24th INTERNATIONAL LUNG SOUNDS CONFERENCE

MARBURG, GERMANY - OCTOBER 6 - 8, 1999

Conference Location: Institute of Physiology,

Deutschhausstr. 1, 35033 Marburg

PROGRAM

Mit Unterstützung der Deutschen Forschungsgemeinschaft

und der

Deutschen Gesellschaft für Pneumologie

The 24th INTERNATIONAL CONFERENCE ON LUNG SOUNDS

Presented by

International Lung Sound Assocation

October 6-8, 1999

Marburg, Germany

FINAL PROGRAM AND ABSTRACTS

ORGANIZATION

President	Prof. Peter von Wichert
Chairman:	Raymond L.H. Murphy, M.D.
Co-Chairman:	Robert Loudon, M.D.
Executive Committee:	Noam Gavriely, M.D.
	Steve Kraman, M.D.
	Shoji Kudoh, M.D.
	Hans Pasterkamp, M.D.
	Anssi Sovijarvi, M.D.

The 24th Conference President

Prof. Peter von Wichert — Pulmonary and Crit. Care Med.
Philipps-Univ. Marburg,
Germany

Local Organizing Committee

Address of the International Lung Sound Association

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GENERAL INFORMATION

Conference Venue
Institute of Physiology, Deutschhausstr, Marburg

Official Language
English

Registration and secretariat during the conference
Registration will be held at the Institute on Wednesday, October 6, 1999 from 14:00 - 15:00 hours
Registration will also be held on Thursday morning From 9:00 - 9:15 am

Registration fees
Participants $200, spouses/companions $100, scholarship Recipients $100

Certificate of attendance
Participants, duly registered, will receive a certificate Of attendance upon request

Demonstration/Posters
Posters will be on display in the conference room after 8:45 am on Friday, October 6th. The poster discussion will begin at 14:00 hours. An oral presentation of five minutes and a also discussion period of five minutes is scheduled for each poster.

Breakfast, lunch and coffee
A Continental breakfast is available in the hotel for guests. Lunch and coffee are included in the registration fee of active participants at the Institute on October 7th and 8th.

Reception
On October 6th, a reception will be held in the Hotel Sonne at 19:00 hours to welcome the participants and their companions

Farewell Party
This will take place at the restaurant 'Bückings Garten" in Landgraf-Philipp-Str.6, Marburg

Sponsors

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Medilab, Würzburg
Pfizer, Karlsruhe

The 24th International Conference on Lung Sounds
Marburg, Germany   October 6-8, 1999

Authors Index

H. Abrons	A. Avital	P. Barnes
R. Beck	L. Bentur	K. Bergstrom
M. Berman	A. Boonstra	C. Camps
B. Celli	J. Chang	B. Cheetham
W. Cheng	S. Choh	K. Chung
S. Dahnov	F. Dalmasso	F. Davidson
V. Didonna	J. Earis	P. Fachinger
D. Frazer	K. Friend	M. Fröhlich
N. Gavriely	L. Glebova	S. Godfrey
W. Goldsmith	M. Greenburg	V. Grinchenko
L. Hadjileontiadis	S. Hananya	Y. Hashimoto
M. Hino	M. Ho	T. Imai
T. Imai	Y. Inabao	C. Irving
S. Ishikawa	E. Isnardi	E. Israel
T. Iwanaga	T. Jones	KMAT Clinical Coord
K. Komeda	V. Krizhanovsky	S. Kudoh
S. Lim	R. Loudon	K. MacDonell
A. Makarenkow	R. Mantovano	J. Marquina
V. Maydannik	W. McKinney	H. Melbye
M. Mori	A. Murata	M. Murphy
R. Murphy	H. Nakano	N. Narita
S. Nishima	N. Noviski	V. Oliynik
S. Panas	H. Pasterkamp	T. Penzel
E. Petsonk	A. Pohlman	P. Postmus
V. Power	N. Rec	J. Reynolds
G. Righini	P. Righini	M. Rotschild
A. Rudnickiy	F. Sakao	C. Saragiotis
H. Sato	A. Schwartz	S. Sehati
A. Shibuya	B. Shinaui	K. Shirota
S. Shoji	J. Smith	T. Soma
C. Springer	J. Sulzer	Y. Suzuki
Y. Takasaki	M. Takase	H. Tanahashi
K. Tomoda	K. Uwyyed	I. Vovk
H. Watanabe	S. Watkins	P. v. Wichert
D. Young	J. Yuan	

ILSA CONFERENCES - LIST OF PRESIDENTS

1^{ST} - Oct. 1976 - Boston, MA - Raymond Murphy
2^{nd} - Sept. 1977 - Cincinnati, OH - Robert Loudon
3^{rd} - Sept. 1978 - New Orleans, LA - William Waring
4^{th} - Sept. 1979 - Chicago, IL - David Cugell
5^{th} - Sept. 1980 - London, England - Leslie Capel & Paul Forgacs
6^{th} - Oct. 1981 - Boston, MA - Raymond Murphy
7^{th} - Oct. 1982 - Martinez, CA - Peter Krumpe
8^{th} - Sept. 1983 - Baltimore, MD - Wilmot Ball
9^{th} - Sept. 1984 - Cincinnati, OH - Robert Loudon
10^{th} - Sept. 1985 - Tokyo, Japan - Riichiro Mikami
11^{th} - Sept. 1986 - Lexington, KY - Steven Kraman
12^{th} - Sept. 1987 - Paris, France - Gerard Charbonneau
13^{th} - Sept. 1988 - Chicago, IL - David Cugell
14^{th} - Sept. 1989 - Winnepeg, Canada - Hans Pasterkamp
15^{th} - Oct. 1990 - New Orleans, LA - David Rice
16^{th} - Sept. 1991 - Veruno, Italy - Filiberto Dalmasso
17^{th} - Aug. 1992 - Helsinki, Finland - Anssi Sovijarvi
18^{th} - Aug. 1993 - Alberta, Canada - Ralphael Beck
19^{th} - Sept. 1994 - Haifa, Israel - Noam Gavriely
20^{th} - Oct. 1995 - Long Beach, CA - Christopher Druzgalski
21^{st} - Sept. 1996 - Chester England - John Earis
22^{nd} - Oct. 1997 - Tokyo, Japan - Masashi Mori
23^{rd} - Oct. 1998 - Boston, MA - Sadamu Ishikawa
24^{th} - Oct. 1999 - Marburg, Germany - Prof. Peter von Wichert

PROGRAM

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Wednesday, October 6

14:00 - 15:00	Registration
15:00 - 17:00	Acoustic Aspects of Asthma Chairperson - Raymond Murphy, M.D. Panel Members: N. Gavriely, S. Godfrey, R. Loudon, H. Pasterkamp
17:00 - 17:45	Guest Lecture - Advances in Biological Signal Processing - Thomas Penzel, Ph.D.
19:00	Reception and Dinner - Hotel Sonne, Markt 14

Thursday, October 7

9:00	Registration
9:15	Welcoming Addresses

Scientific Session A

Chairpersons: F. Dalmasso/A. Sovijarvi

9:30 - 9:45	Tracheal Whistles - A New Physical Sign of Airway Constriction - N. Gavriely, C. Irving

9:45 - 10:00	Auditory Click Detection in Breath Sounds - M. Greenberg, K. Shirota, H. Pasterkamp
10:00 - 10:15	Acoustic Analysis of Snoring in Patients Undergoing Palatoplasty - T. Jones, MS Ho, B. Cheetham, J. Earis
10:15 - 10:30	Best Method to Study Airflow - Breath Sound Relation - K. Shirota, M. Greenberg, H. Pasterkamp
10:30 - 11:00	Break
11:00 - 11:15	Upside Down Lung Sounds - R. Murphy
11:15 - 11:30	Sensitivity of Acoustic Attenuation to Lung Parenchyma Change - A. Pohlman, S. Sehati, D. Young
11:30 - 11:45	Relationship Between Hysteresis and Crackles in Control and Tween 20-Rinsed, Excised Rat Lungs - D. Frazer, W. Cheng, E. Petsonk
11:45 - 12:00	Wavelet Transformation for Diagnosis of Pneumonia - V. Gross, P. Fachinger, M. Fröhlich, J. Sulzer, T. Penzel, P. v. Wichert
12:00 - 12:20	Photo
12:20 - 13:30	Lunch

Scientific Session B

Chairpersons: N. Gavriely/P. von Wichert

13:30 - 13:45	An Improved System for Measuring Breath and Cough Sounds - W. Goldsmith, K. Friend, W. McKinney, J. Reynolds, D. Frazer, J. Smith
13:45 - 14:00	A System for Reconstruction of Cough Sounds and Cough Sound Components - J. Reynolds, W. McKinney, K. Friend, W. Goldsmith, D. Frazer

14:00 - 14:15 Wheeze Duration in Cough Sounds for Disease Characterization - K. Friend, W. Goldsmith, W. McKinney, J. Reynolds, S. Watkins, E. Petsonk, H. Abrons, D. Frazer

14:15 - 14:30 Quantitative Documentation of Wheezers in Asthma Clinics Using an Automatic Wheeze Quantification Device - S. Lim, N. Gavriely, C. Irving, K.F. Chung, P.J. Barnes

14:30 - 14:45 Break

14:45 - 15:00 Microphone-Based Accelerometers for Lung Sound Recording - F. Sakao, H. Sato, M. Mori

15:00 - 15:15 Discrimination of Lung Sounds Using Higher-Order Crossings - L. Hadjileontiadis, C. Saragiotis, S. Panas

15:15 - 15:30 Methacholine Bronchial Challenge Performed by a Modified Auscultation Method in Young Children - C. Springer, S. Godfrey, K. Uwyyed, M. Rotschild, S. Hananya, N. Noviski, A. Avital

15:30 - 15:45 Lung Sound Analysis in Evaluation of Airway Lability in Asthmatic Children - M. Takase, Y. Inaba, T. Imai, T. Imai

15:45 - 16:00 Use of Respirogram in Diagnosis of Respiratory Organ Diseases in Children - V. Maydannik, V. Grinchenko, L. Glebova, A. Makarenkow, A. Rudnickiy

16:00 - 16:15 Acoustic Nocturnal Monitoring of Pediatric Patients - Methods and Practice - R. Beck, L. Bentur, C. Irving, N. Gavriely, KMAT Clinical Coordinators

16:15 - 16:30 Acoustic Bronchial Provocation Tests in Asthmatic Children - B. Shinaui, R. Beck, L. Bentur, C. Irving, N. Gavriely

Friday, October 8

Scientific Session C

Chairpersons: S. Ishikawa/S. Kudoh

9:00 - 9:15	Change of Respiratory Sounds in Patients with Acute Attacks of Bronchial Asthma Treated with Non Invasive Positive Pressure Ventilation - Y. Hashimoto, A. Murata, T. Soma, M. Hino, Y. Takasaki, S. Kudoh
9:15 - 9:30	Detection of Respiratory Effort During Obstructive Apnea by Tracheal Sounds Analysis - H. Nakano, T. Iwanaga, S. Shoji, S. Nichima,
9:30 - 9:45	Acoustical Bronchial Provocation Tests in Asthmatic Adults - E. Israel, C. Irving, J. Chang, N. Gavriely
9:45 - 10:00	Analysis of Acoustic Features of the Tracheal Sounds in Patients with Bronchial Stenosis - Effect of the Height of a Pillow - S. Choh, Y. Suzuki, K. Tomoda, K. Komeda, H. Watanabe, A. Shibuya, H. Tanahashi, S. Kudoh, A. Murata, N. Narita
10:00 - 10:15	Break
10:15 - 10:30	Comparison of the Interpretation of Chest Roentgenograms and Lung Sound Waveforms in Chronic Obstructive Lung Disease - M. Murphy, V. Power, K. Bergstrom, M. Berman, R. Murphy
10:30 - 10:45	Dynamics of Changes in Acoustical Characteristics of Respiratory Tract of Pneumonic Patients in Process of Treatment - I. Vovk, V. Grinchenko, S. Dahnov, V. Krizhanovsky, V. Oliynik
10:45 - 11:00	Acoustic Properties of Rhonchi - N. Gavriely

11:00 - 11:15 The Relationship of Lung Sound Amplitude and Tidal Volume During Positive Pressure Ventilation - F. Davidson, V. Power, N. Rec, A. Schwartz, R. Murphy

11:15 - 12:00 - Guest Lecture - Philosophy of Measurement - Peter Janich, Prof. of Philosophy, Phillipps-Univ. of Marburg

12:00 - 13:30 Lunch

13:30 - 14:00 Business meeting

Scientific Session D

Chairpersons: M. Murphy/H. Pasterkamp

Poster Discussion

14:00 - 14:10 Lung-Sound Analysis of Bronchial Breathing in Patients with Pneumonia - P. Fachinger, V. Gross, M. Frohlick, J. Sulzer, T. Penzel, P. v. Wichert

14:10 - 14:20 Learning Lung-Auscultation via Intranet, A Multimedia Junior-Doctor-Teaching Project - J. Yuan, C. Camps, P. Postmus, A. Boonstra

14:20 - 14:30 Relations Between Normal Lung Sounds and Subcutaneous Fat Layer on the Back - M. Frohlick, V. Gross, P. Fachinger, T. Penzel, P. v. Wichert

14:30 - 14:40 Acoustic Features of Psychogenic Cough: Case Report - F. Dalmasso, P. Righini, R. Mantovano

14:40 - 14:50 A Cough Monitoring System Based on a Portable Phono-Meter - F. Dalmasso, G. Righini, P. Righini, V. Didonna, E. Isnardi

14:50 - 15:00 Wheezers and Nonwheezers - S. Ishikawa, J. Marquina, K. MacDonnell, B. Celli

15:00 - 16:00	Lung Sounds and Lung Function - An Educational Video - H. Melbye
16:00 - 16:30	Conference Summary - John Earis
16:30	Closing Remarks - Raymond Murphy
17:00	Steering Committee Meeting
19:00	Farewell Party - Restaurant "Bückings Garten" Landgraf-Philipp-Str.6, Marburg

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12:20 - 13:30	Lunch

TRACHEAL WHISTLES – A NEW PHYSICAL SIGN OF AIRWAY CONSTRICTION

Noam Gavriely* and Charles S. Irving
Karmel Medical Acoustic Technologies Ltd. Yokneam Illit, Israel 20695

We describe a new class of wheezes that are only detectable over the trachea and have a frequency range that is too high (i.e. 1500 to 4000 Hz) to be detected by stethoscopic auscultation. We propose the term “Respiratory Whistles” to describe this new kind of Continuous Adventitious Breath Sounds.

Methods. Contact phonopneumography (PPG) sensors with broad frequency response (50 to >4,000 Hz) were applied with adhesive pads over the tracheae of 45 asthmatic patients during regular clinic visit (n=12) and during methacholine bronchial provocation test (BPT) (n-33). The whistles were detected by an automatic wheeze detection device (PulmoTrack® Model 1010, Karmel Medical, Yokneam Illit, Israel) and were confirmed by playback of recorded sounds to expert physicians.

Results. Respiratory whistles were found in 27 (60%) of the asthma patients during bronchoconstriction. Whistles were not present in non-asthmatics. Whistles were not present in the asthmatics when they were not bronchoconstricted, and they disappeared after administration of inhaled bronchodilator (Albuterol). Whistles differ from wheezes by their properties as outlined in the Table:

Property	Wheezes	Whistles
Frequency range	< 1500 Hz	>1500 Hz
Location	Trachea and chest wall	Only over trachea
Duration	Long, 0.4 to 2 sec	Short, < 0.4 sec
Timing	Throughout the breath	Beginning and end
Frequency Dependence on flow rate	Stable frequency with minor changes	Frequency increases with flow rate
Frequency stability	Stable frequency	High frequency variability
Airways status	Substantial constriction	Mild constriction

Discussion. Respiratory whistles constitute a new physical sign of bronchoconstriction. They are distinctly different from wheezes and are probably generated by a different mechanism that is not related to flow-limitation (e.g. phased-locked turbulent shedding of eddies). Respiratory whistles are detected only over the tracheae of bronchoconstricted subjects when broad frequency acoustic sensors are used.

* This study was conducted while Prof. Gavriely was on Sabbatical leave from the Technion – Israel Institute of Technology. The authors have a financial interest in Karmel Medical Ltd.

AUDITORY CLICK DETECTION IN BREATH SOUNDS

Matthew Greenburg †, Kazuhiko Shirota§, and Hans Pasterkamp
Acoustic Research Unit, Section of Respirology, Dept. of Pediatrics and Child Health, University of Manitoba, Winnipeg, Canada

Computerized analysis of respiratory sounds requires a reliable identification of impulse noises (clicks, crackles). We questioned the use of human auditory perception as the reference standard for this identification. To determine the threshold of audibility for crackles in breath sounds, we used a MATLAB routine that generated spike patterns and superimposed these on recorded breath. The width of the spikes was chosen within the range reported for fine to coarse crackles (1,2). They were superimposed during the first, second, or third part of inspiratory tidal volume, corresponding to early, mid, or late inspiratory crackles. Two experienced listeners were asked to identify low amplitude spikes superimposed on sounds that were recorded during breath hold. The lowest audible spike amplitude was used as the reference for spikes superimposed on inspiratory breath sounds. Our analysis of loudness perception and temporal resolution followed standard signal detection theory (3). Masking effects of inspiratory breath sounds were observed and suggest that slow inspiratory manoeuvres which generate little breath sound should be used to detect fine inspiratory crackles in lung disease. Details of audibility relative to spike and breath sound characteristics will be presented. Our data should provide important information for the development of automated crackle detection routines required in computerized lung sound analysis (4).

References

(1) J. Hoevers and G. Loudon, Measuring Crackles, *Chest* 1990; 98:1240-43

(2) M. Munakata, H. Ukita, I. Doi, Y. Ohtsuka, Y. Masaki, Y. Homma and Y. Kawakami. Spectral and waveform characteristics of fine and course Crackles, *Thorax* 1991; 45:651-657

(3) B. Moore. An Introduction to the Psychology of Hearing, 3 ed. Academic Press, Longon 1992

(4) A. Sovijarvi, P. Helistö, L. Malmberg, K. Kallio, E.Paajanen, A. Saarinen, P. Lipponen, S. Haltsonen, L. Pekkanen, P. Piirilä, L. Näveri and T. Katila, A new versatile PC based lung sound analyser with automiatic crackle analysis (HeLSA); repeatability of spectral parameters and sound amplitude in health subjects, *Technology and Health Care* 1998; 6:11-22

† M. Greenberg is supported by the Children's Hospital Foundation of Manitoba
§ K. Shirota is supported by the Manitoba Lung Association

Acoustic Analysis of Snoring in Patients Undergoing Palatoplasty

T. Jones*, MS Ho**, BMG Cheetham**, JE Earis*
*Aintree Chest Centre, University Hospital, Aintree, Liverpool
**Dept. Computer Science, University of Manchester, UK

Surgical intervention for snoring was first performed 30 years ago with the development of uvulo-palato-pharyngoplasty (UPPP) by the Japanese surgeon Ikematsu. Since Fujita introduced the procedure to the West in 1981, many variations of the original UPPP have been described. However, there have been few attempts to measure surgical outcomes objectively. The main aim of this study is to use acoustic analysis of snoring to objectively measure the outcome of palatal surgery. In addition, we believe that identifying the acoustic characteristics of snoring sounds originating from the soft palate may provide a means of predicting the outcome of palatal surgery.

Fifty patients seeking treatment for heavy snoring by palatoplasty are being investigated. To be eligible, each of these patients must have had a susceptibility to obstructive sleep apnea excluded by sleep monitoring. The investigation involves each patient undertaking limited sleep studies pre-operatively, one month post-operatively and six months post-operatively. The limited sleep studies include over-night observation with an infra-red video camera while snoring sounds are recorded by a free-field microphone. All patients have simulated snoring recorded prior to the operation, and the majority will undergo stepwise sedation to induce snoring. When snoring occurs during sedation, it is recorded and nasendoscopy is performed to directly visualize the vibrating structures.

To date, forty-eight patients have undergone palatal surgery, 28 of these have also had nasendoscopy and 14 patients have completed the whole protocol. All patients and their partners have completed a questionnaire to identify the subjective success of the procedure.

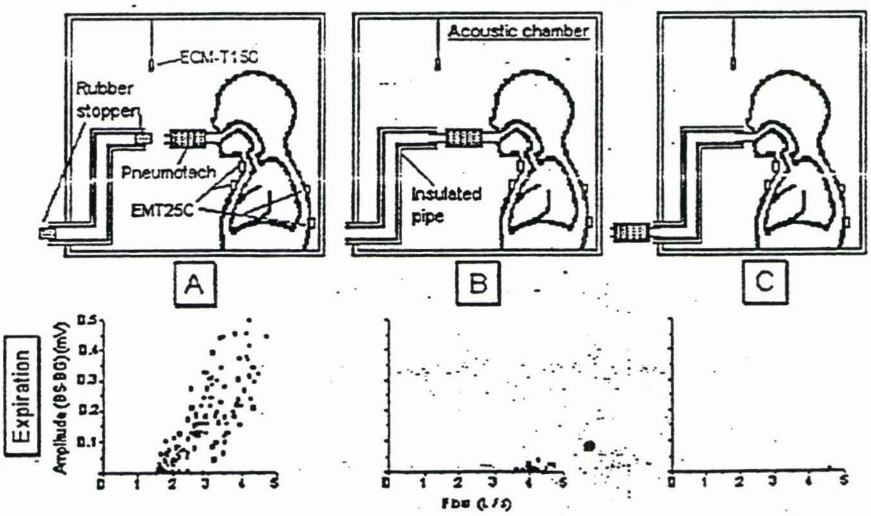
Time-domain and spectrographic analysis of the sound waveforms produced during snoring usually reveal a predominant quasi-periodic structure with multiple harmonics colored, as expected, by the reflections within the upper airways. A second pattern is also often observed consisting of a more complex waveform without a clear harmonic structure in the time domain. The predominant pattern usually arises from palatal snoring and was the most common pattern seen in simulated snoring while the more complex waveforms are thought to be an interaction between vibrations in pharyngeal, palatal and other upper airway structures.

The investigations are being carried out using digital signal processing software developed to automatically analyze lengthy files of overnight data stored on DAT tape. This software automatically counts the number of snoring events, the individual energy of each snore and the aggregate energy of all the snores over time. An algorithm under development is designed to subtract the 'palatal snore sounds' from other snoring sounds to give an index of how much palatal snoring occurs in a given patient. It is hoped that this will allow us to predict which patients will benefit from palatal surgery.

BEST METHOD TO STUDY AIRFLOW – BREATH SOUND RELATION

Kazuhiko Shirota§, Matthew Greenberg†, and Hans Pasterkamp
Acoustic Research Unit, Section of Respirology, Dept. of Pediatrics and Child Health, University of Maintoba, Winnipeg, Canada

The relation of breath sound amplitude (BSA) to air flow (V) is of interest since it can reflect regional ventilation and airway characteristics. Previous studies found linear to quadratic relations. We have reported how ambient respiratory noise can affect the measurement of respiratory sounds particularly at high flows. Breathing through a pneumotach generates noise that contributes to the recording. To study the best pneumotach placement, we recorded reath sounds, ambient noise and V with 3 different methods. Breath sounds over the anterior right upper, su[perior and basal right lower lung and at the trachea were recorded with 4 transfucers (Siemens). An electret microphone (Sony) 30 cm above the mouth registered ambient noise. Data were acquired at flows of 0.8, 1.2, 1.8, 2.7 and 4.1 L/s ± 20%, and for at least 5 sec at zero flow during each recording. After subtraction of zero flow spectra, the average BSA within frequency bands 150-300, 300-600, 600-1200 and 150-1200 Hz (also 1200-2400 and 150-2400 Hz for trachea and room noise) was calculated for each 100 ms epoch, recording site, respiratory phase, flow and method. BSA was plotted against V for wach recording site, frequency band, respiratory phase and method. We determined the BSA-V relation using a nonlinear least square fit. Ambient respiratory noise affected the relation especially during expiration. For accurate assessment of BSA-V relations, the best method therefore avoids placing a pneumotach close to the subject and directs expiratory flow away from the immediate surrounding breath sound sensors.



Ambient noise amplitude – air flow relation during expiration (150 - 2400 Hz)

§ K. Shirota is supported by the Manitoba Lung Association
† M. Greenberg is supported by the Children's Hospital Foundation of Manitoba

UPSIDE DOWN LUNG SOUNDS

R. Murphy, F. Davidson, V. Power

Considerable evidence gathered from radioactive xenon studies supports the concept that there is a vertical gradient of pleural pressure from the apex to the base of the lung and that this gradient is responsible for regional variation in the distribution of ventilation. In the upright position, during a slow deep inspiration ventilation goes first to the apex and later to the base. At the vase, the ventilation is greater as the perfusion is largest because of gravitational effects on the distribution of ventilation. When a subject is upside down, the pleural pressure gradient 2° to gravity is reversed and theoretically the ventilation should no longer go initially to the apex.

A number of investigations have shown that lung sounds reflect regional ventilation. We studied the relationship of lung sounds from microphones placed vertically from the apex to the base in a normal subject both in the upright and head down positions.

Lung sounds appeared first at the most superior positions and later at the bases in the upright position. This effect was reversed when the subject was upside down. These observations are consistent with theoretical changes in pleural pressure gradients and with the concept that lung sounds reflect regional ventilation.
R.M. has a financial interest in Stethographics, Inc.

SENSITIVITY OF ACOUSTIC ATTENUATION TO LUNG PARENCHYMA CHANGE

Andreas Pohlman, Sepe Sehati, Duncan Young*
Medical Instrumentation Research Laboratory, Oxford Brookes University, Oxford, UK;
*Nuffield Department of Anaesthetics, University of Oxford, Oxford, UK

For diagnosis and monitoring of respiratory diseases, the measurement of acoustic transmission through the respiratory system may offer an alternative to x-rays and CT. In order to investigate the feasibility of an acoustic lung imaging system (ALIS), two prototypes have been developed and studies with volunteers have been carried out. The main objective was to resolve the dependence of attenuation of sound in lung parenchyma on its density. Using the ALIS-1 system, white noise, band-pass filtered to 50-700Hz, was introduced at the mouth of 7 subjects, and transmitted signals recorded with microphones. Acoustic attenuation was calculated using FFT's of four posterior site signals related to a reference signal on the extrathoracic trachea. In order to investigate the effect of different lung densities, measurements were taken at 5, 25, 50 and 75 percent of the forced vital capacity (FVC) of each volunteer. Induced changes in the lung volume had a significant effect on attenuation, particularly at the right top site. For each volunteer, a frequency of minimum variation (1-3dB) and maximum variation (15-30sB) could be identified. Initial studies with the ALIS-2 system are carried out and full results will be presented. The system features light-weight accelerometers, an FFT-matched multi-frequency sound cycles, i.e., while lung density is chaning.

The findings suggest the possibility of developing a simple, cheap and non-invasive technique for diagnosis and monitoring of respiratory diseases.

RELATIONSHIP BETWEEN HYSTERESIS AND CRACKLES IN CONTROL AND TWEEN 20-RINSED, EXCISED RAT LUNGS

D. G. Frazer[1], W. Cheng, and E. L. Petsonk[2]

[1] Engineering and Control Technology Branch,
Health Effects Laboratory Division
and
[2] Surveillance Branch
Division of Respiratory Disease Studies

National Institute for Occupational Safety and Health
Morgantown, WV
USA

We have examined the relationship between pulmonary hysteresis and the recruitment-derecruitment of lung units (Cheng et al., 1995). The recruitment process is represented by a sequence of discrete events, in which each event represents a configurational change in the lung tissue structure. There is evidence that energy is dissipated in the form of crackles during this process. The goal of this study was to record the energy dissipated as lung sounds, measured at the trachea for lungs inflated from different end-expiratory pressures, and correlate sound energy with the normalized hysteresis of individual pressure-volume (P_L-V_L) loops recorded for excised rat lungs. P_L-V_L curves were also recorded for lungs rinsed with Tween 20, a nonionic detergent, to estimate the role of alveolar surfactant on the recruitment-derecruitment process.

It was found that lung sound energy and P_L-V_L loop hysteresis were highly correlated and similarly related to end-expiratory pressure. In experiments involving Tween 20 rinsed lungs, the lung sound energy had nearly the same relationship with end-expiratory pressure as control lungs, while the hysteresis index had two distinct inflection points. One inflection point occurred at low end-expiratory pressures, similar to control lungs, while the second occurred at much higher end-expiratory pressures. These 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 energy measured at the trachea.

WAVELET TRANSFORMATION FOR THE DIAGNOSIS OF PNEUMONIA

V. Gross, P. Fachinger, M. Fröhlich, J. Sulzer, Th. Penzel, P. v. Wichert

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Introduction

Wavelet transformation based analysis is a good tool for detecting and analyzing discontinuous lung sounds like crackles [Hadjileontiadis 1997]. The continuous lung sounds also contain important diagnostic information. Normally, they are analyzed with the Fast Fourier Transformation (FFT). We developed a simple method of frequency band analysis using Wavelet Transformation (WT) to extract a parameter from lung sound recordings that could determine the probability of bronchial sound pattern.

Methods

The lung sounds of 12 patients with unilateral pneumonia were recorded simultaneously with two air-coupled microphones (Sony ECM 77) at standardized airflow (160PC, Honeywell-Microswitch Minneapolis). The exact pneumonia locations were determined by auscultation and by x-ray-picture analysis. A symmetric position to the median-sagittal plane was kept in all cases as control. The signals were prefiltered with an antialaising-filter (GEPA. TPF-MF-O1-48-B, 1800 Hz) and digitized with 12 bit resolution and a sampling rate of 5512 Hz (SORCUS. M4/486, AD-M 12/16). After that the respiratory-signals were analyzed with WT based frequency band analysis (MATLAB 5.3, wavelet-toolbox). We used the Daubechie Wavelet with 8 coefficients. The coefficients of the 3rd frequency band (345-690 Hz) were computed for each respiratory cycle. We calculated the ratio between the same-length inspiratory and expiratory phase (0.1s). The values of the quotient Q were calculated for both sides. The same was done with the FFT spectral power values for the equal frequency band.

Results and Discussion

12 patients with one-sided pneumonia were investigated. For all patients, the quotient Q was significantly higher on the pneumonia side then on the healthy side for wavelet transformation and for FFT [$p=0.003$, means: $Q(FFT)_{healty}=0.34$, $Q(FFT)_{pneumonia}=1.10$, $Q(WT)_{healty}=0.33$, $Q(WT)_{pneumonia}=1.06$]. The values from wavelet transformation have smaller standard deviations [STD(FFT)≈60%, STD(WT)≈50%], so the quotient Q from wavelet transformation could be a good parameter for detecting bronchial sound. Further investigations are necessary to look for threshold values for an automatic detection.

Scientific Session B

Chairpersons: N. Gavriely/P. von Wichert

13:30 - 13:45	An Improved System for Measuring Breath and Cough Sounds - W. Goldsmith, K. Friend, W. McKinney, J. Reynolds, D. Frazer, J. Smith
13:45 - 14:00	A System for Reconstruction of Cough Sounds and Cough Sound Components - J. Reynolds, W. McKinney, K. Friend, W. Goldsmith, D. Frazer
14:00 - 14:15	Wheeze Duration in Cough Sounds for Disease Characterization - K. Friend, W. Goldsmith, W. McKinney, J. Reynolds, S. Watkins, E. Petsonk, H. Abrons, D. Frazer
14:15 - 14:30	Quantitative Documentation of Wheezers in Asthma Clinics Using an Automatic Wheeze Quantification Device - S. Lim, N. Gavriely, C. Irving, K.F. Chung, P.J. Barnes
14:30 - 14:45	Break
14:45 - 15:00	Microphone-Based Accelerometers for Lung Sound Recording - F. Sakao, H. Sato, M. Mori
15:00 - 15:15	Discrimination of Lung Sounds Using Higher-Order Crossings - L. Hadjileontiadis, C. Saragiotis, S. Panas
15:15 - 15:30	Methacholine Bronchial Challenge Performed by a Modified Auscultation Method in Young Children - C. Springer, S. Godfrey, K. Uwyyed, M. Rotschild, S. Hananya, N. Noviski, A. Avital

15:30 - 15:45	Lung Sound Analysis in Evaluation of Airway Lability in Asthmatic Children - M. Takase, Y. Inaba, T. Imai, T. Imai
15:45 - 16:00	Use of Respirogram in Diagnosis of Respiratory Organ Diseases in Children - V. Maydannik, V. Grinchenko, L. Glebova, A. Makarenkow, A. Rudnickiy
16:00 - 16:15	Acoustic Nocturnal Monitoring of Pediatric Patients - Methods and Practice - R. Beck, L. Bentur, C. Irving, N. Gavriely, KMAT Clinical Coordinators
16:15 - 16:30	Acoustic Bronchial Provocation Tests in Asthmatic Children - B. Shinaui, R. Beck, L. Bentur, C. Irving, N. Gavriely

AN IMPROVED SYSTEM FOR MEASURING BREATH AND COUGH SOUNDS

W. T. Goldsmith, K. A. Friend, W.G. McKinney, J. S. Reynolds, and D. G. Frazer, J. Smith
E&CTB, HELD, NIOSH, Morgantown, WV 26505

Lung sounds are influenced by the geometry and mechanical properties of the airways and lung tissue. If the characteristics of breath and cough sounds related to lung structure and function can be identified and quantified, they may assist in the diagnosis of lung disease. In order to minimize errors associated with many current techniques of measuring lung sounds, a new system consisting of a series of tubes, a microphone, a pneumotach and an anechoic termination was developed to record breath and cough sounds along with flow from the mouth. Signals were generated with a speaker and flow simulator to examine system characteristics. Tubing length, tubing type, anechoic termination type and pneumotach position were varied to find the combination that most reduced reflections. The system was used to record the respiratory maneuvers (maximal expiratory flow maneuvers and coughs) of healthy volunteers. Spectral examination of all maneuvers provided evidence of acoustical energy up to the maximal analysis frequency of 25.6 kHz. Analysis at frequencies other than those generally examined during most lung sounds investigations may provide useful information that would assist in the diagnosis of lung disease.

A System for Reconstruction of Cough Sounds and Cough Sound Components

JS Reynolds, WG McKinney, KA Friend, WT Goldsmith, and DG Frazer

Engineering and Control Technology Branch,
Health Effects Laboratory Division
National Institute for Occupational Safety and Health
Morgantown, WV

The purpose of this project is to develop an auscultatory system that could be used to train physicians to identify components of cough sounds associated with lung disease. The system recreates cough sounds obtained using a previously described cough sound recording system [1]. A subject coughs through a mouthpiece coupled to a long flexible tube. In the tube, a microphone is mounted tangential to the tube wall near the mouthpiece. Cough sounds are digitized at 65.538 KHz and transferred to a personal computer. The playback system is similar. A speaker, in place of the subject, is coupled to the mouthpiece and a stethoscope is mounted next to the microphone. When played back, the original cough is normally distorted by the speaker. A system identification algorithm is utilized to obtain the playback system transfer function. The playback system is modeled as an n^{th} order digital filter. The filter order can be determined using Akaike's information theoretic criterion. The filter coefficients are determined using a batch least squares estimation technique. The inverse filter can then be used to modify the input to produce the original cough sound. Similarly, components of the cough such as wheeze may be identified, reconstructed and played back. Wheezes are extracted from the original cough using an adaptive filter technique. The complete system for playback and reconstruction of cough sounds is developed as a virtual instrument using the Labview software package. The system is capable of reconstructing cough sounds and cough sound components. Accurate reproduction of the original cough and/or wheeze is delivered to the stethoscope for screening or training.

1] Goldsmith, WT, JS Reynolds, WG McKinney, KA Friend, D Shahan, DG Frazer. A System for Recording High Fidelity Cough Sound Measurements. Proceedings 3rd International Workshop on Biosignal Interpretation, 1999; 178-81.

WHEEZE DURATION IN COUGH SOUNDS FOR DISEASE CHARACTERIZATION

K.A. Friend, W.T. Goldsmith, W.G. McKinney,
J.S. Reynolds, S.A. Watkins, E.L. Petsonk[1], H.L. Abrons[2], D.G. Frazer

Engineering and Control Technology Branch,
Health Effects Laboratory Division
And
[1]Surveillance Branch
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National Institute for Occupational Safety and Health
Morgantown, West Virginia

[2]Pulmonary and Critical Care Medicine
West Virginia University School of Medicine
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Pulmonary physicians use auscultatory techniques to assist in the diagnosis and management of lung disorders. Wheezing is one characteristic that is heard in many types of lung disease. For example, wheezing may be a clinical sign of chronic obstructive pulmonary disease or an asthma episode. To optimize the utility of lung sound assessment, characterization of the wheeze by location, intensity, pitch, and duration in the respiratory cycle is essential. In this study, the duration of wheeze in different disease groups was examined.

A system was developed to record and analyze cough sounds. The system included a microphone positioned with its diaphragm tangent to the inner surface of a metal tube. A flexible 13-ft hose with 1-inch inner diameter was connected to the metal tube just past the microphone at the opposing end of the mouthpiece. Cough sound pressure waves generated were digitized at 12.8KHz and recorded using a sound analyzer. The signal was transferred to the computer for analysis.

The coughs were obtained from patients awaiting testing at the West Virginia University Hospital pulmonary function laboratory. Patients were diagnosed using a fuzzy logic technique that incorporated actual and predicted spirometry values of FEV1 and FVC within the fuzzy logic rule sets. Diagnosis led to the categorization of the patient in a particular disease group. Spectrograms were calculated from the patient's cough sound pressure waves. For each spectrogram, the number of wheezes and the duration of those wheezes were recorded and can be seen in Figure 1.

In the figure, the patients (n=31) were categorized according to the following disease type- 1) obstructive disease (n=9), 2) restrictive disease (n=4), 3) combination of obstructive and restrictive disease (n=10), and 4) control (n=8). Each patient had at least one nodal point (■,◆,▲, or ●). The number of nodal points and their positions describe the number of wheezes and their respective duration. The result for each patient is shown from longest to shortest wheeze duration per disease type. From the figure, it can be seen that the control group has less wheeze with shorter duration than the groups with pulmonary pathology. It also appears that of the groups with pulmonary pathology, the restrictive disease group has shorter wheeze duration. To better characterize the utility of this approach, statistical analysis will be forthcoming. Future studies will also include the recording of cough sounds from patients with diverse lung disorders of varying degrees of severity.

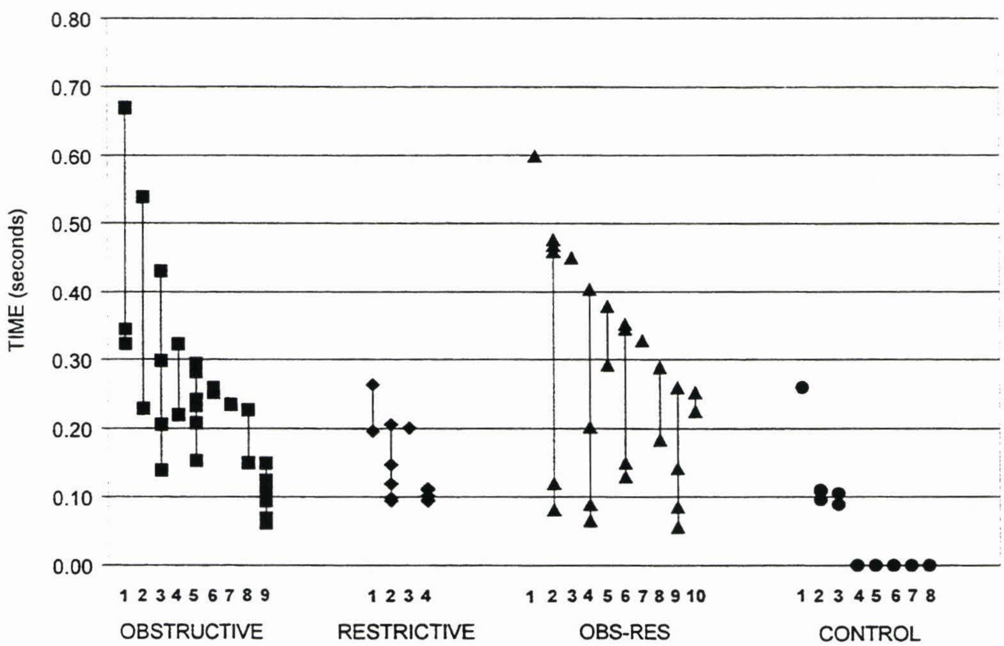

Figure 1: Disease Group and Patient Identification Number
For example, Obstructive Patient #3 was found to have four wheezes each with duration of 0.14, 0.21, 0.30, and 0.43 seconds.

QUANTITATIVE DOCUMENTATION OF WHEEZES IN ASTHMA CLINICS USING AN AUTOMATIC WHEEZE QUANTIFICATION DEVICE

S. Lim[1], N. Gavriely[2*], C.S. Irving[2*], K.F. Chung[1], and P.J. Barnes[1]
Department of Thoracic Medicine, Imperial College School of Medicine at National Heart & Lung Institute, London UK[1] and Karmel Medical Acoustic Technologies, Yokneam Illit, Israel[2].

Aim: Stethoscopic auscultation is an important component of the clinical assessment of asthma, however this is subjective, qualitative and does not provide a permanent record. We evaluated the use of an automatic wheeze quantification (AWQ) device (PulmoTrack® Model 1010 KMAT, Yokneam Illit, Israel) to document wheezing in asthmatic subjects.
Methods: Digital recordings of breath sounds were made during AWQ measurements in 21 patients with asthma of varying severity. Sound records were played back and scored by expert physicians for the presence of wheeze, whistles and rhonchi. The physicians' findings were compared to the Wheeze Rate (%ratio of wheezing time to breathing time), as determined by the device.
Results: We examined a random sample of 70 sound files generated by the patients. At the time of the examination 70% of the patients had wheezing. Using the physicians' scores as a reference, the AWQ measurements were found to have a sensitivity of 89% (n=37) and a specificity of 91% (n=33) for the presence of sounds associated with airway obstruction.
Conclusions
Automatic wheeze detection can quantify wheezes accurately and reliably in asthmatic patients. Objective and quantitative wheeze documentation may be a useful tool in the assessment of asthma patients in the future.

* This study was conducted while Prof. Gavriely was on Sabbatical leave from the Technion – Israel Institute of Technology. Gavriely and Irving have a financial interest in Karmel Medical Ltd.

"MICROPHONE-BASED ACCELEROMETERS FOR LUNG SOUND RECORDING"

Fujihiko Sakao*, Hiroshi Sato and Masashi Mori**
*School of Engineering, Kinki University, Takaya-Umenobe, Higashihiroshima, Japan
**National Tokyo Hospital, Kiyosee-shi Takeoka 3-1-1, Tokyo, Japan

A simple accelerometer-type lung-sound sensor presented last year at this meeting was further improved. It is composed of a small electret condenser microphone which itself is an acceleration-sensitive mass, with an enclosed cavity in front of it. The sensor is small (d=2.5 cm), light-weight (2.5g or less), yet with sufficiently high sensitivity.

The choice of substance for the elastic support of the microphone cartridge is found to be crucial for a good sensor. To eliminate a resonance peak in the frequency characteristics and extend the frequency range of a good response, the substance should have good damping characteristics. The substance we selected this time is a silicon compound with improved damping factor, however, we are still looking for something better.

The frequency response of the new version sensor has a small resonance peak of about 10 dB at around 2kHz, but otherwise, has a flat frequency response up to 3kHz. Application of the sensor to human lung sounds is not under way.

DISCRIMINATION OF LUNG SOUNDS USING HIGHER-ORDER CROSSINGS

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The diversity of lung sounds (LS) characteristics yields the grounds for developing efficient discrimination tools. The present study proposes a new way to discriminate LS using higher-order crossings (HOC). More specifically, the method explores the LS features by processing their time domain oscillations. In particular, the application of a specific sequence of filters on LS, the corresponding gives the sequence of zero-crossings counts and results in the so-called 'HOC sequence' which constitute the 'HOC-domain', a domain between the time and spectral domains. The projection of the LS recordings in the HOC-domain reveals a new field in their discrimination analysis. In the presented work, three HOC-based discrimination indices were used, i.e., the *white noise test* (WNT), the *weighted* ψ^2 statistic (W-ψ^2), and the HOC-*scatter plots* (HOC-SP). The WNT is based on measuring the distance of different categories of LS from the white Gaussian noise; the W-ψ^2 statistic quantifies the initial monotone rate of increase in HOC sequences, while the HOC-SP depict the most distant pair of HOC (D_j,D_k). The method was implemented on pre-classified LS (educational tapes) digitized at 5000kHz. Pairs of coarse and fine crackles (fibrotic lung-10 and 9 subjects, respectively) and pairs of normal and abnormal tracheobronchial LS (consolidated lung – 9 and 9 subjects, respectively) were analyzed for discrimination. The experimental results prove that the HOC-based indices result in fast, easy, and efficient discrimination of LS, even in cases of LS with similar acoustical impression.

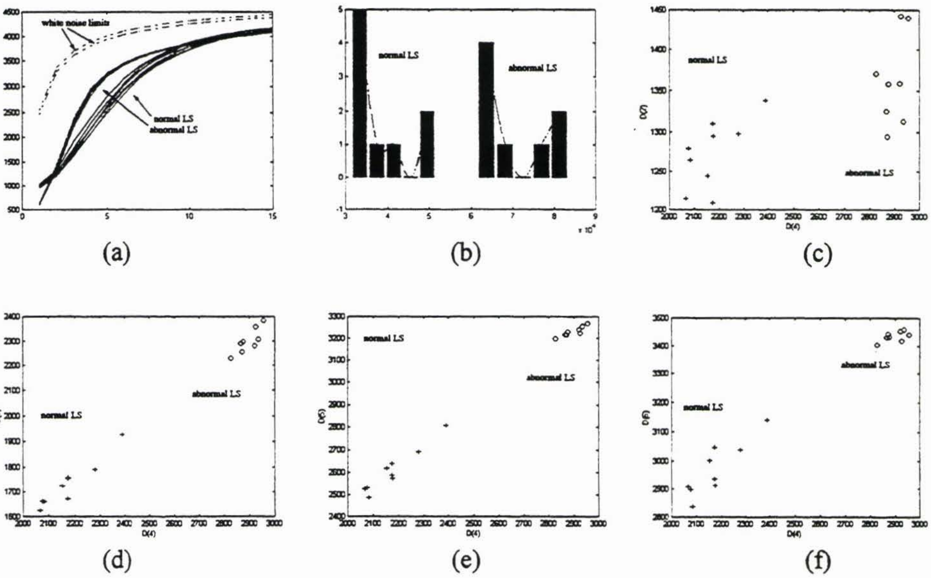


Fig.1: Discrimination of normal tracheobronchial LS from abnormal ones (a) WNT, (b) W-ψ^2 statistic, (c)-(f) HOC-SP

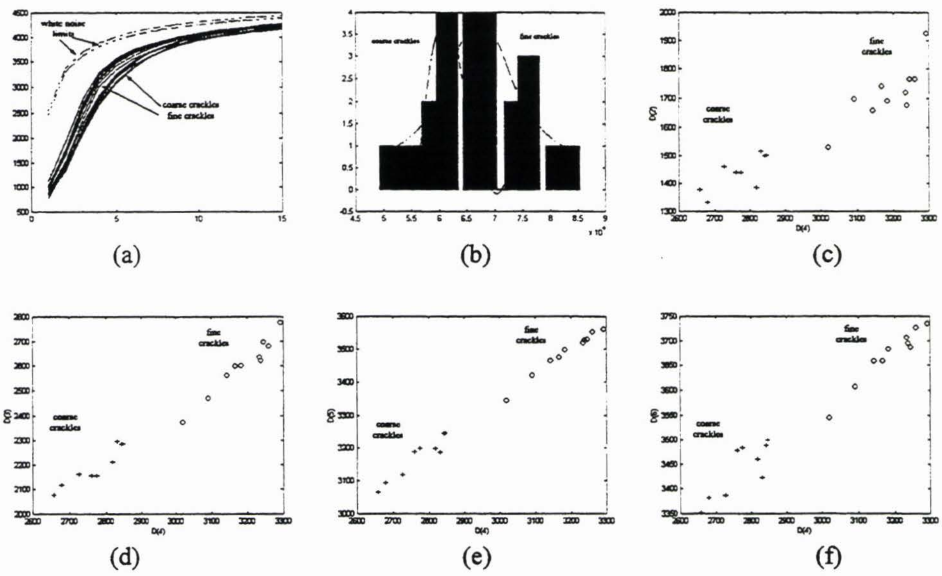


Fig.2: Discrimination of coarse from fine crackles (a) WNT, (b) W-ψ^2 statistic, (c)-(f) HOC-SP

METHACHOLINE BRONCHIAL CHALLENGE PERFORMED BY A MODIFIED AUSCULTATION METHOD IN YOUNG CHILDREN

Chaim Springer, MD, Simon Godfrey, MD,PhD,FRCP, Kamal Uwyyed, MD, Moshe Rotschild, MD, Shai Hananya, MD, Natan Noviski, MD and Avraham Avital, MD

Institute of Pulmonology, Hadassah University Hospital & Hebrew University- Hadassah Medical School, Jerusalem, Israel

Objectives: 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 your asthmatic children.

Methods: 146 young children with asthma (mean age 4.3 years) 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}).

Results: A positive response using the auscultation method was observed in 95.9% of the younger children and wheeze alone or in combination with other signs appeared in 80.8% of them. The mean desaturations at the end point were 4.6% (PCW) and 5.0% (PC_{20}) with a similar pattern in the two groups.

Conclusions: The modified auscultation method is effective and sage, with wheeze appearing at the end point in the large majority of the children.

LUNG SOUND ANALYSIS IN EVALUATION OF AIRWAY LABILITY IN ASTHMATIC CHILDREN

Masato Takase, Yaoki Inaba, Takehide Imai, Taiyo Imai, Department of Pediatrics, Nippon Medical School, Tokyo, Japan

The objective of the study was to find whether lung sound analysis could be used to evaluate the airway lability of children with bronchial asthma. We made two groups of known asthmatic children, 'symptom-stable' and 'symptom-unstable' by choosing five children, aged 10-13, each from the participants in an asthma summer camp program. Spirometry and lung sound recordings were performed for three consecutive days when they were free of acute exacerbation. Recordings were made using two contact-type sensors (Siemens, EMT25C) over the right upper anterior and the right lower posterior chest. The subjects breathed through a pneumotach, targeting at 15ml/kg/sec $\pm$ 20%. Lung sound data were digitized at 10,240 Hz and stored on the computer. Several lung sound parameters characterizing the average spectra were obtained after applying FFT (fast Fourier transform). We calculated the mean and the variability rate (defined as amplitude % best) for each spirometric and lung sound parameter. Comparison of the two groups revealed that FEF 25-75% variability was significantly higher in the 'symptom-unstable' group (unpaired t-test $p<0.05$). The variability of median frequency obtained from inspiratory sounds over the right lower posterior chest showed good correlation with that of FEF25-75% ($r=0.88$), possibly being a useful parameter monitoring the airway lability of asthmatic children.

USE OF RESPIROGRAM TO DIAGNOSIS OF RESPIRATORY ORGAN DISEASES IN CHILDREN

V.G. Maydannik, V.T. Grinchenko, L.P. Glebova, A.P. Makarenkow, A.G. Rudnickiy

The purpose of the investigation is to compare the accuracy of diagnosis by using traditional clinical-instrument method and by the method of lung sound visualization by the respirosonograms. The method is based on computer polychromatic visualization of the lung sound recorded by developed methods.

In the course of the clinic experiment, sixteen (16) children (seven boys and nine girls) at the age from 8 to 13 years were inspected. The patients had diagnosis: six patients with acute obstructive bronchitis, seven patients with bronchopneumonia complicated by syndrome of obstruction, three patients with polysegmental bronchopneumonia. All patients were admitted in the state of average grade of disease with predominatingly expiratory dyspnea and symptoms of respiratory insufficiency of I-II degree.

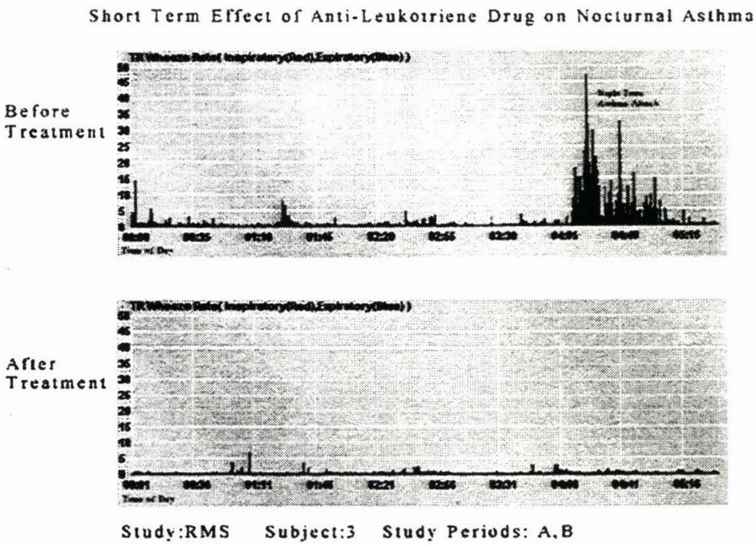
The diagnostic feature searching has been carried out by the comparison of the acoustic data and data of radiology inspections. The comparison gives possibility to show specific stable signatures of diseases in the respirosograms. Acoustic data give possibility to diminish roentgen charge on patient that is very important beside Chernobyl area, are very descriptive, and provide a way to document the medical treatment process.

ACOUSTIC NOCTURNAL MONITORING OF PEDIATRIC PATIENTS – METHODS AND PRACTICE

Rafael Beck, Leah Bentur, Charles Irving, Noam Gavriely, and KMAT Clinical Coordinators.
Rambam Medical Center, Haifa; The Rappaport Faculty of Medicine, Technion – Israel Institute of Technology, Haifa; and Karmel Medical Acoustic Technologies Ltd, Yokneam Illit, Israel.

Worsening of asthma symptoms at night is common and troublesome, yet is a poorly recognized component of the disease. Objective measurements of airflow obstruction during sleep are difficult. The use of acoustic monitoring of tracheal and/or chest wall breath sounds requires no patient cooperation and can be done during sleep. We hereby describe our practical experience using the PulmoTrack Model 1010 for monitoring pediatric asthma patients during sleep. Studies were carried out in two groups: (I) in the hospital, simultaneously with monitoring of esophageal pH in children under 1 years old, and (II) at the patient's home in older children 6 to 18 years old. The studies were done after informed consent was obtained from the parents. Sensor attachment to standard locations required thorough cleansing of the skin to assure adherence of the sensor pads for the duration of the night. We found that sensor wires are best collected and attached with tape to the back of the neck, to minimize wire pull during patient turning. The patients were visually monitored throughout the duration of the study to prevent wire tangling. Data acquisition is continuous and automatic. However, quality assurance by occasional listening to the sounds emerging from all the sensors via headphones was practiced, but was found to be unnecessary beyond the initial onset of the night study. Ambient noise interference was usually rejected well by the variety of noise cancellation methods on the device. However, when very loud talking was present near the patient, or when a baby was crying in the room (in the hospital) the sounds could interfere with the steady flow of data and required operator's intervention. This did not represent a significant issue in these studies. Both children and babies tolerated the sensor placement and their removal well and were able to sleep normally during the study. It was interesting to note that some patients who had significant episodes of wheezing activity did not wake up. No studies had to be aborted for any reason.

We conclude that monitoring wheezes in asthma patients is feasible and does not present technical difficulties. The studies can be conducted either at the patient's home or in the hospital with no significant interference from environmental noises.



The Figure shows the results of two night studies done on the same 9 year old patient before (Top panel) and two days after (Bottom panel) onset of treatment with Leukotriene modifying drug. Note the early morning wheezing attack between 4 and 5 am.

ACOUSTIC BRONCHIAL PROVOCATION TESTS IN ASTHMATIC CHILDREN

Shinaui B., Rafael Beck, Leah Bentur, Charles Irving and Noam Gavriely
Rambam Medical Center, Haifa; The Rappaport Faculty of Medicine, Technion – Israel Institute of Technology, Haifa; and Karmel Medical Acoustic Technologies Ltd, Yokneam Illit, Israel.

Background: Bronchial provocation tests (BPT) are often used to diagnose bronchial hyper-reactivity (BHR), an essential component in the pathogenesis of asthma. When the patient is capable of performing repeated spirometric measurements, it is the preferred method at the present time. However, when the patient cannot perform repeated spirometries, as is usually the case with children under 5 years of age, other methods that do not require substantial patient cooperation must be used. The usefulness of acoustic monitoring of the chest has been documented in many published reports in the last 10 years. We hereby describe our experience with an automatic wheeze detection device (PulmoTrack® Model 1010, Karmel Medical Acoustic Technologies Ltd, Yokneam Illit, Israel) in a group of pediatric asthma patients 6-13 years of age. All of the patients have previously been diagnosed as having asthma. The BPT were carried out with Adenosine Mono Phosphate and were repeated three times for each patient: before onset of treatment with a Leukotreine modifying agent, 48-72 hours after the onset of treatment and 6 weeks after the onset of treatment.
Methods: The patients inhaled the diluent and then the provocating agent through a face mask starting at 0.4 mg/ml and duplicating the concentration up to 400 mg/ml. Breath sounds were monitored continuously from 5 standard chest (bilateral bases and axillae) and tracheal sensors. In addition, 30 sec records of raw data were obtained after each dose was delivered. Spirometry was performed after the end of the recording and documented. The acoustic data was reduced by calculating the Wheeze Rate (Wz%) parameter, calculated as the percent ratio of the wheezing duration to the breathing duration. Wz% at each step was compared to the FEV1.0.
Results: Total of 24 BPTs were done on 8 patients. All patients tolerated the test well and were able to perform the spirometric studies adequately. The onset of detectable wheezing (PC_{wheeze}) preceded or coincided with the drop of FEV1.0 by over 20% (PC_{20}). All of the subjects had BHR. Within each child, the test-to-test variability was small and potentially fully explained by modifying effects of the treatment.
Conclusions: We conclude that acoustic monitoring during BPT in children is technically feasible and substantially correlates with results of conventional spirometric methods.

Friday, October 8

Scientific Session C

Chairpersons: S. Ishikawa/S. Kudoh

9:00 - 9:15	Change of Respiratory Sounds in Patients with Acute Attacks of Bronchial Asthma Treated with Non Invasive Positive Pressure Ventilation - Y. Hashimoto, A. Murata, T. Soma, M. Hino, Y. Takasaki, S. Kudoh
9:15 - 9:30	Detection of Respiratory Effort During Obstructive Apnea by Tracheal Sounds Analysis - H. Nakano, T. Iwanaga, S. Shoji, S. Nichima,
9:30 - 9:45	Acoustical Bronchial Provocation Tests in Asthmatic Adults - E. Israel, C. Irving, J. Chang, N. Gavriely
9:45 - 10:00	Analysis of Acoustic Features of the Tracheal Sounds in Patients with Bronchial Stenosis - Effect of the Height of a Pillow - S. Choh, Y. Suzuki, K. Tomoda, K. Komeda, H. Watanabe, A. Shibuya, H. Tanahashi, S. Kudoh, A. Murata, N. Narita
10:00 - 10:15	Break
10:15 - 10:30	Comparison of the Interpretation of Chest Roentgenograms and Lung Sound Waveforms in Chronic Obstructive Lung Disease - M. Murphy, V. Power, K. Bergstrom, M. Berman, R. Murphy
10:30 - 10:45	Dynamics of Changes in Acoustical Characteristics of Respiratory Tract of Pneumonic Patients in Process of Treatment - I. Vovk, V. Grinchenko, S. Dahnov, V. Krizhanovsky, V. Oliynik

10:45 - 11:00	Acoustic Properties of Rhonchi - N. Gavriely
11:00 - 11:15	The Relationship of Lung Sound Amplitude and Tidal Volume During Positive Pressure Ventilation - F. Davidson, V. Power, N. Rec, A. Schwartz, R. Murphy
11:15 - 12:00 -	Guest Lecture - Philosophy of Measurement - Peter Janich, Prof. of Philosophy, Phillipps-Univ. of Marburg
12:00 - 13:30	Lunch
13:30 - 14:00	Business meeting

Scientific Session D

Chairpersons: M. Murphy/H. Pasterkamp

Poster Discussion

14:00 - 14:10	Lung-Sound Analysis of Bronchial Breathing in Patients with Pneumonia - P. Fachinger, V. Gross, M. Fröhlick, J. Sulzer, T. Penzel, P. v. Wichert
14:10 - 14:20	Learning Lung-Auscultation via Intranet, A Multimedia Junior-Doctor-Teaching Project - J. Yuan, C. Camps, P. Postmus, A. Boonstra
14:20 - 14:30	Relations Between Normal Lung Sounds and Subcutaneous Fat Layer on the Back - M. Fröhlick, V. Gross, P. Fachinger, T. Penzel, P. v. Wichert
14:30 - 14:40	Acoustic Features of Psychogenic Cough: Case Report - F. Dalmasso, P. Righini, R. Mantovano

14:40 - 14:50	A Cough Monitoring System Based on a Portable Phono-Meter - F. Dalmasso, G. Righini, P. Righini, V. Didonna, E. Isnardi
14:50 - 15:00	Wheezers and Nonwheezers - S. Ishikawa, J. Marquina, K. MacDonnell, B. Celli
15:00 - 16:00	Lung Sounds and Lung Function - An Educational Video - H. Melbye
16:00 - 16:30	Conference Summary - John Earis
16:30	Closing Remarks - Raymond Murphy
17:00	Steering Committee Meeting
19:00	Farewell Party - Restaurant "Bückings Garten" Landgraf-Philipp-Str.6, Marburg

Change of Respiratory Sounds in Patients with Acute Attack of Bronchial Asthma Treated with Non-invasive Positive Pressure Ventilation

Yasushi Hashimoto, Akira Murata, Tomoyuki Soma, Mitsunori Hino, Yuji Takasaki, Shoji Kudoh

The Fourth Department of Internal Medicine, Nippon Medical School, Tokyo, Japan

Wheeze, as well as dyspnea, is a cardinal symptom in patients with an acute attack of bronchial asthma. These symptoms decrease with improvement of the acute attack. The causes of wheeze are mainly bronchial constriction and mucus plug, which also produce auto-PEEP and exert an extremely high airway pressure on the patients. For patients with an acute attack of bronchial asthma, conventional mechanical ventilation will be a cause of barotrauma and heart failure. Recently, non-invasive positive pressure ventilation (NIPPV) has been introduced in clinical medicine. Its effectiveness in treatment of patients with it; changing expiratory and inspiratory airway pressure, recording changes of respiratory sound, measuring PFT (pulmonary function test) and examining the relationships between them.

Subjects: Patients with acute attack of bronchial asthma.
Methods: Patients were set in sitting position, treat with NIPPV (8, 6, 4 cm H20 at inspiratory phase, 6, 4, 2 cm H20 at expiratory phase) and respiratory sounds were recorded by the microphone set on the chest wall while measuring PFTs.

Results: Judging from auscultation, the respiratory sounds changed as soon as they were treated with NIPPV. The sounds which high frequency components remained but those with low frequency components were diminished. This suggests that NIPPV may decrease auto-PEEP in patients with an acute attack of asthma.

DETECTION OF RESPIRATORY EFFORT DURING OBSTRUCTIVE APNEA BY TRACHEAL SOUNDS ANALYSIS

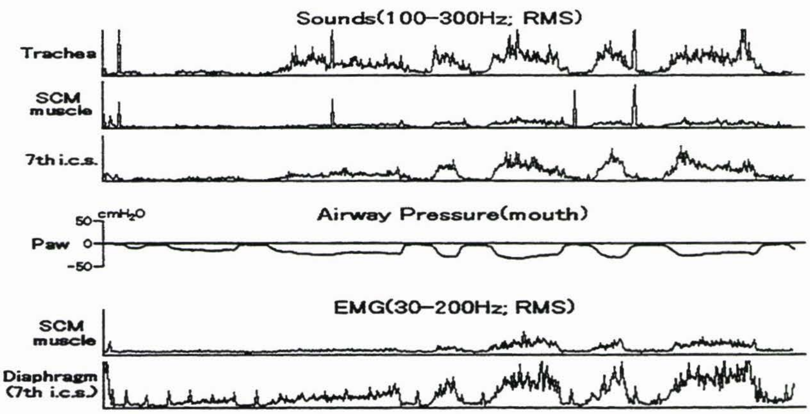
Hiroshi Nakano, Tomoaki Iwanaga, Shunsuke Shoji, and Sankei Nishima.

National Minami-Fukuoka Chest Hospital, Fukuoka, Japan

We analyzed tracheal sounds during apnea events using a sound-spectrogram in ten patients with obstructive sleep apnea syndrome. In about 80% of obstructive apnea events, sounds of low frequency range below 300Hz were detected simultaneously with respiratory movements without airflow.

To elucidate the source of the sounds we analyzed sounds from chest wall and tracheal region during isovolume inspiratory effort in healthy men. Simultaneously, surface electromyograms (EMG) of sternocleidmastoid muscle and diaphragm were recorded. Sound of a low frequency band was detected during inspiratory effort. The sound was prominent at the tracheal region as well as the chest wall and resembled diaphragmatic EMG in time course of the root mean square curve (Fig.). Therefore the sound was considered to have originated from respiratory muscle contraction. The frequency contents dominant for the sounds by respiratory effort and those dominant for tracheal breath sounds were far different.

We conclude that respiratory effort during occluded breath may be detectable by tracheal sounds analysis.



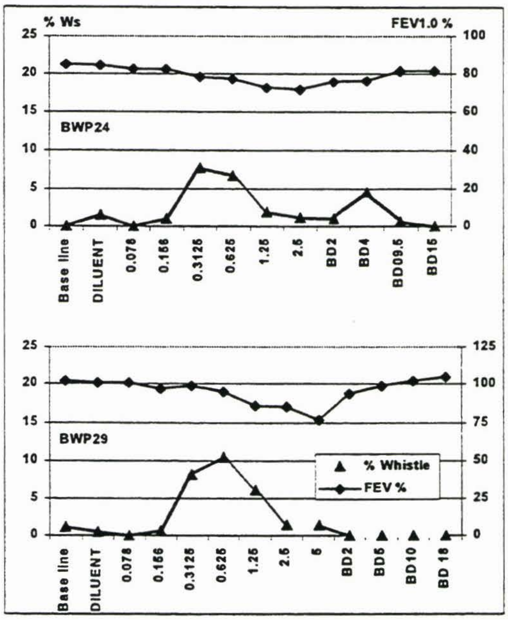
ACOUSTIC BRONCHIAL PROVOCATION TESTS (BPT) IN ASTHMATIC ADULTS

Elliot Israel[1], Charles S. Irving[2], Jin Chang[1] and Noam Gavriely[3,2]

Asthma Clinical Research Center, Pulmonary and Critical Care Division, Brigham and Women's Hospital, Boston MA, USA; Karmel Medical Acoustic Technologies Ltd. Yokneam Illit; and the Pulmonary Physiology Unit, Rappaport Faculty of Medicine, Technion – Israel Institute of Technology, Haifa, Israel.

Introduction: Previous studies on the use of pulmonary acoustics to determine the end-point during bronchial provocation tests (BPT) in adults showed that only about 40% of the patients responded with wheezes when they dropped FEV1.0 by 20% (PD20). Recently, we discovered the presence of high frequency (>1500 Hz), rapidly changing (df/dt > 2 Hz/msec), short continuous tracheal breath sounds in bronchoconstricted patients. The present study evaluates the usefulness of automatic detection of "Whistles", a new subtype of continuous adventitious sounds in adult BPT.

Methods: 32 asthmatic adults underwent Methacholine BPT using conventional spirometric indices to determine end-point. Acoustic measurements of wheezing breath sounds were added on to the protocol, but were not used to determine the end point. Five identical, coin-size PPG sensors were attached to standard pick up locations on the chest and over the trachea. The signals were amplified (X 600-6000) and band-pass filtered (75-4000 Hz). Electrical impedance of the chest wall was used to determine the respiratory phase. All signals were digitized at 10,000 Hz per channel and analyzed using a proprietary automatic wheeze/whistle detector algorithm (KMAT). Wheezes and whistles were quantified as percent wheeze or whistle time over total breathing time, designated as Wheeze Rate (Wz%) and Whistle Rate (Ws%), respectively.



Results: Only 37.5% (12 of 32) of the patients developed wheezes on the trachea and/or the chest wall before or at PC_{20}. However, when whistle detection was included, 87.5% (28 of 32) developed whistles and/or wheezes at, or before PC_{20}. 27 of the 28 responders had tracheal whistles. In some of the patients whistles appeared before PC_{20}, but diminished with subsequent doses as shown in the Figure. Three of the 32 subjects (9.6%) had whistles at baseline (none had wheezes) while their mean baseline FEV1.0 was 83% of predicted. The range of Wz% in the subjects who responded with wheezes was 1.4-55.1%. Ws% ranged from 1.3% to 13.8% with a mean of 5.7% and SD of 4.5%. In all of the subjects except two who had a rebound, the whistles disappeared after a dose of bronchodilator (Albuterol).

Conclusions: Detection of tracheal whistles increases the sensitivity of acoustic bronchial provocation tests in asthmatic adults to the point where it becomes feasible to use it in clinical practice, particularly in those adults who cannot perform repeated spirometric measurements. In view of the fact that 12.5% of the patients did not develop whistles or wheezes by the time they reached PC_{20}, we recommend using pulse oxymeter in all patients undergoing acoustic BPT. A study should be conducted on a control group of non-asthmatic adults to determine the positive predictive power (specificity) of acoustic BPT.

This study was conducted while Gavriely was on Sabbatical from the Technion. NG and CI have a financial stake in Karmel Medical Acoustic Technologies Ltd.

Analysis of Acoustic Features of the Tracheal Sounds in Patients with Bronchial Stenosis

- Effect of the Height of a Pillow –

Sumito Choh [1], Yuko Suzuki [1], Koichi Tomoda [1], Kazuyuki Komeda [1], Hiroyuki Watanabe [1], Atsuo Shibuya [2], Hitomi Tanahashi [2], Shoji Kudoh [3], Akira Murata [3], Nobuhiro Narita [4]

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4) Second Department of Medicine, Nara Medical University, Kashihara, Nara

We studied how the height of the pillow affects the respiratory sounds of patients with bronchial stenosis. The subjects consist of three patients whose bronchial stenosis was confirmed by bronchoscopy, and eight normal controls. The respiratory sounds were recorded on a digital data recorder through the microphones attached to anterior neck over the trachea and the anterior chest of stenotic side. The recordings were done in four postures; sit up position, supine position without a pillow, with a low pillow (7 cm), and with a high pillow (11 cm). We analyzed the power spectra using the Fast Fourier Transform (FFT).

In the group of the patients, the diminution coefficient beyond cut-off frequency augmented as the height of the pillow raised; on the other hand the effects of the height of the pillow for the normal controls were not as distinct as those of patients. The lung sounds recorded on the anterior chest were not influenced by the height of the pillow in either case.

COMPARISON OF THE INTERPRETATION OF CHEST ROENTGENOGRAMS AND LUNG SOUND WAVEFORMS IN CHRONIC OBSTRUCTIVE LUNG DISEASE

M. Murphy, V. Power, K. Bergstrom, M. Berman and R. Murphy

We studied 42 patients with chronic obstructive lung disease (COPD) and 42 subjects who denied significant lung disease and whose spirometric function was within normal limits. Standard postero-anterior and lateral chest roentgenograms were available on all subjects. They were interpreted by 3 board certified radiologists and 3 board certified pulmonologists who were unaware of the diagnosis.

Lung sounds were recorded for 10 seconds at 20 chest wall sites, using a multi-channel lung sound analyzer (Stethographic M87). Waveforms of the lung sounds were randomly interspersed and read by observers also unaware of the diagnosis.

RESULTS

TABLE I ROENTGENOLOGIC INTERPRETATION

	Radiologists	Pulmonologists
% correct	81	88
	79	86
	71	67
Average	77	80.3

TABLE II LUNG SOUND WAVEFORM INTERPRETATION

	94
	86
	80
Average	86.7

The details of the variability in these interpretations will be presented.

DYNAMICS OF CHANGES IN ACOUSTICAL CHARACTERISTICS OF RESPIRATORY TRACT OF PNEUMONIC PATIENTS IN PROCESS OF TREATMENT

I.V. VOVK, V.T. GRINCHENKO, S.L. DAHNOV, V.V. KRIZHANOVSKY, V.N. OLIYNIK

The dynamics of the acoustical characteristics of the respiratory tract of patients with pneumonia receiving intense therapy were studied on the base of the Central Military Clinical Hospital of the Ministry of Defense of Ukraine. The data were registered, analyzed and documented by means of specialized computer complex developed in the Institute of Hydromechanics of National Academy of Sciences of Ukraine.

The signals were detected by a miniature kinematic sensor according to a two-channel scheme that allowed spectral-correlation processing.

In particular, the 'transfer functions' of channel of propagation of breath sounds between neck and different segments of lungs were derived. Simultaneously the spectrographic processing was carried out that provided respirosonograms useful for uncovering of irregular diagnostic features of signal such as crackles, wheezing and so on.

It has been shown that in case of pneumonic disease, during which the physical parameters of lung tissue change, the behavior of 'transfer functions' is the efficient indicator of pathology. This allows accurate localization of the affected zone by lung segment. In the process of patient's recovery, the 'transfer functions' change to normal, and this in principle gives the possibility to carry out the control of quality of treatment according to one more independent parameters based on the objective data of acoustical measurements.

ACOUSTIC PROPERTIES OF RHONCHI

Noam Gavriely
Pulmonary Physiology Unit, Rappaport Faculty of Medicine, Technion – Israel Institute of Technology, Haifa, Israel., and Karmel Medical Acoustic Technologies Ltd. Yokneam Illit, Israel;

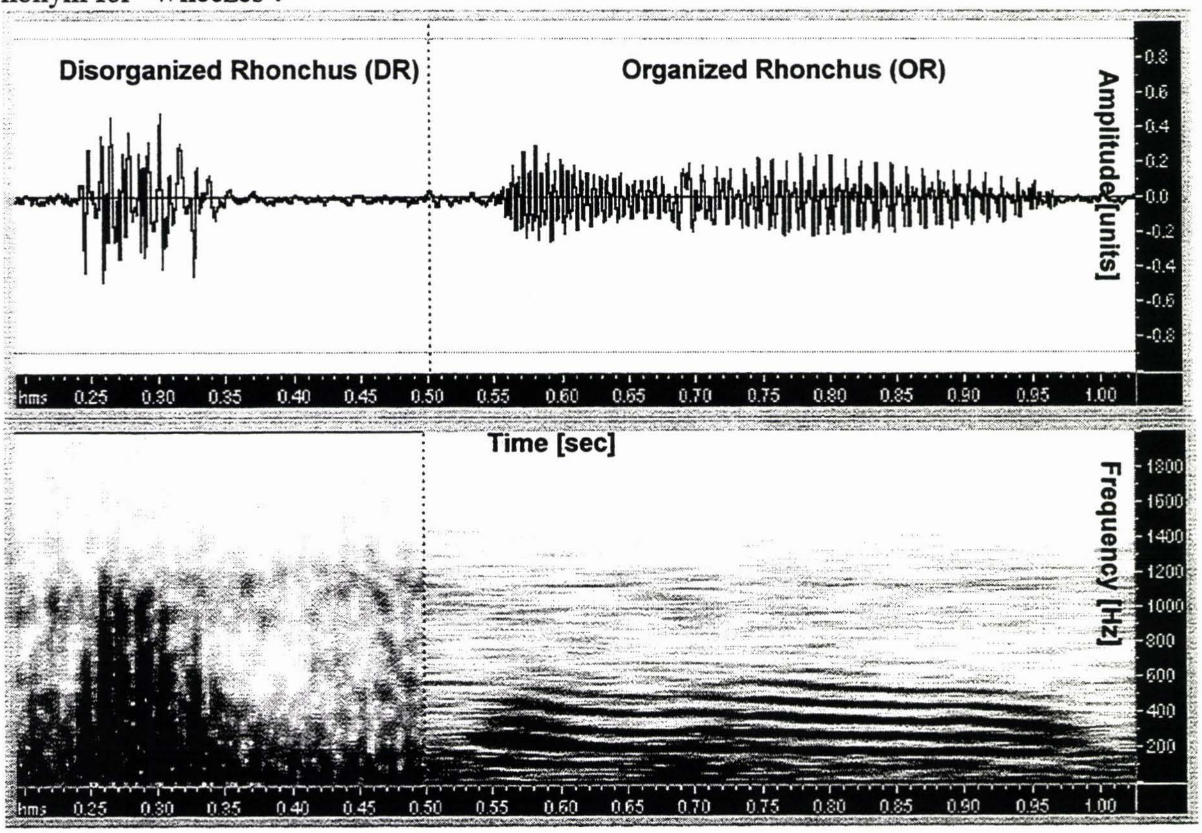
The term 'Rhonchi' is widely used in clinical practice and in published reports. However, it is used in reference to two distinct and mechanistically unrelated breath sounds: (a) it is still used as a synonym to the term 'Wheeze', and (b) it is used to describe low pitch continuous nonmusical breath sounds. The purpose of this report is to provide a clear definition of the acoustic properties of Rhonchi in auscultatory and engineering terms and to describe their clinical context.

Two subtypes of Rhonchi have been identified: organized and disorganized. Organized Rhonchi (OR, right side of Figure) are periodic signals constructed of succession of complex sound structures that are equally spaced in time at a rate of 70-120 complexes per second (upper panel of Figure). The spectral pattern of OR has multiple, equally spaced peaks of power and their sonogram shows multiple parallel lines (lower panel). Disorganized Rhonchi (DR, left side of Figure) are constructed of a succession of crackle-like signals that are irregularly spaced in the time domain, and have a spike-like broad-spectrum sonographic character.

Both subtypes of Rhonchi are distinctly different from wheezes, which have a simple waveform (sinusoidal, or slightly distorted sine wave). Wheezes are usually of higher pitch than Rhonchi and are always periodic.

OR are detected when the airway walls become non self-supporting with a tendency to collapse, such as occurs in tracheo or broncho-malacia and represent flapping flutter of the airway walls. DR are associated with air passage through liquid (mucus)- filled airways, with or without an added component of airway wall softening.

Conclusion: The term Rhonchi should be reserved for the breath sounds that are composed of a regular (OR) or irregular (DR) succession of discrete sound structures. As such they have characteristics of both continuous and discontinuous adventitious breath sounds. The mechanisms of Rhonchi generation are distinctly different from those of wheezes and therefore the term Rhonchi should not be used as a synonym for 'Wheezes'.



<u>Figure:</u> Time (top) and sonographic representation of Rhonchi. Data from a 9 months old baby with history of prolonged intubation and mechanical ventilation in the first month of life (RMPG03002.002_AR).

THE RELATIONSHIP OF LUNG SOUND AMPLITUDE AND TIDAL VOLUME DURING POSITIVE PRESSURE VENTILATION

F. Davidson, V. Power, N. Rec, A. Schwartz and R. Murphy

We studied the relationship of variations in tidal volume delivered by a positive pressure ventilator to lung sound amplitude over the chest in a healthy adult male. Tidal volumes of 400, 600, 800, 1,000 and 1,200 cc's were input via a face mask from a Siemens ventilator in the SIMV mode. The subject was lying on a hospital bed with the head of the bed elevated 30° above the horizontal. Lung sounds were recorded at 10 posterior sites and over the trachea using a multi-channel lung sound analyzer (Stethographics M995).

Lung sound amplitude during inspiration remained flat until tidal volumes of 1,000 cc or more were input to the subject. RMS values then increased with increasing tidal volumes. The expiratory RMS values were unaffected by the changes in tidal volumes. Sound applitude at the upper (cranial) and lower (caudal) sites were not significantly different.

The results of this study support the hypothesis that lung sound analysis can be useful in assessing the effects of ventilator setting changes.

LUNG-SOUND ANALYSIS OF BRONCHIAL BREATHING IN PATIENTS WITH PNEUMONIA

P. Fachinger, V. Gross, M. Fröhlich, J. Sulzer, Th. Penzel, P. v. Wichert

Dept. of Medicine, Div. Pulmonary and Crit. Care Med.,
Philipps-University Marburg, Germany
Baldingerstraße 1, D-35033 Marburg

Introduction

Bronchial breathing sounds can often be heard in patients with pneumonia, especially the expiratory breathing-sounds that change in terms of frequency to higher values. To obtain objective data on these changes, we examined patients with unilateral pneumonia at standardized air flow, who had bronchial breathing patterns and very few disturbances by other breathing sounds, such as crackles.

Methods

We recorded the lung sounds of 12 patients with unilateral pneumonia with two Sony ECM77 air-coupled-microphones. The diagnosis of pneumonia was confirmed by clinical symptoms, auscultation, chest x-ray and blood test results. The exact position of the microphones was chosen by ordinary auscultation based on sufficient sound intensity. A symmetric position to the median-sagittal plane was kept in all cases as their own control. The sounds were amplified and prefiltered in an analogue way (GEPA bandpass 60-1800 Hz, 48 dB/octave). The air flow was measured with a pneumotachograph (160PC, Honeywell-Microswitch Minneapolis) and simultaneously presented on a computer screen to allow breathing at a predefined flow of 1.3 l/sec. Patients had to breathe with the flow of 1.3 l/sec as exactly as possible. All signals were digitized with 5512 Hz and 12 Bit resolution. A time segment of 0.1 sec with constant flow was used for further Fast Fourier Transformation (FFT) sound analysis (Matlab 5.3). The spectrum for the pneumonia side and for the contralateral healthy side was characterized by a ratio Q of an inspiratory and expiratory frequency band (f=300–600 Hz; Q=exp/insp).

Results and Discussion

For all 12 patients a significant Q-difference between the pneumonia and the healthy side was found ($p=0.003$, Wicoxon test). Q always was elevated on the pneumonia side [means: $Q(FFT)_{healty}=0.33\pm0.12$, $Q(FFT)_{pneumonia}=0.95\pm0.69$]. In conclusion, we are convinced that the quotient Q is a good parameter for detecting bronchial sound patterns.

Learning Lung-auscultation via Intranet,
A Multimedia Junior-doctor-teaching project

J.Z. Yuan*, medical student
Drs. C.J.L.H. Camps**
Prof. Dr. P.E. Postmus*, Pulmonologist
Dr. A. Boonstra*, Pulmonologist

*Academic Hospital Free University
**Free University, Medical Faculty

Teaching lung auscultation can be divided into two main parts: learning the technique and learning the different pathological sounds. The first can be easily done on available healthy volunteers (mostly co-students). The latter is dependent on the availability of sick patients with the various lung sounds. Therefore, many recordings are available on various soundmedia. These are to our knowledge hampered by the fact that they are not interactive. A major point in recognizing lung sounds is comparing them with normal sounds, and listening longer or shorter as needed. It has been shown before that reliability of diagnosis of lung sounds is dependent on education.

Therefore, we plan to develop a multimedia; Intranet (in the future, Internet) based application in which medical students can practice in recognizing the various pathologic lung sounds. It is constructed in a way that it copies reality as much as possible. The main goal is teaching lung sounds, but in the future, it can be expanded with differential diagnosis, investigation, therapy and follow-up.

Among the diseases to be recorded are: asthma, COPD/emphysema, pneumonia, heart failure, pleural fluid, bronchiectasis, bronchiolitis, pneumothorax and fibrosis. Most of them have already been recorded. We compared the sounds of three commercially available, or in near future available, devices: Top-phono, Stethos (Hewlett Packard), and Meditron. Among the problems that are encountered are: noise to sound ratio, background noise, difference in sound character between electronic recorded sounds and via classic stethoscope.

The sounds are digitally recorded: the effects of the various compression algorithm that occur, e.g. in recording on a Sony minidisc.

The presentation of the cases will be done in a way that it can be practiced via the various available browsers on Intranet. The software is partially custom-made and includes a system that new patients and sounds can be easily included.

The presentation of sound remains a problem as sound via normal speakers is not comparable to stethoscope generated sound. We will present a solution with various headsets.

RELATIONS BETWEEN NORMAL LUNG SOUNDS AND SUBCUTANEOUS FAT LAYER ON THE BACK

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Baldingerstraße 1, D-35033 Marburg

Introduction

Relations between normal lung sounds and subcutaneous fat layer on the back have not been investigated. We hypothesize that the correlation between lung sounds and BMI found in preliminary investigations are caused by the thickness of the fat layer on the back. We suspect that the fat layer has a filter function for the lung sounds.

Methods

The lung sounds of 100 volunteers (50 male and 50 female) were recorded with four Sony ECM77 air-coupled-microphones (locations: 3^{rd} ICS paravertebral left and right, 7^{th} ICS medio-clavicular line left and right). Skinfold thickness was measured with a Holtain Skinfold Caliper at the same positions as lung sounds were recorded. The absence of lung diseases was checked by lung function. The sounds were prefiltered in an analogue way. The air flow was measured with a pneumotachograph (160PC, Honeywell-Microswitch Minneapolis) and simultaneously presented on a computer screen to allow breathing at a standardized flow of 1.5 l/sec. All signals were digitized with 5512 Hz and 12 Bit resolution. A time segment of 0.1 sec with constant flow was used for further frequency analysis with Fast-Fourier-Transformation (Matlab 5.3). The power spectrum was characterized by median frequency and the ratio R of two different frequency bands [f1 = 60-330 Hz, f2 = 330–600 Hz; R = rel. Power(f2) / rel. Power(f1)].

Results and Discussion

There are no significant changes of breathing sounds with an increase of subcutaneous fat layer on the back. In healthy persons breathing sounds are not dependent on skinfold thickness. The correlation between lung sounds and BMI must be caused by other parameters than skinfold thickness.

ACOUSTIC FEATURES OF PSYCHOGENIC COUGH: CASE REPORT

F. Dalmasso, P. Righini, R. Mantovano, Divisione di Pneumologia Lab. Fisiopatologia ed Acustica Respiratoria, "Mauriziano" Torino, Italy

The cough phonogram is typically characterized by a succession of two or three sounds ("bursts") according to the pathological disorder causing cough and its stage. The presence of a single burst, without any other sound was found in patients after laryngectomy and transiently in patients with vocal cord paralysis. Korpas found cough with a single burst in patients with psychogenic disorders. A student girl, eleven years old, presented with persistent cough for four months. She had whooping-cough: the personal history, the physical examination, function, imaging and hypersensitivity tests performed did not clarify the problem. Questioning the patient, she disclosed school problems and conflicts with other students and teachers. During examination the cough signal was recorded and sent to the Audio-Card Multi Sound Tahiti for acquisition and reproduction of the signal and then analyzed by Spectra Plus System 3, 16, in the time-frequency domain. The cough events are typically characterized by a single "burst" of short to middle duration (100-240 ms). The events are separated by a short time interval (20-110 ms) and typically repetitive. Sonogram identifies immediately the repetitive cough pattern. The time history is identical during the all recording (28 min) and the impulsive events have similar duration spectrum frequency and percentiles of the spectrum. It was possible to clearly distinguish the voice of others present and the voluntary cough events produced by the physician as a control. The automatic identification of cough events is also possible. The recorded signal, spectrum, and tri-dimensional presentation (waterfall, sonograms) will be simultaneously performed during the poster exhibition..

A COUGH MONITORING SYSTEM BASED ON A PORTABLE PHONO-METER

F. Dalmasso, G. Righini, P. Righini, V. Didonna, E. Isnardi, Division di Pneumologia e Lab. Fisiopatologia e Acustica Respiratoria. Osp. "Mauriziano", L. go Turati 62, Torino, Italy

Various types of apparatus have been used to monitor cough. They generally use sensors attached to the skin to detect sounds. For triggers of identification, they use abdominal muscle EMG and/or ECG. The aim of this study is to provide a new approach to the problem by detecting cough in free field without any physical connection to the patient. The detection of cough was made by observing the subjects (n=4) and the patients (n=4) cough spontaneously and asking them to cough voluntarily as well as to speak loudly, to sigh and to snore. This was done in order to identify the event of cough and validate the system.

The equipment consists of: 1) An Integrating Sound Level Meter which provides the simple sound analysis, real time frequency and Fast Fourier Transform analysis (System 824 SLM/RTA,LD, USA), 2) A Software N&V (Spectra s.r.l. MI,I), 32 bit for Windows for calculation, analysis in the time-frequency domain, graphical representation by sonograms and automatic identification of events working with PC-Autotrsf., Audio File for simultaneous acquisition of the audio associated with the events. In all Sb and Pt studied, the count of cough events (total 124) presenting as sonograms exactly corresponds (100%) to the cough sounds counted by two observers. In all cases (100%), by audio file, it has been possible to identify a single cough event, random, or in a series and the differentiation from similar impulsive events due to the voluntary simulation i.e., the validation of the system. The automatic counting, based on fixed time-frequency parameters in the 99.9% of cases identify the cough sounds. A monitoring test will be performed during the poster exhibition.

WHEEZERS AND NONWHEEZERS

Sadamu Ishikawa, Jose Marquina, Kenneth F. MacDonnell, Bartolme Celli

Tufts Lung Station, St. Elizabeth's Medical Center, Department of Medicine, Tufts University School of Medicine, Boston, MA, USA

Some asthmatics wheeze and some do not. E intended to identify Wheezers from Nonwheexers by means of lung sounds and pulmonary function testing.

18 patients who came to our Fulmonary Function Laboratory for methacholine challenge testing for possible clinical diagnosis of Bronchia Asthma and were randomly selected. 6 were non responders to methacholine (NR). 6 were responders to Methacholine and developed audible wheezing whose FEV1 fell by 20% or more at the end point of the challenge (WR). 6 were responders to methacholine whose FEV1 fell by 20% or more at the end point of the challenge in the absence of concomitant wheezing (NWR). Lung sounds were recorded at 5 sites, trachea, right upper lobe posteriory, right lower lobe posteriory, left upper lobe posteriory, and left lower lobe posteriory. Using a Fast Fourier transform spectroanalyzer, the recorded sounds were digitized and real time spectrograph displayed and analyzed by computer.

All the responder patients (both WR and NWR) markedly decreased inspiratory sound intensity when FEV1 is decreased more than 20%, while no change in tracheal sounds. The breath sound changes were completely reverted by the inhalation of albuterol. Except for presence of wheezing on quiet breathing, there were no differences in degree of change in breath sound, intensity, breathing pattern or PFT change. We were unable to identify NWR from WR.

Lung Sounds and Lung Function – An Educational Video

Hasse Melbye, MD, PhD, Institute of Community Medicine, University of Tromso, Norway

An educational video has been developed with the aim of presenting updated knowledge about lung sounds to general practitioners and medical students. In the first part of the video normal lung sounds are presented, and the character and intensity of the sounds are shown to depend on the location of the stethoscope and the airflow generated by the patient. The second part demonstrates the most common abnormal sounds: wheezes, crackles and diminished breath sounds. In the third part nine patients are presented, and the auscultatory findings are demonstrated together with medical history and additional examinations. The video is interrupted by questions to the viewers, intended to bring about discussions about the sounds heard, the diagnoses and how the patients should be treated. In an accompanying book, the viewers may find comments concerning the different questions. The duration of the video is about 40 minutes.

Sequences from the video will be shown and some experiences with this video in out medical school and in continuing medical education will be presented.