at 25-ms intervals throughout each signal. There were statistical differences between mean intensity levels for normal breath sounds in children between 2 and 6 years and the mean intensity levels for wheezing sounds in the same age group, as well as wheezing sounds in asthmatic patients over the age of 8 years (P less than 0.002). Also, the mean intensity levels for normal breath sounds could be clearly differentiated from intensity levels for other sounds from the chest, including heart sounds and voice sounds. Thus, computer digitized airway

phonopneumography (CDAP) proved to be a reproducible, quantifiable method for demonstrating airway obstruction in those children and patients unable to perform pulmonary function testing

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741. Whitmoyer, T. B. Modeling and measurement of the input acoustic impedance of the lung. 1991. WEST VIRGINIA UNIVERSITY.
Ref Type: Thesis/Dissertation

742. Yonemaru, M., T. Abe, H. Kobayashi, T. Kawashiro, and T. Yokoyama. 1991. [Changes in sound transmissibility through the canine thorax due to the experimental pleural effusion]. *Nihon Kyobu Shikkan Gakkai Zasshi* 29:829-835.
Abstract: The authors studied the effects of pleural effusion on sound transmissibility through the canine thorax. In the supine position, dogs received sound ranging from 100 to 1000 Hz at the tracheostoma. Using the microphones attached to the dorsal and ventral part of the chest wall, the relative level of the transmitted sound wave was determined in reference to the amplitude of the sound wave at a tracheostom. Measurements of sound transmissibility were performed before and after injecting saline into the bilateral pleural space which was intended to be experimental pleural effusion. In the dorsal part, the experimental pleural effusion decreased sound transmissibility in the frequency range between 100 and 300 Hz. At 100 Hz, the pleural effusion of 5, 10, and 15 ml/kg/hemithorax caused a decrease in sound transmissibility by 3.7 +/- 3.7, 6.6 +/- 4.9, and 10.0 +/- 5.7 dB, respectively. In the ventral part, the reduction in sound transmissibility in the low frequency range due to the pleural effusion was small. In contrast, introduction of pleural effusion caused an increase in sound transmissibility by 5 to 9 dB in the frequency range above 500 Hz. We consider that these changes in sound transmission are implicated in the physical findings such as "aegophony" and reduction in vocal fremitus or vocal ausculation

743. Anderson, K., S. Aitken, R. Carter, J. E. MacLeod, and F. Moran. 1990. Variation of breath sound and airway caliber induced by histamine challenge. *Am.Rev.Respir.Dis.* 141:1147-1150.
Abstract: Inspiratory breath sounds were recorded from the chest wall during histamine challenge in five subjects with mild asthma (baseline FEV1 greater than 60% of predicted normal). The median frequency of the power spectrum of the breath sounds was found to correlate with the percentage change in FEV1 induced by histamine and with FEF50. The analysis suggests that for a decrease in FEV1 of 20%, the median frequency of breath sound would increase by 80 Hz. Variation in airway caliber produced a consistent alteration in the distribution of energy in inspiratory breath sound in the absence of wheeze. Spectral analysis of breath sound may be a useful addition to conventional spirometry in identifying changes in airway diameter

744. Attenburrow, D. P., F. C. Flack, and M. J. Portergill. 1990. The relationship between peak expiratory sound intensity and peak expiratory flow rate in the thoroughbred horse during exercise. *Equine Vet.J.Suppl*43-46.
Abstract: Peak expiratory sound intensity (dB SPL), obtained by means of a radiostethoscope, and peak expiratory flow rate, obtained using a mask incorporating a thermistor flow sensor, were measured in six Thoroughbreds over a range of stride rates from 100 to 140 strides per min. The results show linear relationships between peak dB SPL and stride rate, peak expiratory flow rate and stride rate and also between peak expiratory flow rate and peak dB SPL. Peak expiratory dB SPL can therefore indicate peak expiratory flow rate

745. Beck, R. and N. Gavriely. 1990. The reproducibility of forced expiratory wheezes. *Am.Rev.Respir.Dis.* 141:1418-1422.
Abstract: Previous work has shown forced expiratory wheezes (FEW) to be associated with onset of flow limitation and to have spectral characteristics similar to wheezes heard in patients with obstructive lung diseases. This study was designed to determine whether the acoustic characteristics of FEW are reproducible under controlled lung volume and flow conditions. Six healthy, nonsmoking young adults 28 to 37 yr of age were studied. They performed FVC maneuvers through a set of round apertures (diameters, 14, 12, 10, 8, 6, 4, 2, and 1 mm). Flow, measured with a pneumotachograph, and tracheal lung sounds, recorded with a Hewlett-Packard HP20510A contact sensor, were recorded simultaneously on magnetic tape and analyzed off-line. For each subject, data from three different aperture sizes, measured in triplicates, were analyzed (total of 54 runs); 199 different wheezes were identified (mean, 3.7 wheezes/run), and 56.7 +/- 5.1% (mean +/- SEM) of wheezes found in a certain run (range, 41.7 to 77.8%) were identical to wheezes found in the other two runs of the same aperture size (i.e., same flow rate). In 17 of the 18 sets of triplicate runs analyzed, at least one major wheeze was identical in all three runs of the set. In three of the sets, two different identical wheezes were found. These findings support a deterministic mechanism of generation of wheezes and is in line with the predictions of the "flutter theory."

746. Ben Noun, L. 1990. [Use of stethoscope by mothers of asthmatic children ages 1-5]. *Harefuah* 119:362-364.
Abstract: The mothers of 24 asthmatic children aged 1-5 years, who visited a department of family medicine at the time of the attacks, were assigned alternately to 2 groups. The experimental study group got guidance and instruction in the use of the stethoscope, and also participated in a self-management educational program led by the family physician. The control group only got guidance and participated in the latter program. The purpose of the study was to determine whether mothers could assume more responsibility in decision-making with regard to their children's asthmatic attacks after basic technical guidance in the use of the stethoscope and in the interpretation of auscultatory findings. The results show that the initial steps in self-management were adequate in the 2 groups. These included recognition of the first signs of asthma in the child, a relaxed attitude (not to panic), the dispensing of suitable amounts of fluid, and the administration of bronchodilator medication without waiting for the physician's examination. Instructions to continue bronchodilator drugs, both oral and by inhaler, were more detailed in the experimental group. During the year of follow-up there were fewer visits to the clinic and the emergency room and no hospital admissions by those in the experimental group. The main conclusion of this study is that in conjunction with a self-management program, it is possible to teach mothers to use a stethoscope, to correctly interpret the auscultatory findings and accordingly, to give adequate treatment. This reduces clinic and emergency room visits and hospital admissions, relieves anxiety, and increases confidence in coping with this illness

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749. Debreczeni, L. A., J. Korpas, D. Salat, J. Sadlonova-Korpasova, C. Vertes, E. Masarova, and E. Kavcova. 1990. Spectra of the voluntary first cough sounds. *Acta Physiol Hung.* 75:117-131.
Abstract: The voluntary cough sounds recorded according to Korpas and Sadlonova- Korpasova were sampled at a frequency of 20.000Hz and spectra of six consecutive windows of 50ms were estimated. To digitize signals an autotrigger mode was used. The subjects were healthy volunteers as well as patients with chronic bronchitis, asthma, bronchial carcinoma (growing intraluminarly in the 1st or in the 2nd or in the 3rd order bronchi), emphysema, laryngeal nerve paralyzis or laryngotomy. The duration of averaged cough sounds of patients was longer than that of healthy volunteers. The mean power of the spectra in the successive windows showed different patterns in the same group. In the third window of healthy volunteers (0.10 s-0.15 s) a high modulus broad bandwidth (between 1-2 kHz) spectrum was found which was considered as a bronchial "flute", and was probably related to the lowest resistance as well as to the velocity of airflow of cough manoeuvre. This pattern appeared with a delay and/or it was changed in the diseased groups compared to the healthy volunteers. Due to this delay, the spectra of the fifth window (0.20 s-0.25 s) showed somewhat higher harmonics (400- 800 Hz) in the patients with chronic obstructive pulmonary diseases (COPD), carcinoma and laryngeal nerve paralyzis than in healthy volunteers. In emphysematous patients in the first (0.00-0.05 s), in the third (0.10-0.15 s) and in the fifth (0.20-0.25 s) windows the fundamental frequency was low (156-176 Hz) compared to that of the other groups. The paralyzed vocal cords functioning as an added resistance to the expiratory effort caused a phase-shift in the cough patterns, similarly to that seen in COPD patients. Due to the cannula, the spectra of patients having laryngotomy had a lot of high harmonics. They also had peaks nearly identical to that of bronchitic patients because they suffered from serious chronic bronchitis. It was found that by examination the cough spectra of series of voluntary cough sound signals it was possible to distinguish healthy volunteers from patients. This examination would therefore be useful for screening of bronchial diseases

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751. Hoevers, J. and R. G. Loudon. 1990. Measuring crackles. *Chest* 98:1240-1243.
Abstract: Crackles heard on auscultation can be represented graphically as a time- amplitude plot of the associated waveform. To assess the relative merits of several measures which might be considered for machine implementation in diagnostic instruments, we compared the reproducibility of those based on the initial voltage deflection which begins a crackle with those based on the largest deflection. The latter group showed less interobserver and less intraobserver variability when the same crackles were measured twice by each of two observers. Crackles from a teaching tape, categorized as fine and coarse, were used in this study. The ability of the various measures tested to distinguish between fine and coarse crackles on an individual basis was assessed and found to favor the measures based on the largest deflection. They showed an average of 9.96 percent incorrectly classified crackles, as opposed to 19.53 percent for the two measures based on the initial deflection

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Abstract: The high dependence of conventional optimal filtering methods on the a priori knowledge of the signal and noise statistics render them ineffective in dealing with signals whose statistics cannot be predetermined accurately. Adaptive filtering methods offer a better alternative, since the a priori knowledge of statistics is less critical, real time processing is possible, and the computations are less expensive for this approach. Adaptive filtering methods compute the filter coefficients "on-line", converging to the optimal values in the least-mean square (LMS) error sense. Adaptive filtering is therefore apt for dealing with the "unknown" statistics situation and has been applied extensively in areas like communication, speech, radar, sonar, seismology, and biological signal processing and analysis for channel equalization, interference and echo canceling, line enhancement, signal detection, system identification, spectral analysis, beamforming, modeling, control, etc. In this review article adaptive filtering in the context of biological signals is reviewed. An intuitive approach to the underlying theory of adaptive filters and its applicability are presented. Applications of the principles in biological signal processing are discussed in a manner that brings out the key ideas involved. Current and potential future directions in adaptive biological signal processing are also discussed

753. Kazama, S. 1990. A new stereophonic stethoscope. *Jpn.Heart J.* 31:837-843.
Abstract: A new stereophonic stethoscope is presented. It is characterized by a single chest piece construction housing paired open-bell type sound accumulating chambers and paired diaphragm type sound accumulating chambers. A pair of separate ear tubes connected to each of the paired sound chambers establish two cross talk-free channels for collecting and delivering auscultatory sounds. Selective use of the open-bell and diaphragm sound chambers is assured with this new stethoscope. Advantages of stereophonic auscultation are discussed

754. Koster, M. E., R. P. Baughman, and R. G. Loudon. 1990. Continuous adventitious lung sounds. *J.Asthma* 27:237-249.
Abstract: Recent research has increased the still limited understanding about the generation of continuous adventitious lung sounds. These sounds all have a definite pitch, such as in stridor and wheezing. With the use of waveform analysis, one can examine more closely the relationship between what is heard and the pathophysiology causing the sound. Clinical examples are given to show the utility and limitations of current lung sounds analysis techniques

755. Kraman, S. S. and P. M. Wang. 1990. Airflow-generated sound in a hollow canine airway cast. *Chest* 97:461-466.
Abstract: We examined the distribution of airflow-generated sound within a flexible model of canine airways. Sounds were picked up by a microphone adapted to a glass conical probe which was introduced through puncture holes in the wall of the model. We acquired 341 measurements in 31 airways between 2.0 and 19.0 mm in diameter at airflow rates from 0 to 2.5 L/s in the inspiratory and expiratory directions. We found that in the expiratory direction, the sound amplitude was approximately linearly related to airway cross-sectional area, with the greatest amplitude occurring in the largest airway. In the inspiratory direction the greatest amplitude occurred in airways of 5 to 8 mm in diameter. At all levels within the model, sound amplitude was approximately linearly related to the square of the airflow. Our findings suggest that in canine airways, the predominant vesicular lung sound-producing locations are the large airways for the expiratory component and the medium-sized airways for the inspiratory component

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Abstract: By means of the acoustic reflection technique, termed acoustic rhinometry, cross-sectional areas along the whole upper airway can be measured by an acoustic click. This paper describes the normal values obtained from 134 probands. The normal curve shows the minimal cross- sectional area (I-notch) to be located at the isthmus nasi. The second narrowest segment of the nasal cavity is located at the head of the inferior concha (C-notch). In patients with turbinate hypertrophy due to allergic or vasomotor rhinitis the minimal cross-sectional area is sited at the head of the inferior turbinate. Furthermore, acoustic rhinometry allows exact measurements of size and location of the congested mucosa following challenge with allergens in patients affected with allergic rhinitis. After anterior turbinoplasty of patients with turbinate hypertrophy improved nasal breathing was associated with an enlargement of the cross-sectional areas at the head of the anterior inferior turbinate. Acoustic rhinometry not only enables to distinguish the various deviations of the nasal structures from normal (valve stenosis, septal deviation, turbinate hypertrophy, tumour masses) concerning their location and size, but also allows to demonstrate exactly the efficacy of rhinosurgical techniques

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Abstract: We constructed and tested an inexpensive (less than $50) FM wireless, acoustically shielded, precordial radiostethoscope that enables the anesthetist to follow the heart tones and breath sounds of the patient regardless of the anesthetist's location in the operating room. We compared our acoustically shielded device with a similar, but acoustically unshielded, commercially available device. We found the sound quality of our radiostethoscope to be superior to that of the commercial device; the signal-to-noise ratio of our device was 7.6 for heart tones and 8.4 for breath sounds, whereas the

commercial device had a signal-to-noise ratio of 2.7 and 3.9 for heart tones and breath sounds, respectively. Our device offers all of the advantages of a radiostethoscope and has the added advantages of low cost and high fidelity

758. Moon, J. 1990. The influence of nasal patency on accelerometric transduction of nasal bone vibration. *Cleft Palate J.* 27:266-270.
Abstract: The transmission characteristics of nasal tract energy to a nasal accelerometer were evaluated in relation to nasal tract airway resistance. Ten adult speakers repeated three utterances while recordings of nasal bone vibration, as detected by miniature accelerometers, were obtained simultaneously from both sides of the nose and referenced to a common throat signal. Average nasal-to-oral accelerometry ratios recorded from the more resistant side of the nose were significantly larger in magnitude than those recorded simultaneously from the less resistant side of the nose. While accelerometer ratio waveforms from each side of the nose essentially overlapped for some subjects, others displayed unilateral variations in accelerometer output as a function of time. The anatomic and physiologic condition of the nasal passage appears to be an important variable in the detection of nasal tract acoustic energy using the accelerometric technique

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Abstract: Clinical features on admission of 60 infants with acute bronchiolitis were related to disease severity. Crackles and cyanosis (which are related to oxygen requirements during the hospital stay) most closely correlated with severity, which was assessed by arterial blood gas analysis and pulse oximetry. Respiratory rate on presentation did not predict severity. Transcutaneous haemoglobin oxygen saturation on admission, measured by pulse oximetry, was closely related to cyanosis and maximum oxygen requirements. The best method for initial assessment of bronchiolitis was pulse oximetry

760. Musgrave, T. and A. Verghese. 1990. Clinical features of pneumonia in the elderly. *Semin.Respir.Infect.* 5:269-275.
Abstract: Concomitant pneumonia and influenza constitute the leading infectious cause of death in the elderly and the fourth most common cause of death overall. The presence of concomitant illness and delays in diagnosis contribute to significant mortality from this disease in the elderly; senescence of the immune system seems less important in predisposition to pneumonia than the presence of concomitant illness. Delay in diagnosis is frequently secondary to the atypical presentations of pneumonia in the elderly. The usual symptoms of fever, chills, rigors, and sputum production that are present in young adults all may be absent; confusion may be the only presenting symptom. Tachypnea is frequent, but the physical examination, in addition to often being technically difficult, is not sufficiently sensitive in making a diagnosis. Leukocytosis is common, but by no means specific. Chest roentgenograms frequently show incomplete consolidation and findings are difficult to distinguish from other diseases of the elderly, such as congestive heart failure, atelectasis, pulmonary embolism, and malignancy. Therefore, clinical diagnosis requires a high index of suspicion despite atypical clinical manifestations

761. Mussell, M. J., Y. Nakazono, Y. Miyamoto, S. Okabe, and T. Takishima. 1990. Distinguishing normal and abnormal tracheal breathing sounds by principal component analysis. *Jpn.J.Physiol* 40:713-721.
Abstract: Expired and inspired tracheal breathing sounds (BS) were recorded from 10 normal subjects and 8 patients with respiratory diseases, including bronchial asthma, sarcoidosis, fibrosing lung disease, chronic bronchitis, and radiation pneumonitis. Frequency spectra were generated using Fast Fourier Transform (FFT), and we observed considerable differences between BS spectra of normal subjects and patients. The frequency of peak amplitude and mean frequency of the BS spectra of patients were significantly higher than those of normal subjects. Spectral features were extracted by dividing each spectra into equal frequency bands--each feature being the mean amplitude of each FFT element within a frequency band. We used Principal Component Analysis to compare spectral feature sets and found a clear separation between normal and abnormal tracheal BS for 10, 20, and 40 features/spectra. We conclude that Principal Component Analysis of BS could become a new method of diagnosing respiratory disease in an automated fashion

762. Mussell, M. J., Y. Nakazono, and Y. Miyamoto. 1990. Effect of air flow and flow transducer on tracheal breath sounds. *Med.Biol.Eng Comput.* 28:550-554.
Abstract: Tracheal breath sounds (TBSs) were analysed in 12 normal adult subjects at the air flow levels of 1.6, 2.1 and 2.6 litres-1, using a low- resistance flow transducer, and at an estimated flow of 2.1 litres-1 without the flow transducer. The major findings were that the TBSs were significantly distorted by the flow transducer, but were independent of air flow. We therefore conclude that true TBSs can only really be recorded when an oral flow transducer is not used. The within-subject reproducibility of TBS was relatively good, while the cross-subject comparison of TBS showed that each subject produced their own unique spectral pattern, although the TBSs of normal subjects fall in a common frequency range. Also, inspiratory sounds were significantly lower in peak frequency than expiratory TBSs

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Ref Type: Computer Program

764. Ploysongsang, Y., V. K. Iyer, and P. A. Ramamoorthy. 1990. Inspiratory and expiratory vesicular breath sounds. *Respiration* 57:313-317.
Abstract: Unfiltered breath sounds (NF) from the apical area of the heart, lung volume and ECG signals were recorded in 5 normal subjects. The signals were digitized and subjected to three methods of heart sound cancellation: 75-Hz high-pass filtering (75 HF), ECG-triggered blanking (BL) and adaptive filtering (AF). The sound signals were then subjected to the fast Fourier transform algorithm to obtain power spectra. Inspiratory and expiratory phase sounds of five breaths of each subject were analyzed separately. The inspiratory and expiratory sound power spectra were very similar and skewed slightly to the right, and therefore characterized by median frequencies. The differences between inspiratory and expiratory median frequencies were insignificant for NF: 42.90 +/- 2.03 (mean +/- SD) vs. 46.64 +/- 2.53 Hz (p greater than 0.1); for 75 HF: 106.43 +/- 10.27 vs. 118.22 +/- 6.30 Hz (p greater than 0.5); for BL: 44.46 +/- 3.33 vs. 66.73 +/- 2.93 Hz (p greater than 0.1), for AF: 49.72 +/- 5.68 vs. 79.20 +/- 13.07 Hz (p greater than 0.1). We conclude that the lack of significant differences suggests similar mechanisms and sites of production of inspiratory and expiratory vesicular breath sounds

765. Rao, A. J., H. Niwa, Y. Watanabe, S. Fukuta, and N. Yanagita. 1990. Spectral analysis of airflow sounds in patent versus occluded tracheostomy tubes: a pilot study in tracheostomized adult patients. *Laryngoscope* 100:536-540.
Abstract: Cannula occlusion is a life-threatening postoperative complication of tracheostomy. Current management largely relies on nursing care for prevention of fatalities because no proven mechanical, machine-based support monitoring exists. The objective of this paper was to address the problem of monitoring the state of cannula patency, based on analysis of airflow acoustic spectral patterns in tracheostomized adult patients in the patent and partially occluded cannula. Tracheal airflow sounds were picked up via a condenser microphone air-coupled to the skin just below the tracheal stoma. Signal output from Mic was amplified, high-pass filtered, digital tape-recorded, and analyzed on a mainframe computer. Although airflow frequencies for patient cannulae were predominantly low-pitched (0.1 to 0.3 kHz), occluded tubes had discrete high-pitched spectral peaks (1.3 to 1.6 kHz). These results suggest that frequency analysis of airflow sounds can identify a change in the status of cannula patency

766. Rodenstein, D. O., G. Dooms, Y. Thomas, G. Liistro, D. C. Stanescu, C. Culee, and G. ubert-Tulkens. 1990. Pharyngeal shape and dimensions in healthy subjects, snorers, and patients with obstructive sleep apnoea. *Thorax* 45:722-727.
Abstract: To characterise the relation between pharyngeal anatomy and sleep related disordered breathing, 17 men with complaints of snoring were studied by all night polysomnography. Ten of them had obstructive sleep apnoea (mean (SD) apnoea-hypopnoea index 56.3 (41.7), age 52 (10) years, body mass index 31.4 (5.3) kg/m2); whereas seven were simple snorers (apnoea-hypopnoea index 6.7 (4.6), age 40 (17) years, body mass index 25.9 (4.3) kg/m2). The pharynx was studied by magnetic resonance imaging in all patients and in a group of eight healthy subjects (age 27 (6) years, body mass index 21.8 (2.2) kg/m2, both significantly lower than in the patients; p less than 0.05). On the midsagittal section and six transverse sections equally spaced between the nasopharynx and the hypopharynx several anatomical measurements were performed. Results showed that there was no difference between groups in most magnetic resonance imaging measurements, but that on transverse sections the pharyngeal cross section had an elliptic shape with the long axis oriented in the coronal plane in normal subjects, whereas in apnoeic and snoring patients the pharynx was circular or had an elliptic shape but with the long axis oriented in the sagittal plane. It is suggested that the change in pharyngeal cross sectional shape, secondary to a reduction in pharyngeal transverse diameter, may be related to the risk of developing sleep related disordered breathing

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Abstract: To reduce time committment and expense in the diagnosis of sleep apnea it is necessary to develop simplified monitoring techniques. The monitoring systems to detect apneas should have high sensitivity, good reproducibility, be inexpensive and practical to use. The following methods have been suggested: inductance plethysmography, capnography, flow measurements by thermistors, tracheal sound recording, static charge sensitivity bed, oximetry, activity monitoring, detection of snoring. Some devices to registrate breathing have been combined with oximetry and other methods. The results have been validated by polysomnography and show rather good correlations. However, there exists no information on the time and cost savings of a step wise diagnosis of sleep apnea

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Abstract: Snoring sounds of 5 children with sleep-dependent compromised breathing were recorded. Underlying diseases were large adenoids, adeno-tonsillar hyperplasia, hemangioma of the tongue-base and Rubinstein-Taybi's syndrome associated with micrognathia. For comparison snoring sounds of a 42-year-old chronic snorer were analyzed. Time series of the power spectral density of the breath sounds were calculated as well as the mean power spectra of the recordings. The results show that the frequency spectrum reflects the pathomechanism responsible for the production of the abnormal breath sound. In adults, simple snoring is due in large part to vibrations of the soft palate. This can be identified in the frequency spectrum as a low-frequency component with a large number of harmonics. In children with enlarged adenoids and tonsils the soft palate is impeded in its

movement which can be demonstrated in the frequency spectrum as a lack of low-frequency components and harmonics. Craniofacial anomalies are characterized by special spectral patterns

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Abstract: Non-invasive procedures are proposed to aid the diagnosis of childhood laryngotracheal pathology and to monitor the course of such disease. The procedures capitalize on the one-to-one relationship which exists between the acoustic phenomena (stridors) associated with respiration and the configuration of the respiratory tract. Careful analysis of these acoustic patterns can thus assist in identifying and localizing constrictions, in diagnosis, and in monitoring disease severity. Based on the acoustical analysis of the stridor generated by children with congenital stridor, subglottal laryngitis, and trachea stenosis, the present paper demonstrates that a close relationship exists between the specific pathology and the spectrum of the associated respiratory stridor

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Abstract: A pure tone sound source was introduced at a nostril and monitored by a miniature accelerometer on the throat. During velopharyngeal closure in a swallow, the pure tone component in the accelerometer signal was attenuated. Throat accelerometer recordings were made simultaneously with videofluoroscopy of a modified barium swallow in adults with normal velopharyngeal mechanisms. It was verified that the period of sound attenuation corresponded to the period of velar closure. This noninvasive method of monitoring otherwise silent velopharyngeal closure holds promise for normative studies on swallowing function, as an adjunct method in longitudinal assessment, and as a training aid

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Abstract: We simultaneously recorded tracheal sound and air flow from nine normal subjects (seven males and two females). Sound was picked up at the supra sternal notch with an air-coupled sensitive microphone held in a small airtight probe. Flow was measured at the mouth using a pneumotachograph Fleisch n degrees 2. Both sound and flow were directly digitized at a sampling rate of 5120 Hz and then divided in 128-sample blocks. For each sound block the frequency spectrum was computed using the fast Fourier transform. In order to evaluate instantaneous flow- rate from tracheal sounds we investigated eight methods divided in two groups of four. In the first group (i.e., reference curves methods), we assumed that a relationship existed between sound and flow and was thus reflected by the variations of certain parameters. We chose to use simple straightforward relationships, already known and published. We tested four different parameters. During a calibration phase, we built for each parameter P a reference curve representing the variations of P versus flow and being specific to each subject. Then, an unknown flow was evaluated in calculating P on a 128-sample block, and the reference curve gave the corresponding flow. In the second group, we made a hierarchial clustering analysis of sound spectra for revealing the frequency modifications, induced by the flow. We tested two kinds of spectra as well as two ways of associating a flow to a given cluster. This led us to four other methods for calculating the flow. All the eight methods but one gave a mean uncertainty in the measure of flow of about 15%.(ABSTRACT TRUNCATED AT 250 WORDS)

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Abstract: A practical and portable method is described to analyze the sound spectra of coughs. The system is based upon a personal computer and simultaneously collects the sounds of cough heard both at the mouth and through the chest wall together with the airflow at the mouth produced during the cough. Subsequent analysis produce spectrographs of the cough sound linked to the corresponding airflow. The system will be used initially to examine the effects of exercise on the sound of cough in asthma. Further study of cough spectra in this way may be useful in the management of asthma either diagnostically or in the assessment of therapeutic interventions

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Abstract: The authors recorded the sound signals during suckle feeding of six normal infants within the first two postnatal days. The sounds were recorded onto a cassette tape-recorder from a small microphone attached to the infant's neck, then displayed on an oscilloscope and analysed by digital signal processing techniques. These displays demonstrated acoustic patterns and temporal relationships which are not otherwise audible. The method and findings are described in detail, and the method should be

useful in the clinical investigation of feeding and swallowing problems associated with more subtle neurological impairment and preterm birth

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Abstract: Objectification of the amplitude of the cough sound is important in determining its physiological or pathological nature. To achieve this aim an assembly for computer analysis in the time and frequency region was tested in an attempt to substitute the special equipment used at present by less expensive and readily available computer technique. At the same time the possibilities were assessed for using some statistical characteristics as diagnostic parameters in determining pathological changes of the cough sound. The physiological sound of cough was found to yield a hyperbola connecting the peaks of the individual bars of the frequency histogram which in pathological cough was represented by a line descending from left to right. Thus the two types of cough can be objectively distinguished

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Abstract: Inspiratory lung crackles are a diagnostic feature of interstitial pulmonary fibrosis, but expiratory crackles are not well documented. In a phonopneumographic study of 13 patients with fibrosing alveolitis, expiratory crackles were audible with the stethoscope in 12. Phonopneumographic analysis of these 12 patients showed the crackles to be fine with the initial wave deflection of the expiratory and inspiratory crackles in opposite directions. They were few in number, occurred predominantly in mid- and late expiration, and were not affected by varying the volume history or by breath holding maneuvers. These observations support the theory that some crackles are produced by vibration of the walls of peripheral airways. In addition, this group of patients showed a significant correlation between the number of expiratory crackles and the reduction in predicted transfer factor, suggesting that expiratory crackles may be a clinical indicator of the severity of disease in fibrosing alveolitis

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Abstract: Precise communication among clinicians of chest-auscultation findings depends on use of standardized nomenclature for lung sounds. To identify the current practice of clinicans in describing lung sounds, we surveyed physicians and respiratory care practitioners (RCPs). MATERIALS AND METHOD: Surveys were specifically designed to identify: (1) whether RCPs and physicians use similar terms to describe adventitious lung sounds (ALS), (2) whether changes are occurring in response to the recommendations of the ATS-ACCP Ad Hoc Subcommittee on Pulmonary Nomenclature, and (3) whether RCPs and physicians differ in their ability to accurately recognize ALS. We surveyed 156 RCPs at the 1987 Annual Meeting of the American Association for Respiratory Care and 223 pulmonary physicians (PPs) and 54 nonpulmonary physicians (NPPs) at the 1988 Annual Meeting of the American College of Chest Physicians. Each survey participant was required to listen to five examples of ALS using earphones and an audiocassette player and then to write 'free-form' descriptions of what they heard. (All participants listened to the same ALS.) RESULTS: Fine crackles and high-pitched monophonic and polyphonic wheezes were readily recognized by the majority of RCPs and physicians. Fine crackles were described as rales or crackles; high-pitched, monophonic wheezes were described as stridor or wheezes; however, high-pitched, polyphonic wheezes were usually described as wheezes. RCPs and physicians used a variety of terms to describe coarse crackles and rhonchi. The term rhonchi was frequently used inappropriately by all groups surveyed. There were no significant differences between PPs and RCPs in their ability to accurately recognize adventitious lung sounds; however, PPs were superior to NPPs (p less than 0.05) in this regard. PPs were superior to RCPs and NPPs (p less than 0.05) in appropriately using the term 'fine' for the description of crackles. CONCLUSION: All three groups of clinicians need to improve their ability to recognize and describe lung sounds

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Abstract: We report the terms used by 223 pulmonary physicians and 54 physicians in other specialties to describe eight recorded examples of lung sounds. The participants listened to the lung sounds at the 1988 American College of Chest Physicians annual convention and wrote "free form" answers. Pulmonary physicians used the terms "crackles" and "rales" with equal frequency to describe discontinuous adventitious lung sounds (ALS) and not at all to describe continuous ALS. Other physicians preferred the term "rales" in describing discontinuous ALS. The terms "wheeze" and "stridor" were used only in describing continuous ALS; however, the term "rhonchi" was frequently used to describe continuous and discontinuous ALS. The majority of participants recognized the normal breath sounds but not the pleural friction rub. Most did not use a qualifying adjective to describe ALS, and there was little agreement among those who did. The lung sound terminology used by physicians is not well standardized and the recommendations of the ATS/ACCP nomenclature subcommittee are not widely accepted

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Abstract: The amplitude of sound transmission from the mouth to a site overlying the extrathoracic trachea and two sites on the

posterior chest wall was measured in eight healthy adult male subjects at resting lung volume over the 100- to 600-Hz frequency range. The ratios of the estimated magnitude spectra of transmission of each of the chest wall sites to the tracheal site were determined, with the resulting spectra representing effective transfer functions of transmission in the subglottal system. For the group, the transfer functions exhibited a single peak, which occurred at 143 +/- 13 Hz (mean +/- SD) with a quality factor (Q) of 2.0 +/- 0.2 for the upper chest wall site and at 129 +/- 6 Hz with a Q of 2.2 +/- 0.4 for the lower site. The trend of decreasing spectral energy with increasing frequency was indicated by roll-offs of -10 +/- 4 and -17 +/- 5 dB/octave from 300 to 600 Hz at the two sites, respectively. The fundamental radial mode of a model thoracic cavity, which is a large rigid cylinder filled with lossless lung tissue, provides a good estimate of the observed low-frequency resonance. This agreement suggests that thoracic cavity resonances may have particularly important effects on sound transmission at frequencies below approximately 250 Hz, where the magnitude of parenchymal attenuation appears to be small

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Abstract: The amplitude of sound transmission from the mouth to a site overlying the extrathoracic trachea and two sites on the right posterior chest wall over the 100-600 Hz frequency range was measured in eight healthy adult subjects. An acoustic driver and a rigid tube were employed to introduce sound into the mouths of the subjects at resting lung volume, and the transmission measurements were performed using lightweight accelerometers. Similar spectral characteristics of acceleration were observed in all of the subjects showing peaks in the transmission. These characteristics included 1) two regions of increased transmission over the frequency range of the measurements, 2) a decrease in the magnitude of acceleration of the chest wall as compared to the tracheal site of roughly 20 dB at lower frequencies, 3) a strong trend of decreasing acceleration of the chest wall with increasing frequency. These spectra agreed favorably with the predictions of a theoretical model of the acoustical properties of the respiratory system. The model suggests the primary structural determinants of a number of the observed characteristics including the importance of the lung parenchyma in sound attenuation

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Abstract: A nonlinear digital filter system is proposed for automatic extraction of crackles which are discontinuous adventitious sounds in lung sounds. This system is composed of two nonlinear digital filters; one is a stationary nonstationary separating filter, and the other is a width- discriminating filter. The former separates nonstationary signals from stationary ones in the lung sounds, using the prediction error to the input lung sound signal. If the prediction error is small enough, the lung sound is considered to be stationary, but if the error is large, a nonstationary signal is considered to occur and the nonstationary part is separated. The latter, the width-discriminating filter, performs signal extraction by considering the signal wave form of the crackles, simply realized by logical algebra. This filter extracts an impulsive signal, which is a small-width wave, and its succeeding waves; such wave form is typical of that of crackles. First, crackles are roughly separated by the stationary-nonstationary separating filter as nonstationary signals, and then are more precisely extracted from the nonstationary output by the width-discriminating filter. Some examples of processing actual lung sound data by this system show its high performance

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Abstract: Stridor, a musical, continuous sound often attributed to upper airway narrowing, may be encountered in the recently extubated patient. Recently extubated patients and patients with documented upper airway obstruction were studied. Sounds were recorded from the neck and chest. The sound signal of patients with stridor was compared to that made by asthmatics and extubated patients with no airway obstruction. The frequency spectrum of segments of the sound signal was determined using the fast fourier transform technique. The sound signal associated with stridor had a similar frequency to that found with asthma. However, the signal was more intense over the neck than over the chest, whereas in asthmatics the reverse was true. The musical sounds in patients with stridor occurred during inspiration, whereas in those patients with asthma, they were predominantly expiratory. The major difference between stridor and asthma was the timing of the sound and the prominence of the sound over the neck

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Abstract: Auscultatory percussion of the chest is a clinical examination method that has been purported to detect intrapulmonary masses by their effect on transmission of the percussion note to the posterior chest. Recent findings from this laboratory suggested that the sound of sternal percussion may actually travel through the chest cage and not the lung parenchyma. To investigate this possibility further, we recorded the sound produced by sternal percussion at 63 evenly spaced points over the posterior chest wall of 3 healthy subjects and 4 patients with large, discrete intrathoracic lesions in the right upper lobe (2 patients), left lower lobe, and left upper lobe (1 patient each). We constructed 3-dimensional contour maps of the indices of sound amplitude and frequency to

view graphically the pattern of distribution of the sound. Examination of the maps revealed areas of increased amplitude in the zones of projection of some osseous structures, especially the scapulae, both in the healthy subjects and patients. No disturbances in the pattern reflecting the presence of mediastinal structures or intrathoracic lesions were found despite the existence of deeply situated lung masses as large as 10 cm in diameter. These findings support the argument that the sound of sternal percussion travels to the posterior chest predominantly through chest wall structures

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Abstract: We indirectly determined the transmission path of sound generated by sternal percussion in five healthy subjects. We percussed the sternum of each subject while recording the output audio signal at the posterior left and right upper and lower lung zones. Sound measurements were done during apnea at functional residual capacity, total lung capacity, and residual volume both with the lungs filled with air and with an 80% He-20% O2 (heliox) gas mixture. Three acoustic indexes were calculated from the output sound pulse: the peak-to-peak amplitude, the peak frequency, and the mid-power frequency. We found that the average values of all indexes tended to be greater in the upper than in the ipsilateral lower lung zones. In the upper zones, peak-to-peak amplitude was greater at total lung capacity and residual volume than at functional residual capacity. Replacing air with heliox did not change these results. These experiments, together with others performed during Mueller and Valsalva maneuvers, suggest that resonance of the chest cage is the predominant factor determining the transmission of sternal percussion sounds to the posterior chest wall. The transmission seems to be only minimally affected by the acoustic characteristics of the lung parenchyma

785. Brooks, L. J., P. J. Byard, J. M. Fouke, and K. P. Strohl. 1989. Reproducibility of measurements of upper airway area by acoustic reflection. *J.Appl.Physiol* 66:2901-2905.
Abstract: To evaluate the extent and nature of the variability of measurements of upper airway area by acoustic reflection (AAAR), we made repeated measures of pharyngeal AAAR in 10 normal adult volunteers. We selected mean pharyngeal area as a better index of upper airway size than peak pharyngeal area or pharyngeal volume. Within-run variability of this measure was 8 +/- 4% (SD) (coeff of variation). This variability could not be explained by changes in lung volume or differences in phase of respiration. Five subjects had tracheal and pharyngeal area measured by using both the custom-made wax mouthpiece (W) and a commercial rubber pulmonary function mouthpiece (R). Reproducibility of pharyngeal AAAR was within 10% (coeff of variation) using R, but measurements of pharyngeal AAAR varied with the different types of mouthpiece, as W/R ranged from 0.72 to 1.70. In contrast, measurements of midtracheal area were similar for both mouthpiece types [mean W/R = 0.97 +/- 14 (SD)]. The acoustic reflection technique yields a reproducible index of pharyngeal size that does not vary with phase of respiration or modest changes in lung volume. Either W or R may be used to make clinical measurements, but the type of mouthpiece should be consistent and specified

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Abstract: Flow limitation (FL) has recently been shown to be a necessary condition for the generation of forced expiratory wheezes (FEW) in normal subjects. The present study was designed to investigate whether it is also a sufficient condition. To do so we studied the effects of varying expiratory effort on generation of FEW. Six normal subjects exhaled with varying force into an orifice in line with a high- impedance suction pump. Esophageal (Pes), airway opening, and transpulmonary (Ptp) pressures were measured alongside flow rate, lung volume, and tracheal lung sounds. In each subject a certain critical degree of effort had to be attained before FEW were generated. This effort, measured as Pes at the onset of wheezes, varied among the subjects (range -11 to 45 cmH2O). Similarly, a minimal Ptp had to be reached for FEW to evolve (mean +/- SD -34 +/- 12 cmH2O, range -18 to - 50 cmH2O). These critical Pes and Ptp values were significantly higher than those required for FL. It was concluded that, in addition to the requirement for FL, sufficient levels of effort and negative Ptp must exist before FEW can be generated. By analogy to experimental and theoretical results from studies on flow-induced oscillations in self- supporting collapsible tubes, it was further concluded that these pressures are required to induce flattening of the intrathoracic airways downstream from the choke point. It is this configurational change that causes air speed to become equal to or exceed the critical gas velocity needed to induce oscillations in soft-walled tubes

787. Gavriely, N., T. R. Shee, D. W. Cugell, and J. B. Grotberg. 1989. Flutter in flow-limited collapsible tubes: a mechanism for generation of wheezes. *J.Appl.Physiol* 66:2251-2261.
Abstract: We studied flutter in collapsible tubes as a possible mechanism for the generation of respiratory wheezes. The pressure-flow relationships and the wall oscillations of thick-walled [wall thickness (h)-to-lumen radius (r) ratio 1:1.7 to 1.3] self-supporting latex and Silastic tubes mounted between rigid pipes were measured. A high-impedance vacuum pump was connected to the downstream end. Upstream and downstream valves were used to control corresponding resistances. We found loud honking sounds and tube wall oscillations that occurred only when the tubes were buckled and flow limiting, i.e., when the flow became constant and independent of downstream driving pressure. The overall range of oscillatory frequencies was 260-750 Hz for airflow, presenting as sharp peaks of power on the frequency spectrum. The oscillatory frequencies (f) were higher at higher fluid velocities (u) and with narrower distance between opposing flattened walls (2b), resulting from increasing downstream suction

pressure and the transmural pressure becoming more negative. The effect of u and b on f for a latex tube (h- to-r ratio 1:1.7) were found to be f = 228 + 0.021 (u/b). These relationships were valid throughout the range of oscillations in this tube (283-720 Hz) and with flow rates of 12-64 l/min. The experimental data were compared with predictions of the fluid dynamic flutter theory and the vortex-induced wall vibrations mechanism. We conclude that viscid flutter in soft tubes is the more probable mechanism for the generation of oscillations in the soft tube model and is a possible mechanism for the generation of respiratory wheezes

788. Gilbert, V. E. 1989. Detection of pneumonia by auscultation of the lungs in the lateral decubitus positions. *Am.Rev.Respir.Dis.* 140:1012-1016.
Abstract: Forty-five acutely ill, coughing patients, three with acute dyspnea and cardiomegaly, and 37 control subjects were placed in lateral decubitus positions for auscultation of their dependent lungs to determine if this maneuver would elicit inspiratory crackles, signs of pneumonia. In the upright position, auscultation of the lungs was normal in all control subjects and in lateral decubitus positions their dependent lungs revealed transient late inspiratory crackles in seven of the 37 (18.9%), and transient inspiratory peeling sounds in two others (5.4%). Thirteen acutely ill, coughing patients, free of prior cardiac and pulmonary diseases, had persistent late inspiratory crackles induced in one or both dependent lungs when placed in lateral decubitus positions. These dependent lungs also revealed increased numbers of crackles in three patients, late inspiratory squeaks in four, and wheezes in three others. In the upright position, auscultation of the lungs was normal in 10 of these patients, and a few basilar crackles were heard in three others. All of these abnormal findings cleared after treatment with antibiotics. Thirty-one of 32 acutely ill, coughing patients with bronchitis, sinusitis, or pharyngitis were free of induced crackles in dependent lungs in lateral decubitus positions. However, placement of two other patients in these positions appeared to have elicited the inspiratory crackles of chronic pulmonary disease and early congestive heart failure. These observations suggest that placement of acutely ill, coughing patients into lateral decubitus positions for auscultation of the dependent lungs may be a valuable maneuver for diagnosis of pneumonia

789. Goncharoff, V., J. E. Jacobs, and D. W. Cugell. 1989. Wideband acoustic transmission of human lungs. *Med.Biol.Eng Comput.* 27:513-519.
Abstract: The measurement of sound transmission in human lungs has shown promise to reveal, by noninvasive methods, information about the structure of peripheral airways and lung tissue. The paper gives a detailed explanation of the instrumentation and testing methods developed to measure sound transmission through human lungs and thoracic structures in the 5-20 kHz frequency range and describes in detail experiments comparing the acoustic lung transmission patterns of four different subject groups. The experimental results are compared with those predicted by an acoustical model of sound transmission through lung parenchyma

790. Gross, P. G. The use of a piezoelectric polymer transducer to study the frequency partition of chest wall sounds. 1989. NORTHWESTERN UNIVERSITY.
Ref Type: Thesis/Dissertation

791. Grotberg, J. B. and N. Gavriely. 1989. Flutter in collapsible tubes: a theoretical model of wheezes. *J.Appl.Physiol* 66:2262-2273.
Abstract: A mathematical analysis of flow through a flexible channel is examined as a model of flow-induced flutter oscillations that pertain to the production of wheezing breath sounds. The model provides predictions for the critical fluid speed that will initiate flutter waves of the wall, as well as their frequency and wavelength. The mathematical results are separated into linear theory (small oscillations) and nonlinear theory (larger oscillations). Linear theory determines the onset of the flutter, whereas nonlinear theory determines the relationships between the fluid speed and both the wave amplitudes and frequencies. The linear theory predictions correlate well with data taken at the onset of flutter and flow limitation during experiments of airflow in thick-walled collapsible tubes. The nonlinear theory predictions correlate well with data taken as these flows are forced to higher velocities while keeping the flow rate constant. Particular ranges of the parameters are selected to investigate and discuss the applications to airway flows. According to this theory, the mechanism of generation of wheezes is based in the interactions of fluid forces and friction and wall elastic-restoring forces and damping. In particular, a phase delay between the fluid pressure and wall motion is necessary. The wave speed theory of flow limitation is discussed with respect to the specific data and the flutter model

792. Hudde, H. and H. Slatky. 1989. The acoustical input impedance of excised human lungs--measurements and model matching. *J.Acoust.Soc.Am.* 86:475-492.
Abstract: The input impedance at primary bronchi of excised human lungs was measured in the frequency range from 2-5000 Hz. For the measurements, a self-developed acoustic impedance head and a narrow-band measuring system with sinusoidal excitation were used. The lungs were inflated and deflated by using an arrangement called respiratory state controller. The impedances were thus measured at different states of lung inflation. An already existing mathematical model was developed further to cover not only fairly inflated lungs, but also deflated ones. The parameter sensitivity of this model is investigated. The acoustomechanical parameters of the model were fitted to match the impedances measured. It turns out that some of these parameters are hardly calculable. The values given in this paper were chosen to agree with the measurements and to be physically reasonable. Although

the measurements were performed at primary bronchi, the model is able to predict also impedances at the top end of the trachea (at different respiratory states). This impedance is useful for speech signal processing applications. The model prediction of the trachea impedances agrees well with previous results of other authors

793. Iida, M., K. Gotoh, Y. Yagi, S. Ohshima, N. Yamamoto, F. Deguchi, S. Hirakawa, and Y. Ohsumi. 1989. [Study on the genesis of posturally induced crackles from hemodynamic data--in patients with ischemic heart disease having normal respiratory function]. *Kokyu.To Junkan.* 37:1009-1014.
Abstract: The presence of fine crackles is suggestive of heart failure in patients without pulmonary disease. We have been interested in the clinical observation that fine crackles are frequently detected when posture was changed from sitting to supine positions or in patients going from sitting position to supine position with passive legs elevation in patients without obvious evidence of heart failure. We named these crackles, "the posturally induced crackles (PIC)". We have already reported that PIC was frequently detected in patients with ischemic heart disease. The present study was performed to estimate the mechanism of the genesis of PIC and to clarify its significance. Seventy-three patients with ischemia heart disease were included in this study. Pulmonary sounds were auscultated in sitting and supine positions and during passive elevation of both legs in a supine position. Patients were divided into 3 groups according to the presence or absence of fine crackles, i.e., those in whom fine crackles were not detected in either position (PIC (-)), those in whom fine crackles were detected in a supine position or during passive elevation of both legs, but not in a sitting position (PIC (+)), and those in whom fine crackles were detected even in a sitting position (Persistent crackles). We measured various hemodynamic parameters (cardiac index, RA pressure, PA pressure and PAW) and parameters of pulmonary circulation (pulmonary blood volume, pulmonary "venous" compliance) in these 3 groups and comparisons were made between them.(ABSTRACT TRUNCATED AT 250 WORDS)

794. Iyer, V. K., P. A. Ramamoorthy, and Y. Ploysongsang. 1989. Quantification of heart sounds interference with lung sounds. *J.Biomed.Eng* 11:164-165.
Abstract: An index to quantify the contamination of lung sounds by heart sounds is described. Using the index, the efficacy of high pass filtering and adaptive filtering methods for the reduction of heart sounds is evaluated

795. Iyer, V. K., P. A. Ramamoorthy, and Y. Ploysongsang. 1989. Autoregressive modeling of lung sounds: characterization of source and transmission. *IEEE Trans.Biomed.Eng* 36:1133-1137.
Abstract: In this communication, we discuss the application of autoregressive modeling to lung sounds analysis. The lung sounds source in the airway is modeled as a white noise source, consisting of one or a combination of the following sources: random white noise sequence, periodic train of impulses, and impulsive bursts of energy. The acoustic transmission through the lung parenchyma and chest wall is modeled as an all-pole filter. Using this method, the source and transmission characteristics of lung sounds are estimated separately, based on the lung sounds at the chest wall. To illustrate the potential validity of the model, lung sound segments in known disease conditions were selected from teaching tapes and the source and transmission characteristics were estimated by applying the model. The estimated characteristics were found to be consistent with current knowledge of the generation and transmission of lung sounds in the known conditions

796. Jackson, A. C., C. A. Giurdanella, and H. L. Dorkin. 1989. Density dependence of respiratory system impedances between 5 and 320 Hz in humans. *J.Appl.Physiol* 67:2323-2330.
Abstract: For respiratory system impedance (Zrs), the six-element model of DuBois et al. (J. Appl. Physiol. 8: 587-594, 1956) suggests three resonant frequencies (f1,f2,f3), where f1 is the result of the sum of tissue and airway inertances and tissue compliance and f2 is the result of alveolar gas compression compliance (Cg) and tissue inertance (Iti). Three such resonant frequencies have been reported in humans. However, the parameter estimates resulting from fitting this model to the data suggested that f2 and f3 were not associated with Cg and Iti but with airway acoustic properties. In the present study, we measured Zrs between 5 and 320 Hz in 10 healthy adult humans breathing room air or 80% He-20% O2 (HeO2) to gain insight as to whether airway or tissue properties are responsible for the f2 and f3. When the subjects breathed room air, f2 occurred at 170 +/- 16 (SD) Hz, and when they breathed HeO2 it occurred at 240 +/- 24 Hz. If this resonance were due to Cg and Iti it should not have been affected to this extent by the breathing of HeO2. We thus conclude that f2 is not due to tissue elements but that it is an airway acoustic resonance. Furthermore, application of the six-element model to analyze Zrs data at these frequencies is inappropriate, and models incorporating the airway acoustic properties should be used. One such model is based on the concept of equivalent length, which is defined as the length of an open- ended, cylindrical tube that has the same fundamental acoustic resonant frequency.(ABSTRACT TRUNCATED AT 250 WORDS)

797. Jahed, M., S. J. Lai-Fook, P. K. Bhagat, and S. S. Kraman. 1989. Propagation of stress waves in inflated sheep lungs. *J.Appl.Physiol* 66:2675-2680.
Abstract: If the lung is an elastic continuum, both longitudinal and transverse stress waves should be propagated in the medium with distinct velocities. In five isolated sheep lungs, we investigated the propagation of stress waves. The lungs were degassed

and then inflated to a constant transpulmonary pressure (Ptp). We measured signals transmitted at locations approximately 1.5, 6, and 11 cm from an impulse surface distortion with the use of small microphones embedded in the pleural surface. Two transit times were computed from the first two significant peaks of the cross-correlation of microphone signal pairs. The "fast" wave velocities averaged 301 +/- 92, 445 +/- 80, and 577 +/- 211 (SD) cm/s for Ptp values of 5, 10, and 15 cmH2O, respectively. Corresponding "slow" wave velocities averaged 139 +/- 22, 217 +/- 36, and 255 +/- 89 cm/s. The fast waves were consistent with longitudinal waves of velocity [(K + 4G/3)/p]1/2, where bulk modulus K = 4 Ptp and shear modulus G = 0.7 Ptp. The slow waves were consistent with transverse (and/or Rayleigh) waves of velocity (G/p)1/2, with a G value of 0.9 Ptp. Measured values of K were 5 Ptp and values of G measured by indentation tests were 0.7 Ptp. Thus, stress wave velocities measured on pleural surface of isolated lungs correlated well with elastic moduli of lung parenchyma

798. Kikuchi, K., M. Watanabe, T. Hashizume, M. Kawamura, R. Kato, K. Kobayashi, and T. Ishihara. 1989. [New classification and analysis of lung sounds]. *Nippon Kyobu Geka Gakkai Zasshi* 37:2532-2537.
Abstract: Recently, classification and nomenclature of lung sounds has been changed from assessment based on subjective interpretation to assessment based on objective, measureable criteria related to mechanisms of sound generation. The adventitious sounds was classified to four kinds of principal terms, continuous adventitious sounds (wheezes, rhonchi) and discontinuous adventitious sounds (coarse crackles, fine crackle) at the 1985 International Symposium on Lung Auscultation. Lung sounds in the surgical patients were digitized for the analysis of both the time domain and the frequency domain which had been recorded by tape recorder. Rhonchi, fine crackle and tracheal stenotic sounds were characterized by the analysis of the frequency domain. Lung sound analysis is promising because it is safe, non invasive and may be used for clinical studies in the surgical patients

799. King, D. K., B. T. Thompson, and D. C. Johnson. 1989. Wheezing on maximal forced exhalation in the diagnosis of atypical asthma. Lack of sensitivity and specificity. *Ann.Intern.Med.* 110:451-455.
Abstract: STUDY OBJECTIVE: To determine whether wheezing on maximal forced exhalation is a predictor of asthma in persons with normal or nearly normal baseline spirometry. DESIGN: Prospective study of patients referred for methacholine challenge testing. SETTING: Pulmonary function laboratory at a hospital. PATIENTS: Forty-four patients referred for methacholine challenge testing because of the clinical suspicion of cough variant or otherwise difficult to diagnose asthma, with normal or nearly normal baseline spirometry and without wheezing on routine lung auscultation during quiet breathing. INTERVENTIONS: We listened for wheezing on maximal forced exhalation. Wheezing was defined as a continuous sound with a musical quality. Methacholine challenge testing was done. The concentration of methacholine required to produce a 20% fall in baseline FEV1 (PC20) of less than 8 mg/mL was considered a positive test for asthma. MEASUREMENTS AND MAIN RESULTS: Wheezing was present on maximal forced exhalation in 8 of 14 patients with a positive methacholine challenge test (sensitivity = 57%) and absent in 11 of 30 patients with a negative test (specificity = 37%). Furthermore, wheezing on maximal forced exhalation was present in 13 of 27 patients with a PC20 greater than 16 mg/mL and absent in 2 of 7 with a PC20 less than 4 mg/mL. CONCLUSIONS: Wheezing on maximal forced exhalation is neither sensitive nor specific for airway hyperreactivity

800. Kraman, S. S. and A. B. Bohadana. 1989. Transmission to the chest of sound introduced at the mouth. *J.Appl.Physiol* 66:278-281.
Abstract: We examined the transmission to the chest wall of white noise and 25-Hz square-wave-generated noise introduced at the mouth of five healthy subjects. The output audio signals were recorded over the left and right upper and lower lung zones, posteriorly. Sound measurements were made during apnea at functional residual capacity, total lung capacity, and residual volume both after breathing air and an 80% He-20% O2 (heliox) gas mixture. We calculated the peak-to-peak amplitude, the peak frequency, and the midpower frequency of the output sound. We found no consistent variations in the values of these indexes due to lung volume or resident gas density. In all cases, the transmitted sound was most intense at the right upper zone. This could not be explained on the basis of technical factors but was probably the result of normal asymmetry of the mediastinal anatomy. These data suggest that sound introduced through the mouth of healthy individuals excites intrathoracic structures but is transmitted through the parenchyma in such a manner that it is not markedly affected by familiar physiological variables. This must be taken into account if objective acoustical tests of lung physiology are to be developed

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802. Murphy, R. L., Jr., E. A. Del Bono, and F. Davidson. 1989. Validation of an automatic crackle (rale) counter. *Am.Rev.Respir.Dis.* 140:1017-1020.
Abstract: Crackles are commonly used in clinical decision-making, and in certain diseases the number of crackles reflects the severity of the illness. Auditory crackle estimations are subjective; crackle counting from time amplitude plots of sound (called time-expanded waveforms) is more objective but is cumbersome. We devised a computer-based system to count crackles automatically. One hundred samples of lung sounds from 41 subjects were recorded using an electret microphone air-coupled to the chest wall. Interobserver agreement in estimating the number of crackles per breath was high (r = 0.88, p less than 0.001), and

these counts were significantly correlated with counts made of spikelike deflections seen on time-expanded waveform analysis (r = 0.78, p less than 0.001). The automatic crackle counting correlated with the physician counts (r = 0.74, p less than 0.001). The average number of crackles counted per breath was greater by visual inspiration (8.8) and by automatic analysis (7.8) than it was by the physician observers (5.8). Reasons for the discrepancies include the fact that there are no absolute criteria for crackles and that rapidly occurring crackles are difficult to count by ear. Counting crackles by computer-based methods is feasible and can improve noninvasive cardiopulmonary diagnosis

803. Ono, M., K. Arakawa, M. Mori, T. Sugimoto, and H. Harashima. 1989. Separation of fine crackles from vesicular sounds by a nonlinear digital filter. *IEEE Trans.Biomed.Eng* 36:286-291.
Abstract: Crackles are discontinuous adventitious sounds, and their separation is an important process in the analysis of lung sounds. In order to separate the crackles from vesicular sounds automatically, we used a nonlinear digital filter which was designed to separate nonstationary from stationary signals. We applied this filter to the lung sounds recorded from six patients with pulmonary fibrosis. The separation was satisfactory enough to make this method useful in clinical medicine

804. Pasterkamp, H., C. Carson, D. Daien, and Y. Oh. 1989. Digital respirosonography. New images of lung sounds. *Chest* 96:1405-1412.
Abstract: We used tape recordings from normal subjects and from patients with lung disease to generate spectrographic images of respiratory sounds on a personal computer. These digital respirosonograms presented timing and frequency content of lung sounds, with the sound intensities displayed on a color scale. Respiratory sounds during inspiration and expiration could be recognized by their association with concurrent respiration curves. Contributions of low-frequency cardiac sounds were visually identified by their relationship to simultaneously recorded ECGs. Typical characteristics of normal and adventitious lung sounds were documented and displayed both in the time and the frequency domain. Digital respirosonography provides an easy way to assess lung sound amplitudes, frequencies and timing over several breaths

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Abstract: The high prevalence of sleep-related breathing disturbances (SRBD), in association with cardiopulmonary disease, and the impairment by such disorders of the quality of the patients life, together with the good response of SRBD to therapy when diagnosed early on, point up the importance of incorporating the diagnostic evaluation of SRBD into the routine medical and pneumological diagnostic work-up. Since classical polysomnography requires a considerable effort, a stepwise diagnostic procedure was needed for use in practice. This includes a narrowing down of the indications, a brief questionnaire and a detailed questionnaire. For positive demonstration of a respiratory disturbance or differential diagnostic purposes, the following measures are employed on an outpatient basis in the following order: High-resolution 24-hour (Holter) ECG; analysis of heart rate and respiratory sounds, including, in particular snoring, with the MESAM system; induction plethysmography and continuous oxygen partial pressure measurement (pO2tc). Only after exhaustive use has been made of the ambulatory work- up, are the following diagnostic inhospital measures employed in the order indicated: 10-channel recording using the SIDAS system (respiration 3 channels, oxygen saturation, EOG, actogram, heart rate, intrathoracic pressure fluctuations), complete polysomnography. Once SRBD has been established, the patient is sent to the sleep laboratory to establish a baseline. Baseline measurement is accompanied by the determination of a marker, that is, a readily determined parameter capable of providing information about the success of therapy, is established. This permits complete polysomnography to be concentrated on differential-diagnostic and treatment-refractory problem cases.(ABSTRACT TRUNCATED AT 250 WORDS)

806. Piirila, P. and A. R. Sovijarvi. 1989. Differences in acoustic and dynamic characteristics of spontaneous cough in pulmonary diseases. *Chest* 96:46-53.
Abstract: The aim of this study was to determine whether the flow dynamics and sound spectra of spontaneous cough show characteristic differences in asthma, acute and chronic bronchitis, TBCS and FPD. During the cough, the air flow from the mouth and the sound from the sternal manubrium were simultaneously recorded. The cough sounds were analyzed spectrographically. Peak expiratory flow during cough was significantly lower in asthma than in TBCS, acute bronchitis or FPD. Duration of the first cough sound was longer in asthma than in FPD, TBCS or chronic bronchitis. The number of additional cough sounds was smaller in asthma than in the other conditions. The highest frequency components of cough sound were lower in asthma than in chronic bronchitis or TBCS. The results indicate that pulmonary diseases differ with respect to acoustic and dynamic characteristics of spontaneous cough. This finding may prove useful in the diagnosis of cough

807. Ploysongsang, Y., V. K. Iyer, and P. A. Ramamoorthy. 1989. Characteristics of normal lung sounds after adaptive filtering. *Am.Rev.Respir.Dis.* 139:951-956.
Abstract: Lung sounds were recorded from five normal male subjects during tidal breathing. Simultaneous electrocardiograms were recorded and used as index signals to generate simulated heart sounds for digital subtraction from recorded lung sounds to obtain

purer lung sounds. Five random breaths from each subject were analyzed. Sound signals were band- pass filtered 25 to 1,000 Hz (antialiasing), digitized at 3,000 Hz, and then subjected to (1) direct fast Fourier transform (FFT) without filtering (NF); (2) digital high-pass filtering at 75 Hz and subsequent FFT (75 HzF); (3) adaptive filtering and subsequent FFT (AF). The FFT algorithms of all lung sounds were characterized by mean, median, and mode frequencies. The mean, median, and mode of NF were lower than those of 75 HzF (64.98 +/- 4.04 versus 150.42 +/- 17.49, mean +/- SE, p less than 0.003; 44.57 +/- 2.06 versus 111.81.5.78, p less than 0.0003; 36.81 +/- 1.77 versus 86.16 +/- 3.13, p less than 0.0001) and those of AF (64.98 +/- 4.04 versus 96.87 +/- 11.58, p less than 0.01; 44.57 +/- 2.06 versus 68.23 +/- 10.44, p less than 0.05; 36.81 +/- 1.78 versus 52.24 +/- 8.97, p less than 0.06). The mean, median, and mode of AF were lower than those of 75 HzF (96.87 +/- 11.58 versus 150.42 +/- 17.49, p less than 0.02; 68.23 +/- 10.44 versus 111.81 +/- 5.77, p less than 0.007; 52.24 +/- 8.97 versus 86.16 +/- 3.73, p less than 0.01). The results indicated that by filtering out low frequency heart sounds, the frequency spectrum of lung sounds was moved upward.(ABSTRACT TRUNCATED AT 250 WORDS)

808. Ploysongsang, Y., R. P. Michel, A. Rossi, L. Zocchi, J. Milic-Emili, and N. C. Staub. 1989. Early detection of pulmonary congestion and edema in dogs by using lung sounds. *J.Appl.Physiol* 66:2061-2070.
Abstract: Five mongrel dogs (2 interstitial and 3 alveolar edema) were studied. Lung mechanics were measured by recording the flow, volume, and esophageal pressure according to the standard technique. Edema was produced by infusion of Ringer lactate solution. Lung sounds were recorded on tape from the dependent part of the chest wall. Lung sound signals were high-pass filtered at 100 Hz and subjected to fast Fourier transform. Samples of lung sounds were analyzed before (control) and at 5, 10, 20, 30, and 40 min after the infusion. The mean, median, and mode frequencies of sound power spectra at the control time were, respectively, 169.6 +/- 29.19, 129.6 +/- 29.81, and 136.0 +/- 29.87 (SD) Hz. These values increased significantly at 5 min after infusion to 194.0 +/- 26.08 (P less than 0.0037), 150.2 +/- 23.48 (P less than 0.0085), and 164.6 +/- 28.74 Hz (P less than 0.02), respectively. These values stayed significantly elevated at 10, 20, 30, and 40 min. The pulmonary wedge pressure, lung dynamic compliance, and pulmonary resistance were measured also at the same times. The mean, median, and mode frequencies correlated with pulmonary wedge pressure (P less than 0.00001, P less than 0.0001, P less than 0.0001), lung dynamic compliance (P less than 0.001, P less than 0.0001, P less than 0.0001), and pulmonary resistance (P less than 0.00001, P less than 0.00001, P less than 0.0001), respectively. There were no significant adventitious sounds up to 40 and 50 min after infusion. We concluded that pulmonary congestion and early edema alter the frequency characteristics of lung sounds early, before the occurrence of adventitious sounds. These altered lung sounds may be used as an index of pulmonary congestion and impending edema

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Abstract: The author used a new physiological method in the clinic of patients with pulmonary tuberculosis--photopulmonography, with the purpose of examination of the functional properties and pathological changes in the lungs. A study of 42 patients with different active forms of tuberculosis by this method permitted to evaluate the compensatory and adaptative capacities of pulmonary tissue, to determine the treatment efficacy

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Abstract: The resonance conditions associated with the propagation of a harmonic wave within a rigid, lossless branching structure can be explicitly derived. In this study, exact resonance conditions are derived for multi-order, rigid, asymmetric branching structures. These are compared with resonance conditions for rigid, multi-order, symmetric branching structures which we reported previously. The effect of asymmetry on the form of the higher-order resonance condition is discussed. In the low-frequency range, the resonance condition can be modified into simpler forms which facilitate volume estimation of the branching structure. Two such volume approximation techniques are presented: (a) a fundamental frequency method, in which the lowest resonance frequency is inversely proportional to the structure volume, and (b) an effective-length method, in which an effective length is calculated for all branches distal to the first bifurcation. Equivalence of the two methods is demonstrated. An experimental study was performed to measure the resonance modes of several second-order glass models with asymmetric branching structures similar to those of mammalian lungs. The resulting volume estimates were in close agreement with the true volumes

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Abstract: Glottic caliber is modulated in a way that optimizes the airway resistance and the work of breathing. The midexpiratory glottic narrowing that normally occurs during tidal breathing is enhanced during histamine- or methacholine-induced airway narrowing. Exercise is associated with increased ventilatory demand and midexpiratory glottic widening in healthy subjects. However, the relative contribution of glottic aperture to airflow limitation during exercise-induced asthma is unknown. Consequently, we used the acoustic reflection technique to test whether a decrease in midexpiratory glottic size occurred also during exercise-induced bronchoconstriction in seven asthmatic subjects. Exercise resulted in a 38 +/- 16% (SD) fall in FEV1 from the baseline value (p less than 0.001) and a significant increase in midexpiratory glottic cross-sectional area from 1.89 +/- 0.45 cm2 before to 2.36 +/- 0.71 cm2 during bronchoconstriction (p less than 0.05). This midexpiratory glottic widening was also associated with increased tidal flow rates. We conclude that in marked contrast to airway obstruction induced by histamine or methacholine, exercise- induced asthma is associated with midexpiratory glottic widening, which occurs concomitantly with a decrease in lower airway caliber. We suggest that modulation of glottic aperture during acute asthma is heterogeneous and depends partly on the initiating stimulus

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Abstract: In ten habitually snoring subjects and ten patients with obstructive sleep apnea syndrome, preoperative snoring sounds above a preset sound pressure level were recorded and a frequency spectrum analysis by means of time series Fast Fourier Transformation was performed. All patients underwent uvulopalato-pharyngoplasty after which the snoring sounds were recorded again and analysed under the same conditions. Preoperative frequency spectra in heavy snorers were dominated by a component which results from the movement of the soft palate and uvula and which presents as a low-frequency vibration of 25 to 50 c/s and its harmonics up to several hundred c/s. After UPPP the sound pressure level of the snoring noise in heavy snorers was reduced by 20 to 30 decibels and could not be recorded any more. The frequency spectrum of snoring noises in patients with obstructive sleep apnea syndrome differed from those of heavy snorers. In apnea patients the snoring noise usually consisted of other and higher frequency components which masked the vibration of the soft palate and uvula to a more or less high degree. An extreme degree of masking is reached in snoring noises following apneic episodes when identification of the movement of the soft palate is impossible. After performing UPPP in an apneic patient the low-frequency content of the spectrum below about 400 Hz was reduced dramatically but higher frequency parts were still present. This resulted in only minor reduction of snoring noise sound pressure level. Our results are in agreement with other authors in showing that UPPP is not successful when the site of obstruction is not in the velo- pharyngeal plane.(ABSTRACT TRUNCATED AT 250 WORDS)

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Abstract: In 11 patients with chronic snoring and 12 subjects with obstructive apnoea syndrome the percentage of snoring duration above a preset sound pressure level during one night's sleep was correlated with the radiocephalometric data. Cephalometric distances PAS, PM-Pg, MP-H and angles SNA and SNB representing measures for posterior airway space, size of soft palate, relative position of hyoid bone and relative position of maxilla and mandibula were evaluated. Each patient showed pathological deviations from normal values in at least one of the cephalometric parameters. A significant correlation between snoring duration and a single cephalometric distance could not be found. However, an index combining pathological deviations from all three cephalometric distances showed a highly significant correlation with snoring duration (p less than 0.01 - Fig. 11), as did deviations from normal values of angle SNB (p less than 0.03 - Fig. 10). Our findings indicate that snoring and obstructive apnoea syndrome are not only caused by neurologic dysregulation, and that in addition specific craniofacial anomalies are prerequisites for the development of the disease. For the first time it is demonstrated that these anomalies exist in chronic snorers as well as in apnoeic

patients. Our findings support Lugaresi's hypothesis that heavy snoring and obstructive apnoea syndrome are based on the same defect and differ in severity only

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Abstract: To facilitate the study of respiratory wheezes in an animal lung model, an isovolume, constant-flow excised dog lung preparation was developed. Dog lungs were inflated to 26 +/- 4 cmH2O and coated with layers of epoxy glue and polyester compound. A rigid shell 2 mm thick was obtained around the entire pleural surface and the extra-pulmonary airways. The adhesive forces between the pleura and the shell were strong enough to hold the lung distended after the inflation pressure was removed. Holes 2 mm diam were drilled through the shell over one of the lung lobes in an array, 4 cm across. The holes penetrated the pleural surface, so that constant flow could be maintained in the expiratory direction by activating a suction pump connected to the trachea. Downstream suction pressure and flow rate were measured with a mercury manometer and a rotameter, respectively.

Sounds were recorded by a small (0.6 cm OD) microphone inserted into the trachea. When suction pressure was increased, flow initially increased to 31 +/- 3 l/min. Further increase of suction pressure caused only very slight additional increase in flow (i.e., flow limitation). During this plateau of flow, a pure tone was generated with acoustic properties similar to respiratory wheezes. Both the flow plateau and the wheezing sounds could be eliminated by freezing the lungs. It is concluded that wheezing sounds were associated with flow limitation in this preparation. It is suggested that the stable acoustic properties obtained by this preparation may become useful in the analysis of mechanisms of wheezing lung sounds generation

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Abstract: We review some of the evidence that supports the existence of psychosomatic triggers to bronchospasm in asthmatics, and hypothesize that it may also be possible to consciously reverse bronchospasm using trachea-noise biofeedback. We precipitated significant levels of bronchospasm in 16 asthmatics using exercise or eucapnic- hyperventilation challenges on five occasions, and administered four different treatments and a no-treatment control. The treatments were trachea-noise biofeedback (TNBF), wrong-information TNBF, an inhaled adrenergic bronchodilator, and a placebo inhaler, all given double blind. Half of the subjects had 3 training days in the use of the TNBF device before study. Our results show that TNBF, in the trained subjects only, is associated with a detectable, but not statistically significant, increase in the rate of recovery from bronchospasm over that found with no treatment. We conclude that, although asthmatics seem to have a strong ability to consciously induce bronchospasm, conscious reversal of a full asthma attack using TNBF is limited. Despite contrary conclusions by other investigators, we believe that this study demonstrated little TNBF-assisted recovery from bronchospasm. We suggest that this is because its effect may be inhibited by humoral mechanisms that sustain the attack, but we believe further work is required to support this

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and the snoring pattern can be evaluated. Three cases studies are presented demonstrating the performance of the technique. A 39-year-old female with nonpathological snoring (Fig.2), a 45-year-old male with heavy and regular snoring (Fig. 3) and a 36-year-old male with a full- blown Pickwickian Syndrome (Fig. 4). This patient's response to nasal cPAP is demonstrated in Fig. 5

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Abstract: Hypertrophy of the tonsils and adenoids is the most common cause of obstructive sleep apnea in children. There is relatively little known about the occurrence of subclinical variations in the dimensions of the oropharynx which may predispose to the development of obstructive sleep apnea in children without obvious craniofacial abnormalities. Fifty-one children (3-10 years) were divided into two groups: the first group consisted of 18 patients with small tonsils and no history of snoring who underwent tonsillectomy for chronic tonsillitis. They were compared to a second group of 33 patients with large tonsils who underwent tonsillectomy and adenoidectomy for symptoms of obstructive sleep apnea. Age, height, weight, body surface area and tonsil weight were correlated to the dimensions of the oropharynx obtained by direct measurement intraoperatively including the length of the soft palate, anterior-posterior depth of the nasopharynx and the distances between the medial tonsillar surfaces, anterior tonsillar pillars and lateral pharyngeal walls at mid-tonsil level. Increased patient height, weight and surface area correlated positively to increased distance between the lateral pharyngeal walls and to the length of the soft palate in the patients with small tonsils. No such correlation existed in the patients with obstructive adenotonsillar hypertrophy. In addition, the distance between the lateral pharyngeal walls was significantly decreased in the group with large, obstructing tonsils as compared to those with small tonsils and no history of obstruction (P less than 0.01). However, the patients with small tonsils and no obstruction had significantly longer soft plates (P less than 0.01) and less depth tot eh nasopharynx (P less than 0.01).(ABSTRACT TRUNCATED AT 250 WORDS)

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Abstract: In an attempt to elucidate whether changes in posture (from sitting to supine) result in reduction in pharyngeal area, thus promoting pharyngeal occlusion during sleep in so predisposed persons, we studied 12 snoring apneic patients and 6 snoring nonapneic control subjects. in all subjects, we employed acoustic reflection technique to measure pharyngeal area at FRC sitting and supine. We also examined changes in pharyngeal area resulting from the application of positive intrapharyngeal pressure in sitting and supine posture. We found that (1) pharyngeal cross-sectional area at FRC was similar in both groups, (2) decrease in pharyngeal area with assumption of supine posture was also similar in both groups (21 +/- 11% in patients with OSA versus 15 +/- 13% in nonapneic control subjects), and (3) pharyngeal distensibility was significantly higher in apneic snorers than in nonapneic control subjects (0.090 +/- 0.039 cm H2O-1 in apneic snorers versus 0.032 +/- 0.027 cm H2O-1 in nonapneic control subjects; p less than 0.005). We conclude that changes in posture alone are not sufficient to convert a snorer into a patient with OSA; however, when physiologic abnormalities ("floppy" pharynx) are superimposed on postural reduction in pharyngeal area, airway occlusion results

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relationship between the wheeze and the shape of the flow rate curve. We analyzed ten parameters in 83 forced expirations produced by 32 normal subjects (16 men and 16 women) using multidimensional scaling techniques. Among these expirations, 53 presented a wheeze. The first two axes of the analysis define a plane on which forced expirations are divided into four quadrants. Two opposite quadrants (upper right and bottom left) contain the wheezing expirations, while the two others only have the ones with no wheezing. This distribution corresponds to specific shapes of the flow rate curve. We found that wheezes are associated with two main shapes. One of them consists of a short onset until a sharp peak, followed by a fast exponential decay. The other is about triangular, with a late appearance of the wheeze, and is only produced by women

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Abstract: In order to determine more precisely the accuracy with which the acoustic reflection technique (ART) can infer airway area during spontaneous breathing, we compared acoustic measurements of airway area with equivalent areas measured from computerized tomographic (CT) scans of the neck and chest in 7 patients (mean age, 54 yr; range, 33 to 69 yr) with a history of upper airway abnormalities. At the time of the study, all patients were clinically stable and had no recurrent nerve palsy. Measurements of airway area by ART and CT were performed in the supine posture while patients breathed quietly at FRC. We found that there was considerable intersubject variability in area-distance functions determined by acoustic reflections. None of the subjects had a flat tracheal plateau. Once the acoustic and CT data were aligned, we compared cross-sectional areas at various distances from the glottis. Comparison points were separated by 1 cm, and as many as 13 different CT sections were used in some subjects. Mean values for all data points (n = 83) were 2.45 +/- SD = 0.69 cm2 and 2.56 +/- SD = 0.82 cm2 for the acoustic and CT methods, respectively, Z = 0.93; p greater than 0.05. Linear regression analysis revealed a correlation coefficient (r) of 0.92; p less than 0.0001. On the basis of these findings, we conclude that the acoustic reflection technique may be used reliably for clinical and physiologic studies of the upper airways in humans

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Abstract: We used the acoustic reflection technique to measure the cross-sectional area of tracheal and bronchial airway segments of eight healthy adults. We measured airway area during a slow continuous expiration from total lung capacity (TLC) to residual volume (RV) and during inspiration back to TLC. Lung volume and esophageal pressure were monitored continuously during this quasi-static, double vital capacity maneuver. We found that 1) the area of tracheal and bronchial segments increases with increasing lung volume and transpulmonary pressure, 2) the trachea and bronchi exhibit a variable degree of hysteresis, which may be greater or less than that of the lung parenchyma, 3) extrathoracic and intrathoracic tracheal segments behaved as if they were subjected to similar transmural pressure and had similar elastic properties, and 4) specific compliance (means +/- SE) for the intrathoracic and bronchial segments, calculated with the assumption that transmural pressure is equal to the transpulmonary pressure, was significantly (P less than 0.05) smaller for the intrathoracic segment than for the bronchial segment: (2.1 +/- 2.0) X 10(-3) cmH2O-1 vs. (9.1 +/- 2.1) X 10(-3) cmH2O-1. Direct measurements of airway area using acoustic reflections are in good agreement with previous estimates of airway distensibility in vivo, obtained by radiography or endoscopy

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Abstract: Wheezes are defined as high-pitched, continuous, adventitious lung sounds. They are produced by oscillation of opposing airway walls whose lumen is narrowed. Although asthma is the most common cause of wheezing, a wide variety of disease processes may result in wheezing due to airway obstruction. This obstruction may be caused by airway edema, smooth muscle constriction, increased secretions, vascular congestion, mass lesions, scarring, or foreign bodies. Stridor is a special kind of wheeze described as a loud musical sound of constant pitch, which is heard in patients with tracheal or laryngeal obstruction. The full differential diagnosis of airway obstruction should be carefully considered in any patient with wheezing or stridor

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Abstract: Within individuals, lung size as assessed by total lung capacity (TLC) or vital capacity (VC) appears to be unrelated to airway size as assessed physiologically by maximum expiratory flows (MEF). Green et al. (J. Appl. Physiol. 37: 67-74, 1974) coined the term dysanapsis (unequal growth) to express this apparent interindividual discrepancy between parenchymal and airway size. We have reexamined this discrepancy using both physiological and anatomic indexes of airway size. Airway area by acoustic reflectance (AAAR), peak expiratory flow rates (PEFR), MEF, and lung volumes were measured in 26 male and 28 female healthy nonsmoking adults. The effect of sex on these indexes of large airway size was significant when assessed in a subset of males and females whose TLC's were matched (5.0-6.5 liters). Within this subset, male AAAR was 2.79 +/- 0.45 cm2, whereas female AAAR was 1.99 +/- 0.67 cm2 (P less than 0.01). Male's PEFR and MEF after 25% of VC had been expired (MEF25) were 23% greater than those of females within this subset (P less than 0.05). For the entire group of subjects, once these sex-related differences had been accounted for, AAAR was not significantly related to TLC, whereas PEFR and MEF25 remained at best weakly related to TLC. We conclude that tracheal areas in males are significantly larger than those of females even after controlling for TLC and that after controlling for sex-related differences, tracheal size in adults is unrelated to lung size across a broad range of lung sizes

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Abstract: The time it takes audible sound to travel from the trachea to the pleura in five intact, excised horse lungs and one dog lung inflated with several gases was measured. Regression estimates of sound speed at total lung capacity (TLC) using straight line distance from the carina to the pleura are: helium, 775 +/- 60.5 m/s (means +/- 95% confidence limits); air, 282 +/- 23.5; carbon dioxide, 219 +/- 25.5; sulfur hexafluoride, 142 +/- 43.5. With the exception of sulfur hexafluoride, these speeds are 15%-20% less than the free-field speed of sound in each gas. Total airway length did not predict time delay any better or worse than straight line distance, but the high correlation between these two predictors (r = 0.94) prevents showing either to be the more predictive. In one lung, airway length was partitioned according to airway diameter. A regression using partitioned airway lengths significantly improved time delay prediction (p less than 0.001) over an unpartitioned model. Sound speed in the trachea equals free-field sound speed. Sound speed in air-filled airways 1 to 25 mm in diameter equals 268 +/- 44 m/s. We conclude that the first sound to reach the surface travels in the airways for at least 90% of the distance, spending at least 87% of the total travel time there

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Abstract: Auscultatory percussion is a new method of physical examination developed by Guarino [Lancet i: 1332-1334, 1980]. It consists in tapping lightly the manubrium sterni with the distal phalanx of the middle finger while listening over the chest wall posteriorly with a stethoscope; a decrease in sound intensity is usually attributed to lung abnormalities. The aim of our study was to assess the validity of the method as compared to classical percussion, a point not entirely clear in the original study. Two observers independently examined 281 unselected patients (170 men; 111 women) referred for chest X-ray studies. Roentgenographic analysis, carried out by a third observer, revealed 12 categories of abnormalities in 96 patients. The validity of auscultatory and conventional percussion was calculated by taking the product of sensitivity and specificity of each method. For both observers and both methods, the values of this index were always found to be below 0.25, indicating that the results can be explained entirely by chance. When the roentgenographic category was taken into account, both methods of percussion were valid only to detect large pleural effusions. Auscultatory percussion failed completely to detect many other abnormalities including solitary nodules less than 6 cm in diameter. There is no single hypothesis to explain these results. Various possibilities are discussed

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Abstract: Pharyngeal size and the dynamic behavior of the upper airway may be important factors in modulating respiratory airflow. Patients with obstructive sleep apnea are known to have reduced pharyngeal cross- sectional area. However, no systematic measurements of pharyngeal area in healthy asymptomatic subjects are available, in part due to the lack of simple, rapid, and noninvasive measurement techniques. We utilized the acoustic reflection technique to measure pharyngeal cross-sectional area in 24 healthy volunteers (14 males, 10 females). Pharyngeal area was measured during a continuous slow expiration from total lung capacity (TLC) to residual volume (RV). We compared pharyngeal cross- sectional areas in males and females at three lung volumes: TLC, 50% of vital capacity (VC), and RV. In males, pharyngeal areas (means +/- SD) were 6.4 +/- 1.3 cm2 at TLC, 5.4 +/- 0.9 cm2 at 50% VC, and 4.1 +/- 0.8 cm2 at RV. In females, pharyngeal areas were 4.8 +/- 0.6 cm2 at TLC, 4.2 +/- 0.5 cm2 at 50% VC, and 3.7 +/- 0.6 cm2 at RV. The difference in area between males and females was statistically significant at TLC and 50% VC but not at RV. However, when the pharyngeal cross-sectional area was normalized for body surface area, this difference was not significant. In males there was a negative correlation of pharyngeal area with age. We conclude that sex differences in pharyngeal area are related to body size, pharyngeal area shows a similar variation with lung volumes in males and females, and in males pharyngeal area reduces with age

893. Brown, I. G., N. Zamel, and V. Hoffstein. 1986. Pharyngeal and glottic changes following methacholine challenge in normal subjects. *Bull.Eur.Physiopathol.Respir.* 22:251-256.
Abstract: Recent evidence indicates that some normal subjects exhibit glottic narrowing following experimentally induced bronchospasm. Similar findings have been observed during episodes of bronchospasm in asthmatics. The exact mechanism of this effect is unknown but it is thought to occur as part of a generalized reflex response associated with constriction of intrapulmonary airways. We tested the hypothesis that in addition to the glottic changes, coincident with intrapulmonary airway constriction which occurred after inhalation of methacholine, the pharynx would show similar changes. Pharyngeal and glottic cross- sectional areas were measured using the acoustic reflection technique in seven healthy subjects before and after inhalation of metacholine. Before methacholine, pharyngeal and glottic areas (mean +/- SE) were 5.0 +/- 0.2 cm2 and 2.4 +/- 0.3 cm2 respectively. After inhalation of methacholine, these areas were reduced to 4.6 +/- 0.3 cm2 and 1.9 +/- 0.3 cm2 respectively (p less than 0.05). We conclude that inhalation of methacholine induces similar reductions in glottic and pharyngeal areas. The role of local or reflex mechanisms accounting for this reduction remains unclear

894. Brown, I. G., P. M. Webster, N. Zamel, and V. Hoffstein. 1986. Changes in tracheal cross-sectional area during Mueller and Valsalva maneuvers in humans. *J.Appl.Physiol* 60:1865-1870.
Abstract: Pressure-area behavior of the excised trachea is well documented, but little is known of tracheal compliance in vivo. Extratracheal tissue pressures are not directly measurable, but transmural pressure for the intrathoracic trachea is inferred from intra-airway and pleural pressure differences. Extramural pressure of the cervical trachea is assumed to be atmospheric. The difference in transmural pressure between the intra- and extrathoracic tracheal segments should be exaggerated during Mueller and Valsalva maneuvers. We used the acoustic reflection technique to measure tracheal areas above and below the thoracic inlet during these isovolume-pressure maneuvers. We found that 10 cmH2O positive pressure increased tracheal area in the extrathoracic segment by 34 +/- 16% (mean +/- SD) and in the intrathoracic segment by 35 +/- 15%. There was a reduction in area of 27 +/- 16 and 24 +/- 14%, respectively, for the extra- and intrathoracic segments with 10 cmH2O negative pressure. We

conclude that the effective transmural pressure gradients do not vary significantly between intra- and extrathoracic tracheal segments

895. Cugell, David W., Network for Continuing Medical Education., Northwestern University (Evanston, Ill., and Medical School. When the lungs sound sick. 1986. Secaucus, N. J., Network for Continuing Medical Education.
Ref Type: Video Recording

896. D'Urzo, A. D., A. S. Rebuck, V. G. Lawson, and V. Hoffstein. 1986. Effect of CO2 concentrations on acoustic inferences of airway area. *J.Appl.Physiol* 60:398-401.
Abstract: To determine the effect of gas composition on the accuracy of measurements of airway area and distance using an acoustic reflection technique, we employed glass-tube models to simulate pharyngeal (Phar- model), laryngeal (Lar-model), and tracheal (Trach-model) regions of upper and central airways. We made repeated measurements of area- distance functions using gas mixtures containing 0, 2, 4, 6, 8, and 10% CO2, 80% He, and balance O2. The actual area of the model was calculated from the roentgenographic data and compared favorably with an area measured by acoustic reflections using a gas mixture containing 0% CO2. With the different gas mixtures, calculated area was overestimated only at the highest levels of CO2, with Phar-model area increasing from (mean +/- SD) 4.66 +/- 0.03 cm2 measured with 0% CO2 to 4.93 +/- 0.05 cm2 (P less than 0.05) measured with CO2 concentration of 10%. To assess the effect of CO2 concentration on measurements of distance, we isolated two discrete points located in the Phar-model and Lar-model regions. When measurements were performed using 10% CO2 mixture, Phar-model point was shifted by 1.02 +/- 0.03 cm and Lar-model point was shifted by 2.16 +/- 0.09 cm away from the microphone compared with their axial position determined, using 0% CO2 mixture (P less than 0.05). Differences in area-distance calculations at the higher levels of CO2 did not exceed the within-run variability of the technique (10 +/- 4%). We conclude that CO2 absorbers are not required during measurements of airway area by acoustic reflections, provided CO2 concentration does not exceed 10%

897. Dunn, F. 1986. Attenuation and speed of ultrasound in lung: dependence upon frequency and inflation. *J.Acoust.Soc.Am.* 80:1248-1250.
Abstract: The dependence of the speed of sound and the attenuation coefficient upon exposure frequency, in the range of 1-5 MHz, and upon level of inflation, in the range of mass density 0.35-0.7 g/cm3, are reported. The speed of sound decreases linearly and the attenuation coefficient increases exponentially, for all levels of inflation studied

898. Frazer, D. G., L. D. Smith, L. R. Brancazio, and K. C. Weber. 1986. Comparison of lung sounds and gas trapping in the study of airway mechanics. *Environ.Health Perspect.* 66:25-30.
Abstract: We have previously shown that gas is trapped in isolated animal lungs and have proposed that this gas-trapping process is related to meniscus formation in the small airways of the lung. The purpose of this investigation was to compare how the lung sound-generation process and the gas-trapping process are related to airway mechanics and each other. Rats were anesthetized, the heart and lungs were removed en bloc and placed in a liquid-filled plethysmograph. Lung sounds were recorded by using a microphone acoustically coupled to the tracheal cannula. The results show that discontinuous lung sounds in the form of crackles occur during lung inflation at the same time gas trapping takes place

899. Iyer, V. K., P. A. Ramamoorthy, H. Fan, and Y. Ploysongsang. 1986. Reduction of heart sounds from lung sounds by adaptive filtering [published erratum appears in IEEE Trans Biomed Eng 1988 Jan;35(1):76]. *IEEE Trans.Biomed.Eng* 33:1141-1148.

900. Kanga, J. F. and S. S. Kraman. 1986. Comparison of the lung sound frequency spectra of infants and adults. *Pediatr.Pulmonol.* 2:292-295.
Abstract: Auscultation of the infant chest reveals lung sounds that seem different from those of adults. To characterize this subjective difference, we compared the phonopneumographic median frequencies of lung sounds of seven full-term and six premature infants with those of seven adults free of cardiopulmonary disease. The median frequencies over the upper lobes for the adults, term infants, and premature infants were 282 +/- 63(SD) Hz, 383 +/- 80 Hz, and 483 +/- 86 Hz, respectively. At this location the differences among the three groups were significant (p less than 0.01). Over the lower lobes, the median frequencies for the adults, term infants, and premature infants were 243 +/- 56 Hz, 386 +/- 76 Hz, and 390 +/- 63 Hz, respectively. Here the difference between the adults and both groups of infants was significant (p less than 0.01), but that between the term and premature infants was not. We conclude that the normal lung sounds of newborn infants contain higher-frequency components than those of adults. We postulate that this difference is the result of less filtering of the lung sound in infants. This difference should be considered when lung sounds of infants are described or assessed for the presence of abnormalities

901. Kraman, S. S. 1986. Lung sounds for the clinician. *Arch.Intern.Med.* 146:1411-1412.
Abstract: Recent interest in lung sound physiology has led to a sharp increase in the publication of articles that describe new techniques of examining lung sounds. Although most of the results of these investigations are of interest primarily to other researchers, several have practical value and should be of interest to the clinician because of the objective support that they lend to various aspects of the physical examination. This short review provides an outline of recent work relating to vesicular lung sounds, crackles, and wheezes. The information is presented with emphasis on practical applications

902. Kraman, S. S. 1986. Effects of lung volume and airflow on the frequency spectrum of vesicular lung sounds. *Respir.Physiol* 66:1-9.
Abstract: The purpose of this study was to determine whether the vesicular lung sound frequency spectrum is affected by changes in lung volume and airflow. Nine healthy young nonsmokers were studied. The dependent variables were the points that divide the power spectrum of the vesicular lung sound into quarters (1st, 2nd and 3rd quartiles (Q1, Q2 and Q3]. Recording sites were the right upper anterior (RUL) and lower posterior (RLL) chest wall. Lung sounds were high-pass filtered at 100 Hz. To evaluate the effect of volume, lung sounds were recorded during an inspiratory vital capacity (VC) maneuver at near constant airflow rates. The spectral parameters were determined at each sixth of the VC. To assess the effects of airflow, 5 of the subjects breathed from resting lung volume at peak inspiratory airflows of between 1 and 3.0 L/sec for a total of 16 breaths each and the frequency parameters of the lung sounds occurring during peak inspiratory airflows were determined. RESULTS: Volume effects: only at the RUL was there a small but significant decrease in all three parameters with increasing lung volume. Airflow effects: all parameters were independent of airflow except for a weakly positive relationship (r = 0.285, P less than 0.05) for Q3 at the RUL location. Individually, there were weakly significant trends in three of the five subjects. These data suggest that the frequency composition of the vesicular lung sound in groups of healthy adults is not systematically affected by changes in lung volume or airflow

903. Leiberman, A., A. Cohen, and A. Tal. 1986. Digital signal processing of stridor and snoring in children. *Int.J.Pediatr.Otorhinolaryngol.* 12:173-185.
Abstract: Stridor and snoring are common signs of upper airway obstruction. The nature and characteristics of the stridor and snoring depend upon the site of obstruction. Sophisticated analysis of these sounds may provide important information concerning the source of the sound helping to assess the patient more objectively. The preliminary results of computerized digital analysis of stridor and snoring sounds are presented in 5 children. Two main programs were applied to analyse the signal: the Power Spectral Density (PSD) function and the Estimated Cross-sectional Area (ECSA). A consistent pattern according to the site of the produced sound was seen. Further acoustical analyses are needed to standardize this method and to program the computer to indicate the various sites of lesions

904. Mori, M., M. Ohono, M. Iguchi, and S. Koike. 1986. [Pathophysiological bases of lung auscultation]. *Kokyu.To Junkan.* 34:631-635.

905. Munakata, M., Y. Homma, M. Matsuzaki, H. Ogasawara, K. Tanimura, H. Kusaka, and Y. Kawakami. 1986. Production mechanism of crackles in excised normal canine lungs. *J.Appl.Physiol* 61:1120-1125.
Abstract: Lung crackles may be produced by the opening of small airways or by the sudden expansion of alveoli. We studied the generation of crackles in excised canine lobes ventilated in an airtight box. Total airflow, transairway pressure (Pta), transpulmonary pressure (Ptp), and crackles were recorded simultaneously. Crackles were produced only during inflation and had high-peak frequencies (738 +/- 194 Hz, mean +/- SD). During inflation, crackles were produced from 111 +/- 83 ms (mean +/- SD) prior to the negative peak of Pta, presumably when small airways began to open. When end-expiratory Ptp was set constant between 15 and 20 cmH2O and end-expiratory Ptp was gradually reduced from 5 cmH2O to - 15 or -20 cmH2O in a breath-by-breath manner, crackles were produced in the cycles in which end-expiratory Ptp fell below -1 to 1 cmH2O. This pressure was consistent with previously known airway closing pressures. When end-expiratory Ptp was set constant at -10 cmH2O and end inspiratory Ptp was gradually increased from -5 to 15 or 20 cmH2O, crackles were produced in inspiratory phase in which end-inspiratory Ptp exceeded 4-6 cmH2O. This pressure was consistent with previously known airway opening pressures. These results indicate that crackles in excised normal dog lungs are produced by opening of peripheral airways and are not generated by the sudden inflation of groups of alveoli

906. Mussell, M. J. 1986. Trachea noise biofeedback device to help reduce bronchospasm in asthmatics. *J.Biomed.Eng* 8:341-344.
Abstract: Evidence suggests that conscious control of bronchial smooth muscle tone may be possible. The asthmatic wheeze is caused mainly by broncho- constriction and it is hypothesized that if wheeze were consciously reduced, some bronchodilation would occur. Described here is a biofeedback device which records asthmatic tracheal noise with a microphone, and generates both an audio and visual display of the degree of wheeze sound intensity. The subject attempts to reduce wheeze using the device. Wrong information is also generated within the device so that the placebo effect can be investigated

907. Priimak, A. A., T. V. Solomentsova, A. A. Kornilov, and L. I. Nemerovskii. 1986. [Study of the informative value of pulmophonographic indices using the technic of linear discriminant analysis]. *Probl.Tuberk.*33-35.

908. Sadlonova, J., D. Salat, and V. Salatova. 1986. [Changes in the sound of the cough in patients with chronic bronchitis]. *Bratisl.Lek.Listy* 85:458-465.

909. Salat, D., V. Salatova, J. Korpasova-Sadlonova, and D. Palecek. 1986. [Changes in the sound of the voluntary cough in obstruction of the respiratory tract induced by acetylcholine]. *Bratisl.Lek.Listy* 85:466-471.

910. Shee, T. R. Flutter of flexible channels and tubes (oscillation, fluid dynamics). 1986. NORTHWESTERN UNIVERSITY.
Ref Type: Thesis/Dissertation

911. Winter, J. S. and Aaron, D. Chest auscultation: normal breath sounds. 1986. Grants Pass, OR, Rogue Community College.
Ref Type: Audiovisual Material

912. Workum, P., E. A. DelBono, S. K. Holford, and R. L. Murphy, Jr. 1986. Observer agreement, chest auscultation, and crackles in asbestos- exposed workers. *Chest* 89:27-29.
Abstract: Investigators cite observer variability as a problem in using crackles to diagnose asbestosis. We measured agreement on the presence or absence of crackles noted during auscultation of 64 asbestos-exposed workers in order to clarify this question. There was 89 percent agreement between two observers who simultaneously examined subjects breathing from functional residual capacity (FRC). Kappa (kappa), a statistic accounting for chance agreement, was 0.73. Unanimous agreement between four observers who listened to tape recordings of the breath sounds was 81 percent (kappa = 0.69). When the subjects breathed from residual volume (RV) there was 78 percent (kappa = 0.53) and 67 percent (kappa = 0.60) agreement, respectively. Comparing direct to tape-playback auscultation, there was 90 percent (kappa = 0.77) and 84 percent (kappa = 0.58) intraobserver agreement when the subjects breathed from FRC and 90 percent (kappa = 0.79) and 75 percent (kappa = 0.39) when they breathed from RV. We conclude that observer variability is sufficiently low to allow trained observers to monitor asbestos- exposed workers for crackles directly and during tape-playback auscultation

913. Yen, R. T., Y. C. Fung, H. H. Ho, and G. Butterman. 1986. Speed of stress wave propagation in lung. *J.Appl.Physiol* 61:701-705.
Abstract: The speed of stress waves in the lung parenchyma was investigated to understand why, among all internal organs, the lung is the most easily injured when an animal is subjected to an impact loading. The speed of the sound is much less in the lung than that in other organs. To analyze the dynamic response of the lung to impact loading, it is necessary to know the speed of internal wave propagation. Excised lungs of the rabbit and the goat were impacted with water jet at dynamic pressure in the range of 7-35 kPa (1-5 psi) and surface velocity of 1- 15 m/s. The stress wave was measured by pressure transducer. The distance between the point of impact and the sensor at another point on the far side of the lung and the transit time of the stress wave were measured. The wave speed in the goat lung was found to vary from 31.4 to 64.7 m/s when the transpulmonary pressure Pa-Ppl was varied from 0 to 20 cmH2O where Pa represents airway pressure and Ppl represents pleural pressure. In rabbit lung the wave speed varied from 16.5 to 36.9 m/s when Pa-Ppl was varied from 0 to 16 cmH2O. Using measured values of the bulk modulus, shear modulus, and density of the parenchyma, reasonable agreement between theoretical and experimental wave speeds were obtained

914. Archer, L. N. and H. Simpson. 1985. Night cough counts and diary card scores in asthma. *Arch.Dis.Child* 60:473-474.
Abstract: A tape recording system for recording night cough in asthmatics at home is described. Objective cough counts and half hour periods containing cough did not correlate with diary card scores awarded to eight children on seven nights each. Night cough diary scores may mislead in the assessment of symptom severity

915. Austrheim, O. and S. S. Kraman. 1985. The effect of low density gas breathing on vesicular lung sounds. *Respir.Physiol* 60:145-155.
Abstract: Turbulent airflow (largely gas density dependent) in larger airways is believed by many lung sound researchers to be the mechanism responsible for the generation of vesicular lung sounds. To test the validity of this concept, we measured the amplitude of lung and tracheal sounds of 6 subjects alternately breathing air and a low density gas mixture (80% helium, 20% oxygen: He-O2). Lung sounds were recorded from 3 chest wall sites: Anterior right upper lobe (RUL), posterior and posterolateral right lower lobe (RLL), and a site over the proximal trachea below the larynx. The subjects rebreathed into an electronic spirometer filled with the test gas, and achieved a peak inspiratory and expiratory airflow of 2-2.5 L/sec. Lung sound amplitude was determined by an automated, flow-corrected measurement procedure. The mean decrease in sound amplitude when breathing He-O2 compared

to air was: trachea, inspiration 44%; trachea, expiration 45%; RUL, inspiration 13%; RUL, expiration 25%; RLL, inspiration 15% (expiration at the RLL was too quiet to record). Cross-correlation and frequency analyses of the sounds recorded at the two RLL sites on both test gases revealed no consistent change in frequency or time relationships, indicating absence of effect of gas density on sound transmission between the sound generating airways and chest wall. These data suggest that the mechanism of production of the inspiratory vesicular lung sound is not simply turbulent airflow but some other relatively gas density independent mechanism. The tracheal and expiratory lung sounds do appear to be produced by a more density dependent turbulent mechanism

916. Baughman, R. P. and R. G. Loudon. 1985. Lung sound analysis for continuous evaluation of airflow obstruction in asthma. *Chest* 88:364-368.
Abstract: We developed a system for monitoring airflow obstruction noninvasively, based on the principle that the proportion of the breath cycle occupied by wheezing (Tw/Ttot) in any one subject corresponds to the severity of airways obstruction. Lung sounds were recorded continuously from the chest wall. Fifty 250 ms sound segments were randomly chosen from five- minute periods and analyzed for the presence or absence of wheezes. The proportion with wheezes was used as an estimate of Tw/Ttot (Est Tw/Ttot). For 12 wheezy patients, there was a good correlation between the Est Tw/Ttot and the forced expiratory volume in one second (r = 0.893, p less than 0.001). The system was used to evaluate nocturnal asthma. Five subjects were studied over eight nights. It was found that there was more wheezing from 4:00 to 4:30 AM than from midnight to 12:30 AM (p less than 0.05). This technique may prove useful in continuous, noninvasive monitoring of wheezy patients

917. Bhat, K., P. H. Scott, H. Eigen, and P. B. Boggs. 1985. Evaluation of lung sounds by telephone. *Ann.Allergy* 54:109-111.
Abstract: We evaluated the utility of a newly designed electronic stethoscope that can be used with the telephone system. Nine patients with wheezing, crackles, or other adventitious sounds were evaluated by a physician examiner who used a conventional stethoscope and another physician who received the signal of the electronic stethoscope via telephone. When their findings were compared, it was found that physicians agreed in 95% of observations. The potential uses of the electronic stethoscope are discussed

918. Charbonneau, G. and M. Sudraud. 1985. [Measurement of the frequency response of several stethoscopes in common use. Consequences for cardiac and pulmonary auscultation]. *Bull.Eur.Physiopathol.Respir.* 21:49-54.
Abstract: We measured the frequency response of eight stethoscope membranes and of thirteen types of stethoscopes. Measurements were made in an anechoic chamber calculating the ratio between the intensity of a sinusoidal sound coming from a loud speaker and the intensity of the transmitted sound through the membrane of the stethoscope. Small membranes have a bandwidth (without attenuation or amplification) between 10 and 600 Hz while large membranes have a bandwidth twice the size (10-1200 Hz). This good result does not appear in the case of stethoscopes showing increasing attenuation versus frequency, with a mean value from -2.5 to -10.5 dB and variations of 10 dB in the range 50-1200 Hz which is the useful bandwidth for cardiac and pulmonary auscultation. By contrast, fidelity of the measured stethoscopes was good. Discussion of the results suggests modification of stethoscope design to eliminate faults of sound transmission and to elaborate a microphone sensor allowing an electric transmission

919. East, K. A. and T. D. East. 1985. Computerized acoustic detection of obstructive apnea. *Comput.Methods Programs Biomed.* 21:213-220.
Abstract: Cardiac, respiratory and neurologic abnormalities have been identified as causes of Sudden Infant Death Syndrome (SIDS). Recurrent central apnea (no respiratory effort or nasal/oral airflow) and obstructive apnea (respiratory effort without concurrent nasal/oral airflow) in infants are considered risk factors for SIDS. However, using currently available monitoring techniques, normal activities such as yawns, stretches and swallows cannot be distinquished from short obstructive episodes lasting less than 20 s. A system was developed to more accurately detect obstructive apnea in infants using a miniature microphone placed over the trachea, a cassette tape recorder and a MINC- 11 microcomputer. Respiratory sounds were recorded on 5 anesthesized rabbits in which partial and total airway obstruction was artificially induced. Sounds were analyzed by computer using fast Fourier transformations. Amplitude versus frequency was plotted for normal breathing, partial obstruction and total obstruction. Characteristic patterns were identified for each episode demonstrating that acoustic detection of apnea in infants by a microprocessor-based monitor is feasible

920. Fenton, T. R., H. Pasterkamp, A. Tal, and V. Chernick. 1985. Automated spectral characterization of wheezing in asthmatic children. *IEEE Trans.Biomed.Eng* 32:50-55.

921. Gray, L., J. C. Denneny, III, H. Carvajal, and R. Jahrsdoerfer. 1985. Fourier analysis of infantile stridor: preliminary data. *Int.J.Pediatr.Otorhinolaryngol.* 10:191-199.

Abstract: Preliminary data from 3 patients suggest that computerized (Fourier) analysis of infantile stridor can be instructive. Several recordings are quickly collected with a microphone and digital oscilloscope at the patient's bedside. The data are later sent to a computer for spectral analysis. Averaging of several spectra from each patient depicts only those sounds that are consistent from sample to sample. Subtraction of background noise from the averaged stridor removes all but those sounds that are produced by the patient. The results show that the spectra are relatively consistent from sample to sample within the same patient, and that different patients with different pathologies have distinct patterns in their spectra. It thus appears that further acoustical studies of infantile stridor will be productive. We are optimistic that data from a larger series of patients will indicate those spectral patterns which are characteristic of a specific laryngotracheal pathology, and perhaps facilitate rapid diagnosis without invasive procedures. An additional potential of this analysis is that pre- and post-operative spectra can be subtracted to show those sounds that improved or worsened. Such serial comparisons during the management of airway problems could be useful in evaluating treatment

922. Homma, Y., M. Matsuzaki, H. Ogasawara, and M. Munakata. 1985. Phonopneumograph possible for real-time tracing. *Comput.Biomed.Res.* 18:502-509.
Abstract: We constructed a new phonopneumograph that provides real-time tracing of lung sounds at a high speed without the steps of memory and playback by use of a thermal printer system. Accuracy of the recorded wave form was considered adequate even at the maximum speed of 750 mm/sec for detailed wave form analysis. The device is easily connected to a recording system for respiratory flow rate or volume. To test the clinical usefulness of this portable instrument, the difference in the interpretation of four types of basic adventitious lung sounds by different listeners was examined. The "trained" group who had experience in using this instrument interpreted adventitious lung sounds more accurately than did the "untrained" group. Even in the "trained" group, however, the accuracy of identifying certain sounds was sometimes low. These results suggest that this device is useful for bedside interpretation of adventitious lung sounds or for training of auscultation ability

923. Hopkins, R. L. 1985. Differential auscultation of the acutely ill patient. *Ann.Emerg.Med.* 14:589-590.
Abstract: The differential stethoscope is a unique instrument that assists in rapid evaluation of pulmonary problems in the acutely ill patient. Simultaneous auscultation of homologous lung segments eliminates the problem of variability of breathing rate and pattern that must be confronted in conventional auscultation

924. Korpas, J. and E. Galikova. 1985. [Tussiphonogram of workers exposed to toluene]. *Bratisl.Lek.Listy* 83:450-456.

925. Kraman, S. S. 1985. Lung sounds. *Seminars in respiratory medicine* 6:157-242.

926. Matsuzaki, M. 1985. [Polarity of crackle waveforms: a new index for crackle differentiation]. *Hokkaido Igaku Zasshi* 60:104-113.
Abstract: There are three kinds of crackling sounds on chest auscultation, that is, fine crackle, coarse crackle and pleural rub. The trouble in clinical practice is that pleural rub is sometimes indistinguishable from pulmonary crackles. I have found definite rules for the polarity of the initial deflection of the waveforms (crackle polarity: CP) of these sounds. I have investigated CP distribution in 12 patients with fine crackle, 17 with coarse crackle and 8 with pleural rub. Electrical polarity was so adjusted that a positive pressure change results in a positive deflection on the recording paper. CP was positive in 93.3 +/- 6.4% of fine crackle (all on inspiration). In coarse crackle, 91.8 +/- 5.8% of CP was positive on inspiration and 93.8 +/- 10.3% was negative on expiration. In contrast to the homogeneous CP distribution of these crackles, that of pleural rub showed a remarkable heterogeneity. In six of pleural rub cases, predominant CP was positive on inspiration and negative on expiration, but this was in the reverse in the rest of two cases. A few centimeter shift of recording sites resulted in moderate to remarkable change in CP distribution in pleural rub cases, but no positional variety was observed in that of pulmonary crackles. These results show that CP distribution of pulmonary crackles may be explained with dipole stress distribution models and that of pleural rub with quadrupole one. These results suggest that the heterogeneous CP distribution with positional variety is a distinct phonopneumographic feature of pleural rub and that CP analysis is a useful method for basic and clinical study on crackling lung sounds because CP distribution reflects the generation and transmission characteristics of these sounds

927. Minami, Y., Y. Homma, M. Matsuzaki, H. Ogasawara, M. Munakata, and M. Murao. 1985. [Rales in the experimentally induced edematous lung in dogs]. *Kokyu.To Junkan.* 33:319-324.

928. Munakata, M., Y. Homma, K. Tanimura, H. Kusaka, H. Ogasawara, M. Matsuzaki, and Y. Kawakami. 1985. [Production mechanisms of fine crackles]. *Nihon Kyobu Shikkan Gakkai Zasshi* 23:1440-1448.

929. Munakata, M., Y. Homma, M. Matsuzaki, H. Ogasawara, Y. Sasaki, and Y. Kawakami. 1985. Rales in silicosis. A correlative study with physiological and radiological abnormalities. *Respiration* 48:140-144.
Abstract: Pulmonary auscultation, pulmonary function tests and radiological examination were done in 127 hospitalized patients with silicosis. Fine crackle (FC) was heard in 21.3% of patients, coarse crackle (CC) in 28.5%, rhonchi or wheeze (RorW) in 25.2% and friction rub (FR) in 5.5%. In complicated silicosis the incidence of rales was paradoxically lower than in simple silicosis (54.6 vs. 83.3%, respectively, p less than 0.05). In simple silicosis, patients with CC and/or RorW had lower %VC and FEV1/FVC%, but in complicated silicosis, the relation between the presence of rales and pulmonary functional status was not so apparent. These results suggest that in relatively advanced silicosis, all kinds of rales are heard, and in simple silicosis, rales are useful indicators of physiological impairment, but in complicated silicosis, they do not seem to be so useful

930. Pasterkamp, H., R. Fenton, A. Tal, and V. Chernick. 1985. Interference of cardiovascular sounds with phonopneumography in children. *Am.Rev.Respir.Dis.* 131:61-64.
Abstract: We have used fast Fourier transform and power spectra analysis to determine possible interference of cardiovascular sounds with the analysis of breath sounds in children. Ten normal children, 8 to 13 yr of age, were studied with sound transducer over midprecordium, right upper lobe, and right lower lobe along with simultaneously recorded ECG and air flow. Detection of R-waves facilitated sampling of sound segments at defined flow rates, with inclusion or exclusion of heart sounds. Measurements during breath-holding and without heart sounds served as baseline values. Heart sounds were only slightly attenuated over the right upper lobe. There was a considerable overlap in the power spectra of heart and breath sounds, mainly in frequencies below 100 Hz. Analysis of low-frequency components of normal breath sounds requires sampling during parts of the cardiac cycle that are free of cardiovascular sounds

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Abstract: Postexertional wheezing is an important clinical sign of nonspecific airway hyperreactivity. We have studied wheezing after exercise in 6 asthmatic subjects, 13 to 20 yr of age, using spectral analysis of recorded tracheal sounds. Automated spectral characterization was used to measure wheezing as a proportion of respiratory time. Anticholinergic treatment with ipratropium bromide (Atrovent) was compared with placebo to investigate effects on postexertional wheezing, and pulmonary function was compared with the result of respiratory sound analysis. Atrovent did not abolish exercise-induced bronchospasm but improved preexercise lung function and thereby caused a parallel upward shift in the response curves. Wheezing after Atrovent was significantly less, later in onset, and mainly expiratory at 20 min after exercise. Wheezing as a percentage of total respiratory time correlated well with FEV1, Vmax50, and SGaw. Analysis of respiratory sounds and automated quantification of wheezing may be a useful complementary test of bronchial obstruction in asthma

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Abstract: We measured laryngeal resistance (Rla), upper airway resistance (Ruaw), and lower respiratory resistance below the larynx (Rlrs) during methacholine and histamine provocation in 10 normal and 12 asthmatic subjects. In another 10 asthmatic subjects, Rla was measured during medication for spontaneous asthma attack. The Rla was measured with the low-frequency sound method (see reference 9). Direct measurements of Ruaw and Rlrs were obtained using the 3-Hz forced oscillation technique with a needle inserted below the cricoid cartilage. In normal subjects, Ruaw increased in proportion to the increase in Rlrs during methacholine and histamine provocation. In asthmatic subjects, control Ruaw was higher than the control Ruaw in normal subjects (p less than 0.001) and Ruaw did not change despite an increase in Rlrs during methacholine and histamine provocation. After medication for spontaneous asthma attack, Rla decreased in proportion to the decrease in total respiratory resistance (Rrs). We conclude that in asthmatic subjects, Rla contributes to an increase in Rrs during both the nonspasmodic period and the spontaneous asthma attack but does not do so during bronchoprovocation, probably because the larynx is less sensitive than the lower respiratory tract

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Abstract: The invention in 1819 of the stethoscope by Laennec was followed by the first classification of pulmonary adventitial sounds. A number of new nomenclatures based upon acoustic principles have subsequently been suggested. Phonopneumography consists of the recording of respiratory sounds and their breakdown into different harmonics by frequential analysis. Broadly speaking, a distinction is drawn between continuous sounds, including sibilants and rhonchi, and discontinuous sounds, covering crepitations and coarse rales

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Abstract: Snoring is a significant symptom of upper airway obstruction which has not been measured and quantified in a clinically

useful manner. A technique to determine acoustic level, frequency, and duration of snoring is reported. Four case studies illustrate the utility of this method. It is recommended that acoustic monitoring be included in the polysomnographic assessment of selected sleep disorder patients

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Abstract: Lung sounds were recorded in three groups of 5 subjects, 2 conditions associated with pulmonary crackling (asbestosis and pulmonary oedema), and in normal non-smoking males. A technique was used which permitted extraction and analysis of the low-frequency sounds. Differences were evident in the 5-50 Hz range of the frequency spectra which allowed separation of all 3 groups. A prominent feature was the close similarity of the low-frequency sounds within the asbestos group when plotted on a scattergram. The findings suggest that alteration in low- frequency breath sound occurs in parenchymal lung disease and that its potential merits further investigation

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Abstract: Pulmonary sounds were recorded before and after bronchodilator treatment in 20 patients with acute attacks of asthma. Analysis of the sounds showed that improvement in the forced expiratory volume in one second was associated with the following two changes in the sound signal: (1) the proportion of the respiratory cycle occupied by wheeze (Tw/Ttot ratio) was reduced from 86 percent to 31 percent on average; and (2) the sound frequency of the highest pitched wheeze was also reduced, from a mean of 440 Hz to 298 Hz

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Abstract: To determine the accuracy and reproducibility of measurements of airway area by acoustic reflection (AAAR) we made repeated measurements of tracheal areas in human volunteers, glass airway models, and excised canine tracheae. In 10 adult males, the mean ratio of tracheal AAAR to tracheal areas determined roentgenographically was not significantly different from one (1.06 +/- 0.13 SD). Within-run variability was 10 +/- 4% (CV), mean intrasubject day-to-day variability was 9 +/- 4% (CV). A custom-made mouthpiece is necessary for accurate measurements of AAAR. Mean variability related to differences in mouthpiece construction was 7 +/- 6% (CV). The effect of variations in upper airway and glottic sizes on tracheal AAAR measurements was investigated using glass airway models. In model studies, tracheal AAAR measurements were found to be independent of changes in proximal airway size for glottic apertures greater than or equal to 1 cm2 and upper airway areas less than or equal to 8 cm2. Tracheal area was, however, overestimated by 20% in the rigid-walled glass models. The effects of airway wall rigidity were qualitatively investigated by comparing acoustic and roentgenographic measurements of excised canine tracheae surrounded by either air or petroleum jelly. Differences in the accuracy of measurements of AAAR in vitro and in vivo are probably due to differences in airway wall inertance. These studies suggest that the measurement of AAAR yields an accurate and reproducible result that may be clinically useful for the noninvasive detection of changes in central airway geometry

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939. Dalmasso, F., M. M. Guarene, R. Spagnolo, G. Benedetto, and G. Righini. 1984. A computer system for timing and acoustical analysis of crackles: a study in cryptogenic fibrosing alveolitis. *Bull.Eur.Physiopathol.Respir.* 20:139-144.
Abstract: A system for recording and processing lung crackles is described. These are detected by a microphone on the chest wall and recorded simultaneously with flow rate, tidal volume and oesophageal pressure on a four-channel tape recorder. The sound signal is subsequently digitized by an analog-to-digital converter and processed by a minicomputer, using the Time Series Language and the fast Fourier transform algorithm. A preliminary study on seven patients with cryptogenic fibrosing alveolitis (CFA) confirms that crackles typically occur at the end of inspiration; timing seems to be well related to inspired volume and esophageal pressure. Inspiratory crackles of CFA have a well-defined waveform: it consists of a starting component and a damped oscillation, which probably depends on the resonant frequency of the lung. The crackle energy content is mainly concentrated in the frequency range between 100 and 2 000 Hz, the spectrum shape being determined by the energy distribution between the two components of the waveform. This recording and processing system gives more complete information about crackles than auscultation does, allowing their quantification and reproducibility. It may be used to compare crackles in different diseases, and may be simplified and standardized for routine clinical use as an additional noninvasive diagnostic technique

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941. Gavriely, N., Y. Palti, G. Alroy, and J. B. Grotberg. 1984. Measurement and theory of wheezing breath sounds. *J.Appl.Physiol* 57:481-492.
Abstract: We measured the time and frequency domain characteristics of breath sounds in seven asthmatic and three nonasthmatic wheezing patients. The power spectra of the wheezes were evaluated for frequency, amplitude, and timing of peaks of power and for the presence of an exponential decay of power with increasing frequency. Such decay is typical of normal vesicular breath sounds. Two patients who had the most severe asthma had no exponential decay pattern in their spectra. Other asthmatic patients had exponential patterns in some of their analyzed sound segments, with a range of slopes of the log power vs. log frequency curves from 5.7 to 17.3 dB/oct (normal range, 9.8-15.7 dB/oct). The nonasthmatic wheezing patients had normal exponential patterns in most of their analyzed sound segments. All patients had sharp peaks of power in many of the spectra of their expiratory and inspiratory lung sounds. The frequency range of the spectral peaks was 80-1,600 Hz, with some presenting constant frequency peaks throughout numerous inspiratory or expiratory sound segments recorded from one or more pickup locations. We compared the spectral shape, mode of appearance, and frequency range of wheezes with specific predictions of five theories of wheeze production: 1) turbulence-induced wall resonator, 2) turbulence-induced Helmholtz resonator, 3) acoustically stimulated vortex sound (whistle), 4) vortex-induced wall resonator, and 5) fluid dynamic flutter. We conclude that the predictions by 4 and 5 match the experimental observations better than the previously suggested mechanisms. Alterations in the exponential pattern are discussed in view of the mechanisms proposed as underlying the generation and transmission of normal lung sounds. The observed changes may reflect modified sound production in the airways or alterations in their attenuation when transmitted to the chest wall through the hyperinflated lung

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Abstract: Interobserver variation was studied for 11 respiratory signs and for the diagnostic conclusions made on the basis of these signs. Two physicians each, with and without knowledge of the patient's history, performed physical examination of the lungs in a total of 202 unselected patients from a department of internal medicine. The interobserver variation was calculated as the kappa coefficient, using a modified method that made it possible to calculate the interobserver variation for a pair of observers made up by varying physicians. No difference was demonstrated between the kappa coefficients obtained for examinations performed with and without knowledge of the history. The kappa values for the signs ranged from -0.04 to 0.58, and for the diagnoses from 0.15 to 0.68, i.e., expressed by kappa values, poor agreement. In a questionnaire study we asked a number of physicians from departments of internal medicine to guess the size of the interobserver variation for the 11 respiratory signs examined. A total of 47 physicians (90%) returned the questionnaire and the answers showed that the physicians markedly underestimated the interobserver variation

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Abstract: We examined the usefulness of the acoustic reflection technique for measurement of airway area in 6 patients with tracheal stenosis. In each patient, we obtained airway area by acoustic reflections in the upright position, maximal expiratory and inspiratory flow-volume curve, and radiographs of the trachea. We identified acoustic and radiographic stenotic segments and compared their length, their distances from the glottis, and their cross-sectional areas. We found that (1) in all subjects except one, flow-volume curves did not suggest upper airway obstruction, (2) tracheal stenosis was confirmed by acoustic and radiographic measurements in all subjects, and (3) area of the stenotic segment showed less variation with lung volume than that of the nonstenotic segment. Length of the stenotic segment (mean +/- SE) was found to be 4.9 +/- 0.2 cm (acoustic versus 4.8 +/- 0.3 cm (radiographic); distance between the midglottis and maximal stenosis was 5.7 +/- 0.4 cm (acoustic) and 5.6 +/- 0.6 cm (radiographic); minimal acoustic cross-sectional area was 1.7 +/- 0.1 cm2 versus a radiographic circular cross-sectional area of 1.2 +/- 0.1 cm2. During slow expiration from total lung capacity to residual volume, average cross-sectional area of the stenotic segment decreased by 19.5 +/- 3.0% (mean +/- SE), whereas that of the distal nonstenotic segment decreased by 48.5 +/- 2.2% and that of the proximal nonstenotic segment by 43.6 +/- 5%. We conclude that the acoustic technique, which is rapid and noninvasive, is useful in confirming tracheal stenosis in patients with normal flow-volume curves, and in assessing elastic properties of the trachea

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Abstract: We examined the relationship between lung volume and pharyngeal cross- sectional area in 9 obese patients with obstructive sleep apnea and 10 age-matched, obese subjects without sleep apnea. Pharyngeal area was measured in the upright, seated posture using an acoustic reflection technique. Measurements were made at a rate of 5 per second during a slow exhalation from total lung capacity (TLC) to residual volume (RV). In the control subjects, the mean +/- SE pharyngeal area was 5.6 +/- 0.2 cm2 at TLC, and decreased by 30 +/- 5% over the vital capacity range to 3.9 +/- 0.3 cm2 at RV. In contrast to the control subjects, in patients with obstructive sleep apnea, pharyngeal area was 5.0 +/- 0.2 cm2 at TLC, and decreased by 54 +/- 6% over the vital capacity range to 2.3 +/- 0.3 cm2 at RV. The difference in pharyngeal area between the patients and control

subjects was significant at all lung volumes below TLC, as was the difference in the magnitude of change in pharyngeal area with change in lung volume. The results indicate that in obese patients with obstructive sleep apnea, pharyngeal cross-sectional area is abnormally small, and varies considerably with changes in lung volume. The beneficial effects of weight reduction in such patients may relate to the coincident increase in functional residual capacity, causing an increase in upper airway size

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Abstract: The cross-sectional area of airways can be estimated from their response to an acoustic pressure pulse introduced at the airway opening. Errors in these area estimates are expected if the airways do not behave rigidly at these frequencies. In eight dogs we tested the accuracy of this technique to estimate tracheal cross-sectional areas by comparing them with area estimates made from radiographic bronchograms. Tracheal areas using this technique were not statistically different from areas determined radiographically. The results indicate that the dog trachea does behave rigidly enough so that this method can be used to measure its cross-sectional area

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Abstract: Few investigators have examined the relationship between airflow and lung sound amplitude; the available data are contradictory. I measured airflow at the mouth and compared the peak flow (Vmax) to mean and peak lung sound amplitude (mean AMP and peak AMP) at four sites on the chest wall (right and left anterior apices and posterior bases) in four healthy young adults. At each site, the sounds produced by 20 breaths at Vmax ranging between 1.5 and 4 L/s (Vvar) were measured by an automated technique. Ten breaths during nearly constant Vmax breathing (Vcon) also were measured at each site. The lung sound amplitudes at the four sites in each subject were grouped and compared to Vmax by linear regression analysis. The same sounds were also submitted to an automated V-correction procedure to evaluate its adequacy in automatically adjusting for the effect of variations in Vmax on lung sound amplitude. The data showed that lung sound amplitude (mean or peak) was linearly related to V in all subjects (r for mean AMP vs Vmax:0.77, 0.85, 0.69, 0.89; r for peak AMP vs Vmax:0.80, 0.83, 0.79, 0.88), p less than 1 X 10(-7) in all cases. The average mean AMP vs Vmax regression line slope was 0.42, and the average peak AMP vs Vmax regression line slope was 0.45. V-correction decreased the coefficient of variation of the Vvar sounds by 61 percent and flattened the average regression line slopes to 0.128. For the Vcon series, V-correction diminished the coefficient of variation from 12.2 to 10.0 percent. The relationship between lung sound amplitude and airflow appears to be substantially linear and this relationship can be used to adjust effectively for variations in airflow

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Abstract: Bronchial fistulae in communication with atmospheric pressure can be identified by the presence of a squeaking sound heard over the chest wall during a Valsalva maneuver. Furthermore, these leak sounds can help identify the size, location, and communications of the bronchial fistulae. The size of the leak can be inferred by the pitch of the leak sound. Large leaks produce low pitched sounds, smaller leaks (or partially obstructed leaks) produce high pitched squeaks , and multiple leaking sites produce polyphonic leak squeaks . The bronchus responsible for the leak can be identified by cessation of the leak sound during balloon occlusion of the correct bronchial stump. A communication of a bronchial fistula with the chest wall facial plane produces massive subcutaneous emphysema and an early inspiratory click. This click suggests a check valve mechanism of air exiting the leaking bronchus

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Abstract: A resurgence of interest in clinical auscultation is in progress. Recent technical advances permit more objective observations than were previously possible. Quantified lung sounds are being correlated with clinical, physiologic, and roentgenologic information. The purpose of this article is to summarize current knowledge on the production, transmission, and clinical significance of lung sounds. The complex sonic signals arising in the lung during respiration reflect its mechanical state. More precise understanding of pulmonary sounds and their clinical correlations could lead to powerful diagnostic tools, which have particular appeal because of their noninvasive nature

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Abstract: We studied 386 workers exposed to asbestos to assess the value of chest auscultation by a trained technician in detecting asbestosis as defined by previously reported clinical, physiologic, and roentgenologic criteria. The presence and degree of crackles were assessed at preselected basilar lung sites by a technician whose performance was validated by comparison with computer-generated time-expanded waveforms of tape recordings of lung sounds. Asbestosis was present in only 2.8% of the total population, but it was present in 8.6% of those with over 25 yr or more of employment. The technician correctly identified all the workers in whom the diagnosis was most certain, that is, those with all criteria positive. The overall true positive rate was 55%. The

majority (94.8%) of those with no abnormal criteria were correctly classified. Auscultation by an objectively validated technician can be a useful noninvasive method for screening industrial populations exposed to asbestos

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Abstract: Descriptions of adventitious lung sounds in the case reports of eight authoritative medical journals from 1978 through 1982 were tabulated in an effort to identify recent changes in terminology. Adventitious lung sounds were described in 590 case reports. During the five years surveyed, there was a decrease in usage of the term, "rales," and an increase in usage of the terms, "crackles" and "wheezes." Usage of the terms, "rhonchi" and "crepitations," did not significantly change in frequency over the five years surveyed; however, when compared to a previous survey, usage of the term, "crepitations," has declined. British journals predominantly use the terms, "crackles" and "wheezes," to describe adventitious lung sounds. Although American journals most often use the terms, "rales," "wheezes," and "rhonchi," the term, "crackles," is increasing in usage

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Abstract: An accurate recording system was set up and used for analyzing normal and asthmatic breath-sound features. Breath sounds are recorded at the trachea simultaneously with the airflow signal at 0.5- and 1-1/s levels. The study was carried out in the frequency domain using a fast- fourier transform (FFT). FFTs are taken on 1,024-sample blocks (one block = 200 ms) over a duration of about 20 s. Different characteristics of the spectra are calculated in the range 60-1,260 Hz for 11 normal and 10 asthmatic subjects. This allows the computation of an index that discriminates (P less than 0.0005) asthma cases from normal cases. Spectral features strongly depend on the flow rate both for normal and asthmatic subjects. Increasing the flow rate raises the high-frequency components of the spectra

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Abstract: We describe and demonstrate a new lung sound measurement and display technique by which contour maps of lung sound intensity may be constructed. Using this technique, we have studied the lower posterolateral chest wall of ten healthy subjects. The data revealed an unexpectedly high degree of intersubject and intrasubject variation. The reason for this variation is obscure but probably relates to the basic mechanisms of production and transmission of lung sounds

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Abstract: We modeled discrete emission of sound from lung parenchyma as a point source in an ideal medium. The point source, a quadrupole, represents the stress anomaly in lung parenchyma in the neighborhood of a collapsed airway, and its time course when the airway opens. The dynamics of the airway opening event are characterized by a single time constant. The ideal medium, lung parenchyma, was modeled as a homogeneous linearly elastic lossless nondispersive continuum of infinite extent undergoing infinitesimal strains. Despite its simplicity, this elementary model leads to predictions of crackle waveforms, spectral densities, and spatial intensity distributions which are consistent with observations. In particular, the model predicts changes of waveform shape and polarity with observation position relative to the source, dramatic influences of transduction processes, and successive increases in zero crossing time intervals

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Abstract: Complications of endotracheal intubation and mechanical ventilation are infrequent but important causes of intraoperative morbidity and mortality. We have developed a simple method of monitoring the ventilation of both lungs during general anesthesia and have evaluated this technique in 25 patients undergoing surgery under general anesthesia. A small plastic electrocardiographic electrode casing fitted with a microphone was affixed to the skin overlying each hemithorax in a location where preliminary auscultation showed that breath sounds could be heard. The sounds from each microphone were amplified and displayed on an oscilloscope screen in an X-Y format. The patterns seen on the screen allowed easy identification of right mainstem intubation, esophageal intubation, or proper endotracheal tube placement. This preliminary study suggests that our technique is feasible and provides more information about the position of the endotracheal tube than presently used methods

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Abstract: The speed of propagation of vesicular lung sound through the lung has not been clearly established. In a recent study (J. Appl. Physiol.: Respirat. Environ. Exercise Physiol. 54: 304-308, 1983), Rice measured the speed of sound through the parenchyma of excised horse lungs and found it to be 25-70 m/s (less than 20% the speed of sound in air). Filling the lung with helium or sulfur hexafluoride changed the speed of transmission by less than 10%, indicating nongas propagation. The present study was designed to measure the speed of sound through human lungs in vivo. Five healthy, nonsmoking males (aged 27-38 yr) were studied. A microphone was placed on the neck beneath the larynx and another at each of eight locations on the chest wall. Measurements were made at functional residual capacity. White noise was band-pass filtered between 125 and 500 Hz, amplified, and delivered to a loudspeaker connected to a mouthpiece. The speed of sound was measured by cross-correlation analysis of the signals simultaneously detected by the tracheal and chest microphones. This was done after breathing both air and a mixture of 80% He in 20% O2 (He-O2). With air, the mean sound- transit time (trachea to chest wall) ranged from 2 ms at the upper chest to 5 ms at the lower chest (speed of approximately 30 m/s). With He-O2 the mean speed increased by only 10%, whereas the predicted increase of sound speed through gas alone would be greater than 100%. These results are consistent with the in vitro findings of Rice and suggest that within the frequency range of vesicular lung sounds transmission of sound introduced at the mouth is predominantly through the lung parenchyma, not through the airways

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Abstract: When a subject exhales forcefully, a wheeze is usually heard during the latter part of the maneuver. The origin and mechanism of this wheeze has been the subject of speculation but this has never been approached experimentally. In this study, a

computerized frequency analysis technique was used to count the number of discrete frequency components making up the forced expiratory wheeze (FEW) in 10 normal subjects. The number varied from 1 to 5 implying a source in the larger airways. The supports previous theoretical considerations that relate the FEW to the so-called "equal pressure point" (EPP) in the larger airways. Since the EPP is thought to be determined principally by lung static recoil pressure, it can be surmised that this also determines (roughly) the number of wheeze components in the FEW

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Abstract: Bond graphs are used to model the acoustic behavior of the respiratory system. The model includes the distributed dynamics of the upper airways while the lower passage generations are represented by "lumping" of resistance and compliance effects. The lower airway representation is terminated with ten lung segments. The model is accurate for frequencies as high as 8500 Hz. The model is currently capable of predicting system eigenvalues as a function of system parameters and geometry for a "nonbreathing" lung. Future plans include modifying the model to include lung segment expansion and contraction as well as turbulence generation at airway bifurcations

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between different laboratories impossible. To avoid these drawbacks we have developed a method based on phonometric principles. Heart sounds of twenty for normal subjects were recorded by an air-coupled microphone with the standard 6 ml cavity. The response curve of the microphone is flat from .2 to 8000 Hz. The signal was measured and stored on an analogic tape recorder together with the ECG. For each subject the 3 weighting networks (A, B and C, according to the American National Standard Institute) and the linear recording (SPL) were used and the peak value of every record was written down in dB-peak. The amplitude spectra were obtained through the FFT algorithm. Normal heart sounds reached a high frequency limit of 170 Hz. with a maximum amplitude of 67 dB SPL, 24 dB A, 42 dB B and 59 dB C. Each spectral pattern can provide a useful reference to compare with pathological acoustical findings

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Abstract: We have developed and tested a portable audiosystem that will allow as many as 14 persons to listen simultaneously to pulmonary and cardiac sounds when an instructor places a central stethomicrophone on a patient's chest. This system facilitates the teaching and learning of chest auscultation on the clinical setting because it (1) helps to ensure that the student hears what the instructor intends, (2) minimizes patient discomfort by allowing everyone in the group to listen simultaneously rather than in groups of two or three in succession, and (3) provides a means of effectively recording sounds at the bedside for future educational purposes

1029. Majumder, A. K. and S. K. Chowdhury. 1981. Recording and preliminary analysis of respiratory sounds from tuberculosis patients. *Med.Biol.Eng Comput.* 19:561-564.

1030. Murphy, R. L. 1981. Auscultation of the lung: past lessons, future possibilities. *Thorax* 36:99-107.
Abstract: Review of the history of auscultation of the lung reveals few scientific investigations. The majority of these have led to inconclusive results. The mechanism of production of normal breath sounds remains uncertain. Hypotheses for the generation of adventitious sounds are unproven. Advances in instrumentation for lung sound recording and analysis have provided little of clinical value. There has been a recent resurgence of interest in lung sounds. Space-age technology has improved methodology for sonic analysis significantly. Lung sounds are complex signals that probably reflect regional lung pathophysiology. If they were understood more clearly important non- invasive diagnostic tools could be devised and the value of clinical auscultation could be improved. A multidisciplinary effort will be required to achieve this

1031. Pardee, N. E., R. H. Winterbauer, E. H. Morgan, and J. D. Allen. 1981. Determination of mortality risk in obstructive pulmonary syndromes: physical examination compared with measurement of forced expired volume in one second. *Thorax* 36:928-931.
Abstract: A standardised physical examination based on four clinical signs was compared with the FEV1 with regard to ability to determine five-year mortality risk in subjects with varying degrees of obstructive airway disease. Both evaluation methods identified low, intermediate, and high risk groups within the population studied. Individuals with no positive physical signs, or with an FEV1 of 70% of predicted or more had mortality not significantly greater than that predicted on the basis of standard mortality tables. There was no difference between the FEV1 and the physical examination in ability to predict mortality

1032. Ploysongsang, Y., J. A. Pare, and P. T. Macklem. 1981. Lung sounds in patients with emphysema. *Am.Rev.Respir.Dis.* 124:45-49.
Abstract: We recorded an index of breath sound intensity (Ib) and the transmission of white noise (Tn) over four lung regions between apex and base in eight subjects with emphysema. The Ib and Tn were recorded over the whole range of lung volume from residual volume to total lung capacity. Each value was expressed as a fraction of the value recorded over the apical region with the help of an analog divider. The ratio of Ib to Tn was computed to correct for differences in Ib due to differences in transmission of sound. The ratio of Ib and Tn was computed to correct for differences in Ib due to differences in transmission of sound. The ratio of Ib to Tn was also expressed as a fraction of the value recorded over the apex. Both Ib and Tn had definite patterns in subjects with emphysema but varied considerably from breath to breath. The Ib and Tn were more reproducible in normal subjects. The magnitude and the sequence of Ib, Tn, and Ib/Tn were also different in subjects with emphysema and normal subjects. The ratio of Ib to Tn is an index of sound production in both normal subjects and subjects with emphysema. We conclude that both production and transmission of breath sounds vary from breath to breath in patients with emphysema. There are areas of both increased and decreased production and transmission of sound. If regional breath sound production (Ib/Tn) is related to regional ventilation in persons with emphysema as in normal subjects, these findings further suggest that regional ventilation varies from breath to breath and is also altered drastically from the normal pattern, leading to a severe ventilation and perfusion inequality so characteristic of emphysematous lungs

1033. Sakula, A. 1981. R T H Laennec 1781--1826 his life and work: a bicentenary appreciation. *Thorax* 36:81-90.
Abstract: Rene Theophile Hyacinthe Laennec was born on 17 February 1781 in Quimper and spent much of his youth in Nantes, where his uncle Guillaume was Dean of the Faculty of Medicine. He was considerably influenced by his uncle and went to study

medicine in Paris where he qualified in 1804. Among his teachers were Corvisart and Bayle who stimulated his interest in the clinical diagnosis of diseases of the chest and especially tuberculosis, from which Laennec himself suffered. His clinical experience and morbid anatomical dissections at the Necker Hospital culminated in his invention of the stethoscope (1816) and the writing of his masterpiece De l'Auscultation Mediate (1819) which may be regarded as the pioneer treatise from which modern chest medicine has evolved. Despite his great success in Paris, laennec always retained a great love for his native Brittany. When his health finally broke down, he returned to his home Kerlouarnec, near Quimper, and died there on 13 August 1826, aged 45 years. On the occasion of the bicentenary of his birth we pay homage to the memory of this great French physician

1034. Shirai, F., S. Kudoh, A. Shibuya, K. Sada, and R. Mikami. 1981. Crackles in asbestos workers: auscultation and lung sound analysis. *Br.J.Dis.Chest* 75:386-396.
Abstract: We surveyed 270 asbestos factory workers and 222 control subjects matched for age to assess the usefulness of listening for fine discontinuous adventitious lung sound (fine crackles) in detection of the early stages of interstitial fibrosis of asbestosis. Fine crackles at both bases were heard more frequently in asbestos workers (32.2%) than in controls (4.5%) (P less than 0.01). The presence of bilateral basal crackles was related to the duration of asbestos exposure and occurred before abnormalities could be detected by chest radiography. Two observers examined 74 workers randomly chosen from among 270 asbestos workers and found inter-observer agreement to be high (91.9%). There was close agreement between findings on chest auscultation and sound recordings

1035. Takezawa, Y., S. Shirai, M. Sawaki, R. Mikami, S. Kudoh, A. Shibuya, and N. Aisaka. 1981. [Acoustic characteristics of 'wheeze' analyzed by sound spectrograph-- in relation to the respiratory phase and transmission]. *Nihon Kyobu Shikkan Gakkai Zasshi* 19:999-1005.

1036. Urquhart, R. B., J. McGhee, J. E. MacLeod, S. W. Banham, and F. Moran. 1981. The diagnostic value of pulmonary sounds: a preliminary study by computer-aided analysis. *Comput.Biol.Med.* 11:129-139.

1037. Arizaga, J. A. A chest wall simulator for use in evaluating pulmonary auscultation microphones. 1980. Massachusetts Institute of Technology; Dept.of Mechanical Engineering.
Ref Type: Thesis/Dissertation

1038. Donnerberg, R. L., C. K. Druzgalski, R. L. Hamlin, G. L. Davis, R. M. Campbell, and D. A. Rice. 1980. Sound transfer function of the congested canine lung. *Br.J.Dis.Chest* 74:23-31.
Abstract: Alterations of sound transfer function of the lung in pre-congested and congested states were studied in a canine model as an index of the accumulation of lung liquids. Pulmonary congestion was produced by graduated inflations of a balloon in the left atrium. Different degrees of pulmonary congestion were documented by post-mortem wet to dry lung weight ratios. Sound transfer function of the lung was determined utilizing passive sound transmission in the audio freqency range consisting of sinusoidal oscillations swept from 50 Hz to 2 kHz. Sound transfer function in dB was defined as 20 times the logarithm of sound output divided by sound input. These functions were computed for pre- congested and congested states of the lung and the differential values correlated with the post-mortem wet to dry weight ratios of the lung. The magnitude of sound transfer function of the lung correlated well with increasing accumulation of intravascular and extravascular lung liquids and provided a quantitative index of pulmonary congestion

1039. Fredberg, J. J., M. E. Wohl, G. M. Glass, and H. L. Dorkin. 1980. Airway area by acoustic reflections measured at the mouth. *J.Appl.Physiol* 48:749-758.
Abstract: We tested the hypothesis that features of upper airway and tracheal geometry can be inferred from acoustic reflection data recorded at the mouth. In six subjects we computed inferences of airway cross-sectional area vs. distance and compared them with measurements obtained from orthogonal radiographic projections of the trachea. The acoustic data show local area maxima at the uvula and hypopharynx and local minima at the oropharynx and the glottis. With subjects breathing air the inferred tracheal areas markedly exceeded the radiographic measurements. With subjects breathing 80% He-20% O2 there was good intrasubject agreement between acoustic and radiographic data in spite of large intersubject variability. The average coefficient of variation of tracheal area determinations for five trials in all subjects was 0.16. These studies suggest that features of airway geometry between the mouth and carina can be determined accurately and noninvasively in individual subjects from high-frequency reflection data measured at the mouth

1040. Ginott, N., E. Barnea, M. Monosevitch, and R. Buncher. 1980. New vacuum stethoscope for immediate monitoring and recording of resuscitation of the newborn. *Isr.J.Med.Sci.* 16:447-451.

Abstract: A new, low-cost, noninvasive system is described, which accurately monitors and records both the initial respirations and heart rate of the neonate during resuscitation and the first critical seconds of life. The apparatus consists of a vacuum stethoscope attached to an ordinary cassette tape recorder and a 12-inch loudspeaker. The system was found to be a more accurate tool for assessing neonatal heart rate than the empirical estimation as part of the Apgar scoring system. In 6 of 37 births monitored, recordings indicated discrepancy between the actual heart rate and that estimated in the Apgar scoring system

1041. Hirschberg, J. 1980. Acoustic analysis of pathological cries, stridors and coughing sounds in infancy. *Int.J.Pediatr.Otorhinolaryngol.* 2:287-300.
Abstract: In the examination of respiratory pathological sound phenomena in infancy (pathological crying, stridor and coughing sounds), besides the subjective-auditive observations and traditional examination methods (X-ray, endoscopy), acoustic analysis, as a new branch of bioacoustics, may be of much help. The various pathological infant vocalizations originating from the air passageways are merely symptoms, but they may furnish important diagnostic clues. Approximately 200 recordings of pathological sound signals derived from 180 infants suffering from 40 different diseases or anomalies were analyzed by means of sound spectrography, the fundamental frequency meter, and rarely, the minimal-time-interval spectra technique. The acoustical evaluation of the sound phenomena are not only of scientific and documentative value; they are also of great help in diagnostics and prophylaxis, in the suitable choice of diagnostic tools and in education and further training, i.e. in the everyday work of the pediatric otolaryngologist

1042. Huang, S. M. An instrumentation system for quantitative studies of respiratory sounds. 1980. MICHIGAN STATE UNIVERSITY.
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1043. Jackson, A. C. 1980. Serial distribution of airway geometry from acoustic impedance data. *Fed.Proc.* 39:2741-2746.
Abstract: Cross-sectional areas of airways vary with distance from the airway opening to alveoli. Existing techniques for estimating the serial distribution of airway cross section are invasive or depend on interpretations of indirect measurements. A rapid, noninvasive technique based on acoustic impedance data for estimating airway cross section as a function of distance has been described. Cross-sectional areas returned by this technique from measurements in a positive cast of human central airways out to subsegmental bronchi corresponded closely with areas determined from direct measurements. In vagotomized dogs, measurements indicate that vagal stimulation results in reduction of airway cross section at all distances, whereas histamine aerosol caused bronchoconstriction only at larger distances (i.e., peripheral airways). Vagotomy in the dog results in an apparent dilation in most airways to areas twice those in the control state. This increase in airway cross section is larger than has been reported previously. Measurements in humans indicate an apparent overestimation in tracheal cross-sectional areas. These findings might be caused by overestimations in area due to airway wall compliance in the intact human and in the dog without vagal tone. This technique may still be capable of providing useful information about the serial distribution of airway properties

1044. Jackson, A. C. and D. E. Olson. 1980. Comparison of direct and acoustical area measurements in physical models of human central airways. *J.Appl.Physiol* 48:896-902.
Abstract: Total cross-sectional areas were computed from direct measurements made on two human central airway casts. Acoustic pulse-response measurements were obtained on rigid-walled positive replicas of these casts. From the acoustic response data of each cast, we computed the area-distance function of the acoustically equivalent structure (i.e., the structure with regular branching and negligible viscous losses, but with similar acoustic properties). The acoustic data predicted equivalent areas that compared favorably to the total cross-sectional areas in the casts at all points from the beginning of the trachea to distances about 6 cm beyond the carina corresponding to airways of the third, fourth, or fifth generation. These results indicate that, at least in the central airways, branching asymmetry and internal energy losses introduced negligible errors in estimates of cross-sectional areas derived from acoustic pulse-response measurements. This rapid noninvasive technique thus shows promise as a method of detecting upper and central airway obstruction

1045. Kraman, S. S. 1980. Determination of the site of production of respiratory sounds by subtraction phonopneumography. *Am.Rev.Respir.Dis.* 122:303-309.
Abstract: The site of origin of the vesicular lung sound has long been in question. A technique (subtraction phonopneumography) is described here for determining the relative distance of a sound source from the chest wall. This technique involves the simultaneous recording of lung sounds from two different sites on the chest wall, phase inversion of one of the signals, and then mixing the signals in a summing amplifier. The degree of cancellation that results is inversely proportional to the number of sources and the degree to which each source is detected by both microphones simultaneously. A study of six normal subjects revealed little or no cancellation of inspiratory vesicular sounds with microphones separated by 10 cm. During expiration, cancellation did occur at distances well beyond 10 cm and was detectable over several homologous segments of opposite lungs. This finding is consistent with an intrapulmonic and probably intralobar source for the inspiratory component and an upper airway source for at least some of the expiratory component

1046. Krumpe, P. E. and J. M. Cummiskey. 1980. Use of laryngeal sound recordings to monitor apnea. *Am.Rev.Respir.Dis.* 122:797-801.
Abstract: Laryngeal sounds are produced by air flow across the glottis. We found that apnea could be identified by the cessation of laryngeal sounds during continuous monitoring. We recorded laryngeal sounds using a microphone coupled to a stethoscope head taped to the subject's lateral neck. This signal was conditioned using a commercially available amplifier and displayed on a time-based recorder. Laryngeal sound monitoring of apnea could be useful in sleep studies

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1049. Mimca, M., M. Pavlovic, and M. Malinar. 1980. [The significance of auscultation in the detection of chronic obstructive bronchopulmonary disease]. *Acta Med.Iugosl.* 34:231-242.

1050. Mori, M., K. Kinoshita, H. Morinari, T. Shiraishi, S. Koike, and S. Murao. 1980. [Origin of crackles--studied by waveform and spectral analysis (author's transl)]. *Nihon Kyobu Shikkan Gakkai Zasshi* 18:171-179.

1051. Mori, M., K. Kinoshita, H. Morinari, T. Shiraishi, S. Koike, and S. Murao. 1980. Waveform and spectral analysis of crackles. *Thorax* 35:843-850.
Abstract: Crackles were recorded from six patients, four with tuberculosis and two with chronic bronchitis. It was observed by waveform and spectral analysis that most of the frequency components of a crackle were limited within a range of 0.1 to 1 kHz. Characteristically, waveforms of crackles were separable into two segments, initial "starting segments" and subsequent "decay segments." It is suggested that the former represents a shock wave caused by an abrupt opening of the airway and that the latter is a damped sinusoid caused by this shock wave exciting a resonator in the lung. It is speculated that the starting segment is determined by the pressure ratio at the site of the airway opening, and the decay segment by the resonant frequency and the quality factor of the resonator. Because transmission of a crackle is highly directional the waveforms recorded on the chest wall are modified by the positional relationship between the sound source and the microphone

1052. Nath, A. R. and L. H. Capel. 1980. Lung crackles in bronchiectasis. *Thorax* 35:694-699.
Abstract: The inspiratory timing of lung crackles in patients with bronchiectasis was compared with the inspiratory timing of the lung crackles in chronic bronchitis and alveolitis. In severe obstructive chronic bronchitis the lung crackles are typically confined to early inspiration while in alveolitis the lung crackles continue to the end of inspiration but may begin in the early or the mid phase of inspiration. In uncomplicated bronchiectasis on the other hand, the lung crackles typically occur in the early and mid phase of inspiration, are more profuse, and usually fade by the end of inspiration. In addition in bronchiectasis, crackles are also usually present in expiration, they are gravity independent and become less profuse after coughing

1053. Nemerovskii, L. I. 1980. [Analysis of a pulmophonogram for assessing local pulmonary ventilation]. *Med.Tekh.*39-44.
Abstract: The method offered for pulmophonogram processing is based on definition of an easily measured simplest parameter, a relation between maximum and minimum values of the electrical signal being recorded. This value measured under different clinical conditions without considerable methodical errors is used for reliable and precise assessment of three parameters: relative local specific ventilation, relative local specific volume and local specific lung ventilation capacity. The proposed formulas of the local respiration parameters can be applied in both manual pulmophonogram processing with elementary computing aids, and in computer processing of pulmophonographic information

1054. Oster, G. and J. S. Jaffe. 1980. Low frequency sounds from sustained contraction of human skeletal muscle. *Biophys.J.* 30:119-127.
Abstract: Low frequency audible vibrations are produced by human skeletal muscles undergoing sustained contraction. The effect is easily demonstrable with an electronic stethoscope which amplifies sound below 50 Hz. Autocorrelation analysis of the signal shows that it is periodic with a frequency 25 +/- 2.5 Hz. The quality of the sound is the same for all the skeletal muscles tested and is unaffected by changes in tension, ambient temperature, and blood flow. Electrically-stimulated contraction produces a sound which is indistinguishable from voluntary contraction. The amplitude of the sound increases linearly with tension. The sound signals are uncorrelated both in frequency and phase with electromyographic signals obtained simultaneously while the muscle is contacted. Arguments are presented to show that the sounds may be an intrinsic property of muscle contraction

1055. Rice, D. A. 1980. Sound speed in the upper airways. *J.Appl.Physiol* 49:326-336.
Abstract: We measured the velocity of audible sound at frequencies above 10 kHz to be 349 m.s-1 (+/- 1%, 95% confidence interval) in the upper airways of eupneic anesthetized dogs. It appears that the velocity of sound propagation is dependent on lumen gas composition, temperature, and mean flow speed. These three variables are sufficient to explain the velocity variations measured during tidal breathing. Lung volume, transpulmonary pressure, and bronchoactive drugs were not shown to have an appreciable effect on sound velocity. Model studies indicate that sound velocity is little affected by flow profile, lumen cross-sectional shape, or changes in lumen area with position. Flow speed proportionally changes the velocity of sound relative to the airway and therefore can be determined from sound propagation measurements. Dividing volume flow by flow speed gives airway cross-sectional area. Tracheal areas after normalization by the cube root of body weight were about half those previously reported. Acoustically inferred areas were confirmed by mechanical measurement

1056. Andrews, J. L., Jr. and T. L. Badger. 1979. Lung sounds through the ages. From Hippocrates to Laennec to Osler. *JAMA* 241:2625-2630.

1057. Bunin, N. J. and R. G. Loudon. 1979. Lung sound terminology in case reports. *Chest* 76:690-692.
Abstract: Terms used to describe lung sounds in published case reports were tabulated, including qualifying adjectives. Seven journals were reviewed, and a total of 663 case reports were included. From the frequency of usage and similarity of qualifying adjectives it appears that "rales" and "crepitations" are equivalent terms. Many authors feel the need to qualify "rales": sixteen descriptive adjectives were encountered. Some authors distinguish between "rhonchus" and "wheeze," but the terms, for most, appear to mean the same thing. It is evident that current usage varies widely, even in the terminology of the basic categories of sounds

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1059. Longhini, C., F. Portaluppi, E. Arslan, and F. Pedrielli. 1979. The fast Fourier transform in the analysis of the normal phonocardiogram. *Jpn.Heart J* 20:333-339.
Abstract: The present study is focused on spectrum analysis as a useful method of processing the PCG in order to obtain the frequency spectral distribution of normal heart sounds. Thirty normal subjects aged from 17 to 34 were studied. PCG was recorded on the fourth intercostal space at the left sternal border using a sound level meter coupled with a standard 6 ml cavity. The microphone had a linear response from 0.2 to 8,000 Hz. The signal was filtered with the standard B network according to the ANSI specifications and was registered on a four track FM tape recorder. A four channel analyzer with a microprocessor for off-line elaborations was used with 10 KHz sampling frequency. The PCG signal was triggered by a QRS detector on the R wave of the simultaneously recorded ECG. Fast Fourier transform was performed employing either a four channel analyzer with a microprocessor, or an A/D converter with a computer. Finally the results of the analysis were statistically elaborated. The described procedures permit to obtain a direct and exact tracing of the acoustic features of the heart, thus representing an attempt to come closer to the standardization and automatic analysis of the phonocardiographic technique

1060. Marini, J. J., D. J. Pierson, L. D. Hudson, and S. Lakshminarayan. 1979. The significance of wheezing in chronic airflow obstruction. *Am.Rev.Respir.Dis.* 120:1069-1072.
Abstract: Eighty-three patients with chronic airflow obstruction were examined prospectively to determine the relationships among wheezing intensity, severity of obstruction, and response to inhaled isoproterenol. For each patient, expiratory wheezing scores were assigned during deep unforced breathing and during forced vital capacity efforts at spirometry. Unforced wheezing scores were independently correlated with severity of obstruction (r = 0.42) and bronchodilator response (r = 0.46), but these correlations did not permit consistent prediction of either variable for clinical purposes. The highest wheezing scores, however, were uniformly associated with moderate or severe obstruction. Twenty-nine of 48 patients with wheezing but only 3 of 35 patients without wheezing demonstrated 15% or greater improvement in one-second forced expiratory volume after bronchodilator inhalation (p less than 0.001). Wheezing during forced exhalation was not correlated with either degree of obstruction or bronchodilator response

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Abstract: We measured phase and amplitude of compensated breath sounds (Ib/Tn), which are indexes of regional ventilation, with two microphones placed near the apex and base 10 cm apart on the chest wall, lateral to the right anterior axillary line in four seated normal subjects. We compared phase and amplitude of Ib/Tn with phase and amplitude of esophageal pressure changes (Pes) measured by two balloons positioned 10 cm apart and at approximately the same horizontal levels as the microphones. When breathing tidally below closing volume (CV), apical Ib/Tn was louder and earlier than basal Ib/Tn, whereas basal Pes was

greater and earlier than apical Pes. Above CV basal Ib/Tn was louder than apical and the phase differences either disappeared or followed phase differences in PES. The results suggest that below CV, ventilation of lower zones lags behind upper ones probably due to airway closure. Pes measurements indicate that this may lead to an amplification of pleural pressure swings at the base. Above CV, all airways are open, the ventilation of lower zones is greater than that of upper zones, and the sequence of ventilation follows the sequence of pleural pressure changes

1062. Renzetti, A. D., Jr. 1979. Lung sound terminology [editorial]. *Chest* 76:615-616.

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Ref Type: Video Recording

1064. Trainex Corporation. Adventitious breath sounds. 1979. Trainex Corporation.
Ref Type: Audiovisual Material

1065. Attenburrow, D. P. 1978. The development of a radio-stethoscope for use in the horse at rest and during exercise. *Equine Vet.J.* 10:14-17.
Abstract: The development of a radio-stethoscope for horses is described. The equipment consisted of a sound transducer applied to the skin adjacent to the trachea and a radio transmitter attached to the saddle. The signals emitted were detected by telemetry and recorded on a magnetic tape-recorder. The recorder incorporated a monitor earphone so that sounds could be reproduced at the time of recording. The frequency response obtainable ranged from a few Hz to 4 KHz. This technique provided an objective means of studying the respiratory sounds generated during exercise although absolute values could not be measured

1066. Attenburrow, D. P. 1978. Respiratory sounds recorded by radio-stethoscope from normal horses at exercise. *Equine Vet.J.* 10:176-179.
Abstract: A graphic representation is presented of respiratory sounds recorded by a radio-stethoscope from normal horses exercised at the walk, trot, canter and gallop. Methods whereby inspiratory and expiratory sounds were distinguished are discussed. The form of amplitude envelopes of the sounds recorded at different gaits are compared. Certain measurements of relative amplitudes and the form of amplitude envelopes of the recorded respiratory sounds can be recognised as typical of normal horses when exercised at the canter and gallop. The influence of some physiological events (e.g. deglutition on the rhythm of normal respiration at the canter and gallop) is indicated

1067. Bohadana, A. B., R. Peslin, and H. Uffholtz. 1978. Breath sounds in the clinical assessment of airflow obstruction. *Thorax* 33:345-351.
Abstract: In a group of 34 inpatients showing varying degrees of airflow obstruction we studied the relationship between breath sound intensity (BSI) and abnormalities of lung function. The BSI was evaluated by chest auscultation to provide a score, in a manner similar to that described by Pardee et al. (1976), and was found to correlate closely with indices of airflow obstruction of their logarithms such as specific conductance (r = 0.759), maximal expiratory flow at 50% of vital capacity (r = 0.790), forced expiratory volume in one second (r = 0.768), and forced expiratory volume to vital capacity ratio (r = 0.860). Correlations with lung volumes, although statistically significant, were weaker. Multiple correlation studies showed that BSI score correlated independently with indices of both airflow obstruction and lung distension. In our experience, BSI score can be useful not only in the detection but also the quantification of airflow obstruction, although its predictive power is impaired in subjects with associated restrictive disorders. It can also fail to detect mild, pure airflow obstruction

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1069. Crutcher, James C. and Emory University.School of Medicine. The Examination of the chest and lungs. 1978. Emory University, School of Medicine, Woodruff Medical Center.
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1070. Cugell, D. W. 1978. Sounds of the lungs [editorial]. *Chest* 73:311-312.

1071. deLeon, A. C., Jr., W. P. Harvey, D. Canfield, and E. Johnson. 1978. Group teaching of auscultation. Use of a new wireless stethoscope-type headphone. *Am.J.Cardiol.* 41:333-335.

Abstract: A new technique using infrared light for the transmission of heart sounds and murmurs is described. This method enables the simultaneous transmission of heart sounds and murmurs to large groups of persons without the need for hard-wire connections to the amplifying device. The method facilitates teaching of cardiac auscultation at the bedside as well as in the setting of conferences, seminars or postgraduate education programs

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Ref Type: Audiovisual Material

1073. Epler, G. R., C. B. Carrington, and E. A. Gaensler. 1978. Crackles (rales) in the interstitial pulmonary diseases. *Chest* 73:333-339.
Abstract: There is renewed interest in the classification and methods of recording adventitious pulmonary sounds. This is a study of the importance of fine crackles (rales) in the diagnosis and estimation of the severity of diffuse infiltrative pulmonary disease. Among 272 cases documented by lung biopsy, bilateral fine crackles were heard in 60 percent of those with interstitial pneumonias and asbestosis but in only 20 percent of those with sarcoidosis and other granulomatoses. These incidences were identical in 335 patients diagnosed clinically. In 322 selected ambulatory patients with chronic obstructive pulmonary disease, fine crackles were recorded in only 10 to 12 percent, while coarse crackles were not uncommon in patients with chronic bronchitis. In workers exposed to asbestos, crackles correlated with exposure. In serial studies of such workers, the occurrence of crackles alone appeared to be a random event, while among those with crackles together with one other of five criteria, almost one-half developed asbestosis within four to six years. Fine crackles correlated with pathologic severity, with radiographic honeycombing, and with physiologic abnormalities

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1075. Forgacs, P. 1978. The functional basis of pulmonary sounds. *Chest* 73:399-405.

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1077. Fredberg, J. J. and J. A. Moore. 1978. The distributed response of complex branching duct networks. *J.Acoust.Soc.Am.* 63:954-961.
Abstract: We describe an efficient method for stimulating the distributed response of complex asymmetrically branching networks which satisfy requirements of network self-consistency. Individual tree links may be dispersive and lossy. As a case in point we simulate the response of the human lung, and characterize the variations in pressure with frequency, path, and position. The effects of tree asymmetry are found to be significant above 100 Hz in the air-filled lung

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Ref Type: Thesis/Dissertation

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Ref Type: Video Recording

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