THE 22nd
INTERNATIONAL CONFERENCE
ON LUNG SOUNDS

第22回国際肺音学会

Presented by

International Lung Sounds Association

October 15-17,1997

Tokyo, Japan

FINAL PROGRAM AND ABSTRACTS

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GENERAL INFORMATION

Conference venue
Hotel Sofitel Tokyo

Official language (simultaneous interpretation)
English, Japanese

Registration and secretariat during the conference
Registration will be held in front of the conference hall on :

Wednesday, October 15	14:00 -	15:00
Thursday, October 16	8:00 -	10:00
	12:00 -	13:30

Registration fees
Participants $ 200, spouses / companions $ 100, schlorship recipients $ 100

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

Posters
Posters will be displayed in the conference hall from 8:45 a.m. on October 16 until 4 p.m. on October 17. During the poster session, an oral presentation of five minutes and the discussion of seven minutes are held for each poster.

Hotel accommodation
Hotel Sofitel Tokyo
2-1-48 Ikenohata, Taito-ku, Tokyo 110 Japan
Tel. : +81 - 3 - 5685 - 7111, Fax. : +81 - 3 - 5685 - 6171
Accommodation fees (only 14 -17)
Participants : $100 (with one companion : $120) / day

Breakfast, lunch and Coffee
Continental breakfast, lunch and coffee are included in the registration fee of active participants at the Hotel Sofitel Tokyo on October 16th and 17th

Welcome party
On October 15th, a wine and cheese reception will be held in the Hotel Sofitel Tokyo at 6:00 p.m. To welcome the participants and their companions.

Banquet
The banquet will be held at CHINZANSO at 6:00 p.m .on October 16th.
Bus Departure at 5 p.m.

Sponsors
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The 22nd International Conference on Lung Sounds

Tokyo, JAPAN, October 15-17, 1997

1976 Boston, MA
1977 Cincinnati, OH
1978 New Orleans, LA
1979 Chicago, IL
1980 London, England
1981 Boston, MA
1982 Martinez, CA
1983 Baltimore, MD
1984 Cincinnati, OH
1985 Tokyo, Japan
1986 Lexington, KY
1987 Paris, France
1988 Chicago, IL
1989 Winnipeg, Canada
1990 New Orleans, LA
1991 Verona, Italy
1992 Helsinki, Finland
1993 Calgary, Canada
1994 Haifa, Israel
1995 Long Beach, CA
1996 Chester, Engkand
1997 Tokyo, Japan

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A. Zitting

PROGRAM

The 22nd International Conference on Lung Sounds
October 15-17, 1997
Tokyo, Japan

Program

WEDNESDAY, October 15

2:00 - 3:00	Registration
3:00 - 4:00	**Workshop I : Lung Sounds Nomenclature** **S. Kudoh, M.D.,Nippon Medical School, Tokyo**
4:00 - 5:00	**Workshop II : European guidelines for computerized respiratory sound analysis (CORSA)** **A. Sovijarvi, M.D., Helsinki University Central Hospital, Finland** A. Sovijarvi, J. Vandershoot, J. Earis, P. Helisto, F. Dalmasso, E.Ademovic, G. Charbonneau, B. Cheetham, C. Donner, A. Giordano, T.Katila, E. Lens, P. Malmberg, G. Postiaux, G. Righini, M. Rossi, C. Sacco, H. Schreur, S.Stoneman, L. Vannucuni, Finland
6:00 -	Reception and Welcoming Address

THURSDAY, October 16

8:55 -	Welcome - Masashi Mori, M.D.

Session A : Basic Science
Chairmen : H. Pasterkamp, M.D. / S. Stoneman, M.D.

9:00 - 9:20	Changes in normal breath sound spectra during iso-flow maximum volume breathing M. Takase, H. Pasterkamp, Canada
9:20 - 9:40	Chest wall sounds during isometric inspiratory efforts Y. Inaba, G. Chi-Lem, D. Kriellars, H. Pasterkamp, Canada
9:40 - 10:00	Density dependence of sound attenuation between 50 and 600 Hz in excised pig lungs filled with air and helium A. Leung, S. Sehati, J. Young, United kingdom
10:00 - 10:20	The distribution of crackles over the chest wall F. Davidson, R. Murphy, P. Krumhansl, United States
10:20 - 10:40	A simple method for detecting bronchial breathing sound F. Schuttler, J. Sulzer, T. Penzel, P. von Wichert, Germany
10:40 - 11:00	Coffee Break
11:00 - 12:00	**Lecture** Chairman : M. Mori, M.D. **- Change of Shinkansen Noise -** Railway Technical Research Institute (R.T.R.I) Environmental Preservation & Disaster Prevention Technology Development Division Senior Engineer (Aerodynamics & Noise Reduction Group) **Yasuo Zenda, PhD.**
12:00 - 13:30	Photo & Lunch (to TOHTENKOH)

THURSDAY, October 16

Session B : Clinical Science
Chairman : R. Loudon, M.D. / J. E. Earis, M.D.

13:30 - 13:50	Nocturnal wheezing count and serum theophylline concentration in bronchial asthma H. Kiyokawa, M.Yonemaru, S. Horie, Y. Ichinose, K. Toyama, Japan
13:50 - 14:10	The effects of a pillow on the tracheal sounds H. Tanahashi, A. Shibuya, S. Choh, S. Kudoh, Japan
14:10 - 14:30	Lung sound analysis in asbestos exposed subjects P. Piirila, L. Kivisaari, H. Koskinen, H. Lehtola, H. Nordman, S.P. Salo, A. Zitting, A. Sovijarvi, Finland
14:30 - 14:50	Coffee Break
14:50 - 15:10	Cough as a stop consonant R. Loudon, United States
15:10 - 15:30	The acoustic properties of productive cough and its relevance to the symptoms Y. Hashimoto, A. Murata, Y. Kaneko, Y. Taniguchi, A. Azuma, S.Kudoh, Japan
15:30 - 15:50	Sequential distribution of lung sounds during respiration F. Davidson , R. Murphy, United States
15:50 - 16:10	Comparison of tracheal and voice sound spectral features H. Pasterkamp, Y. Inaba, G. Chi-Lem, S. Kraman, G. Wodicka, Canada & United States
16:10 -	Poster Viewing
17:00 -	Banquet (Chinzanso - Bus Departure 17:00)

FRIDAY, October 17

Session C: Instrument / Computer
Chairmen : N. Gavriely, M.D. / C. Druzgalski, PhD.

9:00 - 9:20	Characteristic of the lung-sound transducer A. Suzuki, K. Nakayama, Japan
9:20 - 9:40	Combination of crackle analysis with flow-volume display -A new tool in the assessment of pulmonary disease P. Helisto, J. Vanderschoot, P. Lipponen, P. Piirila, J. Makila, A.Sovijarvi, Finland
9:40 - 10:00	Effects of finite-stiffness support on the frequency characteristics of an accelerometer-type stethoscope F. Sakao, H. Sato, M. Mori, Japan
10:00 - 10:20	Network / pc / mac requirements and formats for archiving and interchange of lung sounds files C.Druzgalski, United States
10:20 - 10:40	Coffee Break
10:40 - 11:00	Utilizing wave audio files for lung sound archiving,telemedicine and case review C. Irving, N.Gavriely, Israel

FRIDAY, October 17

11:00 - 11:20	Continuous monitoring system of respiratory sound for the patient in ICU M. Hosomura, T. Yamahata, M. Nakayama, K. Kikuchi, N. Furuta, H. Tsubakiyama, Japan
11:20 - 11:40	Correction of sound amplitude calculations for adventitious sound contribution in chronic obstructive lung disease patients M. Murphy, K. Bergstrom, P. Krumhansl, L. Mylott, R. Murphy, United States
11:40 - 12:40	Lunch
12:40 - 13:00	Business Meeting

Session D: Clinical science
Chairmen : R. Murphy, M.D. / A. Sovijarvi, M.D.

13:00 - 13:20	Lung sounds frequencies are increased in patients with asthma-like inflammation A.Sovijarvi, A. Saarinen, P. Malmberg, T. Helin, B. Pekkanen, P. Helisto, E. Varsila , T. Haahtela, L.Laitinen, Finland & England
13:20 - 13:40	Effect of the depth of inspiration on expiratory flow and lung sounds in COPD - A video demonstration H. Melbye, Norway
13:40 - 14:00	Changes in lung sounds following bilateral thoracotomy lung volume reduction surgery in patients with emphysema S. Ishikawa, V. Pinto-Plata, I. Kogan, J. Rassulo, J. Stetz, K. MacDonnel, B. Celli, United States
14:00 - 14:20	Characteristics of lung sounds in patients with pneumonia and congestive heart failure R. Murphy, United States
14:20 - 14:40	Coffee Break

Poster Discussion Session
Chairmen : P. Piirila, M.D. / S. Ishikawa, M.D.

14:40 - 15:40 Poster Presentation : Presentation 5 minutes, Discussion 7 minutes

A sonogram-based real time lung sound analyzer and algorithm for real time wheeze detection

J. Makila, P. Lipponen, P. Helisto, Finland

Wheeze originated from the opening of sub-carinal bronchial cyst into main bronchus

T. Takahashi, S. Ohizumi, S. Ogura, M. Munakata, Y. Homma, Y. Kawakami, Japan

Simulation of coarse crackles by simple experimental arrangements

K. Tanaka, Japan

FRIDAY, October 17

A new computer system to detect snoring and apnea/hypopnea by tracheal sounds analysis
H. Nakano, Y. Ohnishi, K. Matsuzawa, J. Maekawa, N. Narita, Japan

Intensity and frequency content of breath sounds in patients with emphysema
K. Sano, H. Nakano, J. Maekawa, N. Narita, Japan

15:40 - 15:50 Closing Remarks - Raymond L.H. Murphy, M.D.

15:50 - Executive Committee Meeting

ABSTRACTS

WEDNESDAY, October 15

3:00 - 4:00 **Workshop I : Lung Sounds Nomenclature**

S. Kudoh, M.D.,
Nippon Medical School, Tokyo

4:00 - 5:00 **Workshop II : European guidelines for computerized respiratory sound analysis (CORSA)**

A. Sovijarvi, M.D.,
Helsinki University Central Hospital, Finland

A. Sovijarvi, J. Vandershoot, J. Earis, P. Helisto, F. Dalmasso, E.Ademovic, G. Charbonneau, B. Cheetham, C. Donner, A. Giordano, T.Katila, E. Lens, P. Malmberg, G. Postiaux, G. Righini, M. Rossi, C. Sacco, H. Schreur, S.Stoneman, L. Vannucuni, Finland

WORKSHOP I : LUNG SOUND NOMENCLATURE - Today

Shoji Kudoh, M.D.
Nippon Medical School, Tokyo

At the International Symposium on Lung Sounds Auscultation affiliated the 10th Conference of ILSA (Tokyo) in 1 985, we discussed about the adjustment on the nomenclature among five countries including US, UK, France, Germany and Japan. Consequently, we defined the terms in these countries regarding four kinds of basic pulmonary adventitious lung sounds according to Laennec's original classification, i.e., fine crackles, coarse crackles, wheezes and rhonchi [1]. Today after more than ten years from the previous Tokyo meeting, several problems seem to remain unsettled on lung sounds nomenclature as follows;

1 . "Medium Crackles": Individual crackle can be classified into fine and coarse crackle according to the wave form by subjective analysis. Is there an intermediate type between fine and coarse in individual crackle? However, "fine crackles" and "coarse crackles" are essentially terms on auscultation by objective acoustic sense. Actually, several coarse crackles may mix in "fine crackles"[2]. "Medium crackles" should be also a term of auscultation, if this category could be accepted. The most important point is in clinical efficacy of this term.

2. Two Types of Rhonchi: Until now, two types of "rhonchi" have been reported. One is a low pitched wheeze that consists of obviously continuous sounds[3]. The other is completely different from a wheeze and is like snoring sounds in wave form, which consist of a pulse-train with regular interval[4]. Is it true that these two types exist in patients? Can we tell the difference by hearing? If we should classify the nomenclature according to mechanisms of sound generation, it is an idea that we call the sounds of a pulse-train as "rhonchi" and the continuous sounds as low pitched wheeze, because it is not important to classify the sounds only according to the quantitative difference and because it has been a problem how to deal with intermediate sounds between 200-400 Hz.

3 . "Squawk" and "Stridor": Pulmonary adventitious sounds are divided into continuous and discontinuous sounds according to the sound duration. If so, "squawk" should be classified as discontinuous sounds, although "squawk" has been sometimes called "short wheeze". In the same way, "stridor" should be classified as continuous sounds. However, I have another question whether we should classify the sounds according to the sound duration, because there is a different stand point in which the sounds are classified according to continuation of the initial sound energy. From this stand point, in case of a triangle or a church-bell with a long echo, the sounds should be classified as discontinuous sounds even if the sounds have long duration. It is also a problem how to deal with rhonchi of the pulse-train.

References:

1)Mikami R. et.al.: International symposium on lung sounds, Chest, 92:342, 1987
2)Gavriely N: Breath sounds Methodology, CRC Press, p2 1, 1995
3)Murphy RLH, et al. : Visual lung-sound characterization by time-expanded wave-form analysis, New Eng J Med, 296: 968, 1978
4)Loudon RG, Murphy RLH: Lung sounds. State of the Art, Am Rev Respir Dis, 1 3 8 :663, 1 984

WORKSHOP II : EUROPEAN GUIDELINES FOR COMPUTERIZED RESPIRATORY SOUND ANALYSIS (CORSA)

A.R.A. Sovijarvi, M.D.
Helsinki University Central Hospital, Finland

A.R.A. Sovijarvi [1], J. Vandershoot, J. Earis, P. Helisto [4], F. Dalmasso[5], E. Ademovic [6], G. Charbonneau [6], B. Cheetam [3], C.F. Donner [7], A. Giordano [7], T. Katila [4], E. Lens [8], P. Malmberg [1], P. Piirila [1], G. Postiaux [8], G. Righini [5], M. Rossi [9], C. Sacco [7], H. Schreur [2], S.A.T. Stoneman [10], L. Vannucini [9].
1 Helsinki University Central Hospital, 2 Leiden, 3 Liverpool, 4 Helsinki University of Technology, 5 Torino, 6 Paris, 7 Veruno, 8 Courcelles, 9 Arezzo, 10 Swansee

CORSA is a concerted action project of the European Community (EC, BIOMED 1) and an European Respiratory Society (ERS) task force for standardization, development and validation of computerized respiratory sound analysis for clinical use. The project was started in 1994. Thirteen centers in Europe have been participating in CORSA.

The CORSA papers to be published include definitions of 150 terms in the field of respiratory acoustics, guidelines for capturing and preprocessing respiratory sounds, suggestions for standardization of experimental conditions and procedures, of digitization of data, guidelines for report contents and form and for basic standards of analysis of respiratory sounds. The papers include also a comprehensive survey of current European activity in the field of respiratory sound studies (methodology and scientific activity) and suggestions for how to produce reference values of respiratory sounds in healthy subjects and in certain disease groups. In addition, a series of original papers for the development of signal processing and feature detection of respiratory sounds have been prepared within the frame work of the CORSA project.

This project is supported by: EC, Biomed 1, BMH1 - CT94 - 0928 and ERS.

THURSDAY, October 16

Session A : Basic Science

Chairmen : H. Pasterkamp, M.D. / S. Stoneman, M.D.

9:00 - 9:20	Changes in normal breath sound spectra during iso-flow maximum volume breathing M. Takase, H. Pasterkamp, Canada
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10:40 - 11:00	Coffee Break
11:00 - 12:00	**Lecture** Chairman : M. Mori, M.D.

- Change of Shinkansen Noise -

Railway Technical Research Institute (R.T.R.I)
Environmental Preservation & Disaster Prevention
Technology Development Division
Senior Engineer (Aerodynamics & Noise Reduction Group)

Yasuo Zenda, PhD.

CHANGES IN NORMAL BREATH SOUND SPECTRA DURING ISO-FLOW MAXIMUM VOLUME BREATHING

Masato Takase [1] and Hans Pasterkamp [2]

1) Dept. of Pediatrics, Nippon Medical School, Tokyo,Japan
2) Dept. of Pediatrics, University of Manitoba, Winnipeg, Canada

It is generally accepted that normal breath sound spectra should be averaged over several breaths in order to obtain a reproducible average spectrum. Typically the sound segments within a defined target flow range will be used in the calculation. In order to obtain as many iso-flow segments in a limited recording time as possible, one might assume that deep breathing at constant flow rate (iso-flow maximum volume breathing) would be the most efficient breathing pattern for lung sound recording. This would be true if the effects of lung volume on normal breath sound spectra are negligible.

We recorded breath sounds of five healthy male adults with normal lung function, using two accelerometers (EMT-25C, Siemens) at the right upper anterior (RUA) and the right lower posterior (RLP) chest. Subjects breathed at a target flow of 1 l/s and then 2 l/s. They were instructed to keep their inspiration and expiration within the target flow range as long as possible. Filtered and amplified sound signals were digitized at 10,240 samples/s and acquired to a notebook computer. Power spectral estimates (2048 point FFT, Hanning window, 50% overlap) of successive sound segments were then calculated. Artifacts were identified and removed from further analysis through visual and acoustical verification. Mean power within 5 octave bands (P1: 75-150Hz, P2: 150-300Hz, P3: 300-600Hz, P4: 600-1200Hz, P5:1200-2400Hz), median frequency and spectral edge frequency within the 150-1200Hz range were calculated for every segment. We then compared these parameters in their relation to lung volume (early 1/3, mid 1/3, late 1/3 of the respiratory phase).

At RUA, P3 showed the closest correlation with flow and had highest power in the early 1/3 of inspiration. At RLP, P3 had highest power in the late 1/3 of inspiration. These observations follow the known pattern of regional pulmonary ventilation. However, at lower frequencies, power tended to be lowest in mid inspiration or mid expiration at either recording site. Power-flow correlation was poorest for P1, suggesting a substantial influence of non- respiratory sounds, e.g. heart and muscle noises in this frequency range. Since lung sound spectra change considerably during iso-flow maximum volume breathing we suggest that breath sounds should be recorded during more natural, effortless breathing in order to minimize the effects of changing lung volume and possible distortion by muscle noise.

Supported by Nippon Medical School (M.T.) and the Children's Hospital of Winnipeg Research Foundation (H.P.)

Chest wall sounds during isometric inspiratory efforts

Yaoki Inaba, M.D., Georgina Chi-Lem, M.D., Dean J. Kriellars, Ph.D.,
and Hans Pasterkamp, M.D.
University of Manitoba, Winnipeg, Canada

Respiratory sounds at the chest wall show most spectral power to be below 300 Hz. In this low frequency range, sound sources other than turbulent flow within airways contribute substantially to the signal. To determine the potential contribution from muscle sounds, we studied 8 healthy adult volunteers (6 male, 2 female, ages 26 to 36). Recordings were obtained during static (isometric) maneuvers at various levels of inspiratory pressure in all subjects. Simultaneous chest surface electromyograms (EMG) were obtained in 3 subjects, and comparative phonomyograms of the vastus lateralis muscle were recorded in 3 subjects. With maximum static inspiratory pressures (MIP) determined, they performed isometric inspiratory maneuvers at 5, 10, 20, 30, 40, 50, 60 and 80% of MIP. Similarly, maximum voluntary contraction (MVC) and different levels of isometric contractions of the quadriceps muscle were performed. Chest wall sounds were recorded at each target with a piezoelectric accelerometer (Siemens EMT25C) on the right lower chest for at least 3 seconds at functional residual capacity (FRC), FRC + 25% of vital capacity (VC) and FRC + 50% VC. Leg muscle sounds were recorded similarly at 20o and 700 of knee flexion. Fast Fourier transformation analysis provided estimates of spectral power within octave bands 1 (40-75Hz), 2 (75-150 Hz), 3 (150-300 Hz) and 4 (300-600 Hz). We found in both chest wall and leg recordings a force dependent linear or curvilinear increase , of spectral power in octave bands 1 and 2, to a lesser degree also in octave band 3, but not in octave band 4. The observed increase was steepest at FRC + 50% VC and at knee flexion of 200, i.e. at shorter muscle fiber length. Chest wall sounds at lower frequencies followed closely the increase in EMG in the 3 subjects who had simultaneous measurements. We conclude that respiratory sounds below 300 Hz at the chest wall overlap substantially with muscle sounds, particularly during increased effort and at higher lung volumes. Our findings may explain the relative lack of gas density effects and the weaker correlation of respiratory sound intensity with air flow at lower frequencies.

This study was supported by the Nippon Medical School, Tokyo (Dr. Inaba) and the Manitoba Lung
Association (Dr. Chi-Lem).

DENSITY DEPENDENCE OF SOUND ATTENUATION BETWEEN 50 AND 600 Hz IN EXCISED PIG LUNGS FILLED WITH AIR AND HELIUM

A.H. Leung, S. Sehati and J.D. Young*
School of Engineering, Oxford Brookes University, Oxford OX3 0BP, UK
*Nuffield Department of Anaesthetics, University of Oxford, Oxford, UK

Introduction: Sound attenuation through lung parenchyma may depend on local density, so mapping attenuation on the body surface may provide a non-invasive technique to monitor lung morphology.

Methods: Ten pairs of excised pig lungs were studied. Pure tones at 12 frequencies between 50 and 600Hz were introduced into the trachea and recorded at the lower trachea and posterior surface of the lung. Sound attenuation was measured at 6 different degrees of inflation (and hence density) of the lung with air and helium.

Results: An iso-attenuation point (constant attenuation at different lung densities) was found 15.5+2dB at 90+10Hz (air) and 9+1dB at 150+10Hz (helium). The maximum change of attenuation with density was 2dB per 0.01g/ml at 150Hz (air), and 1dB per 0.01g/ml at 250Hz (helium).

Conclusion: The iso-attenuation point may indicate the transition from a low frequency gas movement (open cell) model to higher frequency gas compression (close cell) model and is dependent on gas density. Helium can move interregionally better than air so the frequency range of the open cell model is extended. The higher sensitivity of attenuation in air shows that the transmission pathway may not be dominated by parenchyma. This iso-attenuation point may be used to select a reference frequency for sound attenuation mapping of lung density.

THE DISTRIBUTION OF CRACKLES OVER THE CHEST WALL

Davidson F, Holford S, Krumhansl P, Murphy R

In previous work we observed that the radius of dispersion of crackles over the chest wall varied from 4.3 to 6.6 cm in the 258 crackles we analyzed. This work was performed using six microphones placed peripherally in four different circular arrays with a distance (or "radius") from the central to each peripheral site of 2.5, 5.0, 7.5 and 10 centimeters. This procedure did not allow mapping of the size and shape of the area of the chest where an individual crackle is distributed. In the current investigation, we used a multichannel lung sound analyzer to obtain data from 16 channels simultaneously. Our observations concerning the radius of dispersion of crackles confirm our previous ones. The implications of these findings will be discussed in terms of correct theories on crackle generation.

A SIMPLE METHOD FOR DETECTING BRONCHIAL BREATHING SOUND

F. Schuttler, J. Sulzer, T. Penzel, P. von Wichert
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Introduction: Bronchial breathing sounds often contain important diagnostic information. A simple method has been developed to extract a parameter from lung sound recordings that could determine the probability of bronchial sound pattern.

Method: The lung sounds of patients with one-sided pneumonia were recorded simultaneously with four air-coupled microphones (Sony ECM 77) from the 7th and 3rd dorsal intercostal space. The exact location was chosen by ordinary auscultation based on sufficient sound intensity, but a symmetric position to the median-sagittal plane was kept in all cases. The sound signals were prefiltered with a band pass filter, which lets through and amplifies a frequency of 60-21100 Hz (48 dB/oct) (GEPA, TF/TP-MF-01-48-B). All sound signals and the airflow (Fleisch No. 2) were digitally recorded with 12 bit resolution and a sampling rate of 5512 Hz (SORCUS, M-4/486, M-AD-12/16). After the measurement, all sound recordings were classified independently by three experienced physicians. For the spectral analysis of sound signals a 256-point FFT was performed with 50% overlapping of an adjacent Hanning data window (MATLAB 4.2c1). For each window position T the relative power in the frequency band 400-700 Hz was computed and weighted with the corresponding flow value. The result can be described as a function $RP_{400\text{-}700}$ (T). The values of the function were calculated from bronchial breathing sounds (the pneumonia side) and the contralateral vesicular breathing sounds (the healthy side).

Conclusion: 4 patients with pneumonia have so far been investigated. During inspiration, the *RP* ofthe bronchial sound was higher than in expiration in all subjects. This difference was more clear during expiration (see figure). Further investigations are necessary to obtain statistical relevance.

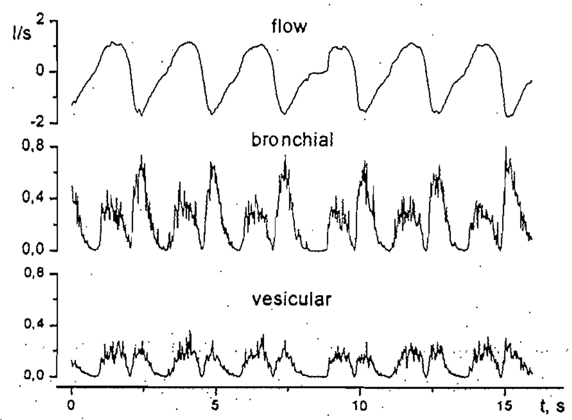

Figure: Relative band power *RP* of the lung sound of one patient with one-sided pneumonia. Top:airflow (positive values mean inspiration), middle: RP function of the bronchial sound pattern, bottom: *RP* function of the vesicular sound pattern.

LECTURE

Chairman : M. Mori, M.D.

- Change of Shinkansen Noise -

Railway Technical Research Institute (R.T.R.I)
Environmental Preservation & Disaster Prevention
Technology Development Division
Senior Engineer (Aerodynamics & Noise Reduction Group)

Yasuo Zenda, PhD.

To obtain the methods to reduce Shinkansen railway noises, it is necessary to locate their sources and to clarify the physical mechanisms of the noise generation. We have been studying and developing the methods of reducing noise and have been applying the countermeasures since an opening of Shinkansen. Here the main devices of countermeasures and the possibilities of noise reduction are outlined.

1 . Noise sources of Shinkansen

The final goal of the research about the railway noise is to find the methods to reduce the noise. The starting point of the noise control is to make clear where the various noises are generated when a car is running, and to find the contribution of each noise source to the total noise at a concerned observation point. We give an outline of noise control.

Noise sources of Shinkansen are classified into two groups, that is, the vibration of various parts of cars and the disturbance of air flow caused by the running train. As the principal noise sources which belong to the former, there are the vibration of a rail and a wheel , the vibration of a gear between a main motor and an axle, and the vibration of a bridge structure. We call each noise generated from each vibration rolling noise, the gear noise and the bridge structure noise respectively. The non-stationary air flow caused by various parts of the ear surface generates the noise, and we call it an aerodynamic noise. The main noises of Shinkansen observed alongside tracks are these 4 types of noise. In addition, we usually divide the aerodynamic noise into two groups, that is, the pantograph aerodynamic noise and the aerodynamic noise induced by parts of the car other than the pantographs (we call it a car aerodynamic noise). It is one of the most important purposes of analysis of the Shinkansen noise to separate the wayside noise into these 5 types of noise and to evaluate each of them quantitatively.

2 . Methods Applied to Reduce Each Noise

(1) Rolling Noise, Gear,Noise

It is widely known that the smoothing of a wheel-tread and a rail surface reduces the noise effectively and has been applied practically. A damped wheel and a resilient wheel were eagerly investigated and didn't have any effect on reducing the rolling noise about 20 years ago, however they have been studied again recently because the weight of a car becomes lighter. There is no attractive trial against the gear noise. It is the subject for a future study. The test of absorbing material on slab track surface has been carried out for the reduction of rolling noise and gear noise at the slab tracks.

The effect of this method depends on how effective the absorbing material is laid on slab track surface. The noise barrier is effective to reduce the noise generated from the lower part of car (rolling noise, gear noise and a part of aerodynamic noise) at the wayside. Now, the straight barrier, the inverted L type barrier and the straight barrier with an interference type muffler are generally built. They are about 2 m high from the rail level. In some cases, the absorbing materials are added on the barriers.

(2) Concrete Structure Noise

The ballast mat has been found effective against concrete structure noise at the ballast track. The isolating sleeper for vibration has also been developed showing the effect of the reducing noise. The low spring constant of rail fastening device is effective for the reduction of structure noise on the slab track.

(3) Pantograph Noise

A spark noise generated when a pantograph separates from an overhead wire has almost vanished by connecting some pantographs electrically with a "bus" and the reduction in the number of pantographs has been tried, Followed these countermeasures, a "pantograph shield" has been developed contributing to reduce the pantograph aerodynamic noise. Recently, new types of a pantograph and a pantograph shield are being developed in order to be mounted on the high speed train,

(4) Car Aerodynamic Noise

The generation of a ear aerodynamic noise depends on the surface of cars. The method of reducing car aerodynamic noise proceeds with the development of high speed trains. The various noise sources on the upper part of the car (the louvers of air inlets and outlets, insulators, air conditioners, antennae) have been removed and the upper part of the ear has been smoothened as far as possible. These countermeasures are effective to reduce aerodynamic noise.

3. Prospect for Shinkansen Noise

The Shinkansen noise generation is found to depend on the car type and the countermeasures taken. We have paid attention to maintaining the noise level ($L_{A, MAX}$) at the wayside 25m away from the track less than 75dB(A) which is regulated by the environmental standard with respect to Shinkansen noise. On the other hand, JR railway companies have embarked on the speed-up of Shinkansen (270-300km/h) since about 1987. A new ear producing less aerodynamic noise has been developed to hold the noise level 75dB (A) under the speedup of Shinkansen. The characteristic of aerodynamic noise is gradually revealed through the speed-up running test, and the information thus obtained is useful for noise control of not only high speed train but also slow train. Accordingly, we can not advance closer to the solution of the problem of noise control until some higher targets are set. Each countermeasure for the noise mentioned above had a motive of its development. Presently, we have reached the stage where Shinkansen noise at the wayside (25m away from the track) is maintained less than 75dB (A) up to 300 km/h by countermeasures mentioned above.

Next target is to attain 75dB (A) at 350km/h for example. This goal will be achieved in the near future. We sort out the problems we have to tackle as follows.

(1) The solution to various kinds of problems including the stability of aerodynamic lift force In development of a new, less aerodynamic noise pantograph.

(2) The countermeasure for the noise generated from the lower part of the ear. Especially, the development of a new method of noise reduction for the rolling noise and the gear noise. The application of the absorbing material under the car floor near the bogies.

(3) The development of a better method for reduction of ca,r aerodynamic noise. The evaluation of the aerodynamic noise generated from the gaps between the adjacent cars and the lower part of cars.

(4) The development of the effective noise barriers.

THURSDAY, October 16

Session B : Clinical Science

Chairman : R. Loudon, M.D. / J. E. Earis, M.D.

13:30 - 13:50	Nocturnal wheezing count and serum theophylline concentration in bronchial asthma H. Kiyokawa, M.Yonemaru, S. Horie, Y. Ichinose, K. Toyama, Japan	
13:50 - 14:10	The effects of a pillow on the tracheal sounds H. Tanahashi, A. Shibuya, S. Choh, S. Kudoh, Japan	
14:10 - 14:30	Lung sound analysis in asbestos exposed subjects P. Piirila, L. Kivisaari, H. Koskinen, H. Lehtola, H. Nordman, S.P. Salo, A. Zitting, A. Sovijarvi, Finland	
14:30 - 14:50	Coffee Break	
14:50 - 15:10	Cough as a stop consonant R. Loudon, United States	
15:10 - 15:30	The acoustic properties of productive cough and its relevance to the symptoms Y. Hashimoto, A. Murata, Y. Kaneko, Y. Taniguchi, A. Azuma, S.Kudoh, Japan	
15:30 - 15:50	Sequential distribution of lung sounds during respiration F. Davidson , R. Murphy, United States	
15:50 - 16:10	Comparison of tracheal and voice sound spectral features H. Pasterkamp, Y. Inaba, G. Chi-Lem, S. Kraman, G. Wodicka, Canada & United States	

NOCTURNAL WHEEZING COUNT AND SERUM THEOPHYLLINE CONCENTRATION IN BRONCHIALASTHMA

Hiroshi Kiyokawa, Makoto Yonemaru, Shinobu Horie, Yuichi Ichinose
and Keisuke Toyama
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Purpose: We previously demonstrated that nocturnal wheezing count (NWC), obtained by intermittent Sleep Tracheal Sounds Recording, was useful in assessing nocturnal asthma. In this study, we compared the NWCs before and after once-daily theophylline (ODT, Uniphyl) administration. Methods: Twelve adult asthmatics who had not taken theophylline within 1 week prior to this study were administered ODT from the night of day 1. Serum theophylline concentration (STC, mcg/ml) was estimated by Bayesian method. NWCs were measured on nights of day 0 (control) and day 7. Results: On the night of day 0, STC wwas 0 and total NWC (/night) was 56.2 + 342.3 (mean + SD). On the night of day 7, these were 8.5 + 2.7 and 30.8 + 198.8 respectively. In more detail, STCs were 0 (day 0, midnight), 0 (day 0, 5AM), 4.7 + 2.0 (day 7, midnight) and 8.1 + 2.5 (day 7, 5AM), while hourly NWCs (/hour) were 34.7 + 67.6, 38.7 + 63.5, 8.6 + 21.8 and 3.9 + 7.7 respectively. Conclusion: Total NWC was decreased after ODT administrtation in asthmatic patients. Reduction in hourly NWC was prominent when STC was elevated. We conclude that NWC can monitor the effect of ODT on nocturnal asthma.

The Effects of a Pillow on the Tracheal Sounds

H. Tanahashi[1]
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S. Choh[2]
S. Kudoh[3]

1) Japan Women's University, 2) Saiseikai Suita Hospital, 3) Nippon Medical School

In order to obtain a comfortable sleep-environment, we are studying the relationship between respiratory function and lung sounds during sleep. In this paper, we examined the effects of height of the pillow to the tracheal breath sounds in six normal awake subjects.

The tracheal sounds were picked up by a microphone attached to the anterior neck over the trachea and were recorded during about 90 seconds in different conditions of the pillow as follows: Height: 3 cm, 7 cm and 11 cm; materials: Urethane and buckwheat chaff; Posture: Sitting position and supine position. Recorded sound signals were analyzed using the fast Fourier transform (FFT) to obtain power spectra and were drawn by symmetrized dot patterns (SDP) for the visual characterization of sound waves.

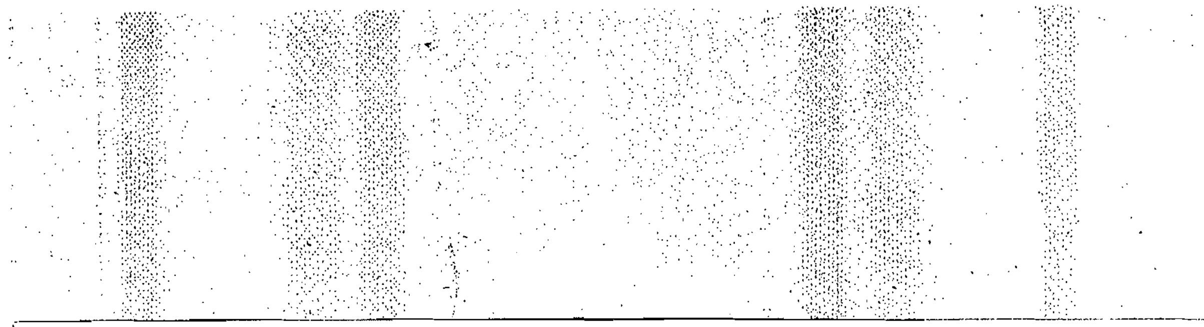
Results: as the pillow became higher, the slope of the power spectra above the peak frequency became steeper. There were no significant differences in the power spectra between the supine position without the pillow and sitting position nor between a urethane pillow and a buckwheat chaff pillow. The power spectra of the tracheal sounds are significantly influenced by the height of the pillow.

LUNG SOUND ANALYSIS IN ASBESTOS EXPOSED SUBJECTS

Piirila P#, Kivisaari L*, Koskinen H#, Lehtola H#, Nordman H#, Salo S-P#, Zitting A# and Sovijarvi ARA*
Finnish Institute of Occupational Health, (#), Helsinki University Central Hospital (*), Helsinki, Finland

Lung sounds of 65 patients with pulmonary asbestosis, pleural plaques or adhesions were studied with a pc-based lung sound analyzer (Helsa Pulmer ltd., Helsinki). Lung sounds were recorded with an air-coupled microphone on the back basal area of the right lung during tidal breathing in a sitting position with a target flow of about 1,25 l/s. Averaged Fast Fourier Transform (FFT) analysis was made for calculation of the maximal frequency (Fmax) and the quartile frequencies (F75, F50 and F25). An automatic crackle analysis was also performed. Chest X-ray, high resolution computer tomography (HRCT), spirometry and diffusing capacity were also studied. The HRCT scores of pulmonary fibrosis (0-5), emphysema (0-3), adhesions (0-2) and pleural plaques (0-2) were compared with the findings in the lung sound and lung function studies. Pulmonary fibrosis detected in HRCT correlated positively with F25 and F50 both in inspiration ($p<0.05$; $p<0.01$) and in expiration ($P=0.001$; $p<0.01$), and with F75 in inspiration (Spearman's $p=0.408$, $p<0.001$). In pulmonary fibrosis, crackles were found both in inspiration and expiration. The beginning and end point of crackling during inspiratory cycles correlated positively with pulmonary fibrosis in HRCT ($p<0.01$). Emphysema found in HRCT correlated negatively with Fmax ($p=-0.319$; $p<0.01$) and F25 ($p=-0.324$; $p<0.01$). The results indicate that parameters of lung sound frequency spectra correlate significantly both with parenchymal and pleural fibrosis as well as with emphysema found in HRCT in asbestos exposed subjects.

grant: Helsinki University Central Hospital research funds, no TYH0033



COUGH AS A STOP CONSONANT

R.G. Loudon, M.B., Ch.B., University of Cincinnati, Department of Medicine,
Cincinnati, OH 45267, USA

Stop sounds and plosive consonants, in speech science terms, are produced by sudden closure or opening of the oral airways, with the nasal airways already closed. In English speech they include the consonants /p/ /t/ /k/ and /b/ /d/ /g/ as the unvoiced and voiced (other terms have been proposed) representatives of labial,postdental, and palatal or velar stops. Airflow may also be stopped and started suddenly at the glottis, and cough may be considered as a glottic stop consonant, although its function is usually that of a protective or clearance mechanism rather than that of communication. Recognition of phonemes, including stop consonants, during speech is a subject of importance in speech science research: recognition and description of cough is of interest in pulmonary medicine. Spectrographic characteristics of stop consonants and of cough sounds have been compared in an effort to define their similarities and differences. Healthy subjects were asked to say "to talk, to cough" and then to give a cough of moderate force, repeating this sequence three times. The sounds were recorded on one channel of digital tape, and an electroglottographic signal on the other channel. The signals were analyzed using a Kay Sound Laboratory system, measuring the voice onset time, articulatory force, and transitional sound and burst characteristics for each of the plosive and stop segments.

The Acoustic Properties of Productive Cough and its Relevance to the Symptoms

Yasushi Hashimoto, Akira Murata, Yasuyuki Kaneko,
Yasuyuki Taniguchi, Arata Azuma, Shoji Kudoh
The Fourth Department of Internal Medicine, Nippon Medical School, Tokyo

Productive cough is a common symptom in patients with chronic airway disease. However, there has been little work published on the acoustic analysis of the productive cough. We investigated the acoustic properties of productive cough and its relevance to the subjective symptoms; easy to bring up sputum and chest tightness.

(Subjects) Five patients with chronic airway disease (Diffuse Panbronchiolitis, COPD and Lung cancer

(Method) The subject was instructed to make a voluntary cough in a sitting position. The cough sounds were picked up by an electlet condenser microphone (Sony EDM-23F3; 20Hz-22kHz) set 225mm from the subject, at an angle of 45o,both in the vertical and horizontal plane to the axis of the cough and recorded into a digital audio tape recorder (Sony TCD-D8; 50Hz-13kHz). The signals were high-pass filtered at 250 Hz, sampled at a rate of 44.1kHz by a 16 bit A/D converter, and processed with a software program of sound analysis (Sound Scope II, GW Instrument Company, U.S.A.). Each cough sound was divided into two to three phases according to the method by Thorpe et al.. Root mean square pressure (RMS) of each phase of cough sound was calculated and the correlations between RMS and the symptoms were analyzed. Symptoms were scored by Visual analog scale. Spearman's rank correlation was employed to determine the correlations.

(Results) RMS of productive cough sounds correlated with the symptoms such as easy to bring up sputum or chest tightness.

SEQUENTIAL DISTRIBUTION OF LUNG SOUNDS DURING RESPIRATION

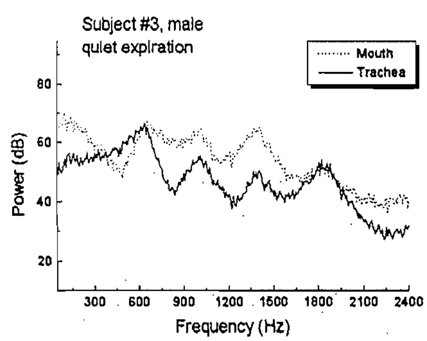
Frank Davidson, Peter Krumhansl and R. Murphy

To study the sequential distribution of sound amplitude over the chest during respiration, we placed microphones over 12 chest sites, over the trachea and at the mouth. Ten seconds of data were digitized using a multichannel lung sound analyzer during breathing at low, medium and high tidal volumes and analyzed in the time and frequency domains. Transmission of voice sounds were also studied. Times of the onset of both inspiration and expiration were observed. Arrival times were surprisingly similar. The relationship of these observations to known theories of regional ventilation will be discussed.

COMPARISON OF TRACHEAL AND VOICE SOUND SPECTRAL FEATURES

Hans Pasterkamp, M.D., Yaoki Inaba, M.D., Georgina Chi-Lem, M.D.
Steve S. Kraman, M.D. and George R. Wodicka, Ph.D.
University of Manitoba, Winnipeg, Canada, VA Medical Center, Lexington, KY, USA
and Purdue University, West Lafayette, IN, USA

Tracheal sound spectra exhibit distinct resonances and anti-resonances. Some of the spectral peaks are closely related to body height and presumably reflect tracheal length while the origin of other spectral features remains undetermined. We speculated that a comparison of voiceless breath sounds, recorded during expiration at the trachea and at the mouth, may show similar spectral peaks. This assumes that the subglottal airways plus the vocal tract constitute a continuous tube, open at the mouth and toward the lungs, when the glottis is wide open. Voiced sounds, however, may result in different spectral features of tracheal sounds compared with those recorded at the mouth since the glottis would be nearly closed, effectively separating subglottal from supraglottal airways during phonation. We recorded simultaneous tracheal and voice sounds (PPG sensor at suprasternal notch, Sony K120 microphone at the mouth) in healthy adult volunteers (5 males and 1 female, ages 28 to 50 years). Recordings were made with the vowel /a/ (glottis presumably almost closed), with the voiceless /h/ ('noisy' expiration, oropharynx presumably narrow) and /h/ ('quiet' expiration, glottis presumably open). Spectral features were extracted by fast Fourier transformation analysis and by linear predictive coding. We found tracheal sound peaks to coincide with peaks of breath sounds at the mouth during 'quiet' expiration (see Figure) in at least one of these frequency bands in all subjects: 600-700, 900-1000, 1300-1400 and 1600-1800 Hz. The observed congruence was less at frequencies below ~900 Hz during 'noisy' /h/maneuvers and disappeared almost completely during voiced /a/. Thus our findings support the theorectical predictions. We believe that comparative analyses of tracheal and voice sounds carry great potential for the non-invasive monitoring of upper airway configuration.



FRIDAY, October 17

Session C: Instrument / Computer

Chairmen : N. Gavriely, M.D. / C. Druzgalski, PhD.

9:00 - 9:20	Characteristic of the lung-sound transducer A. Suzuki, K. Nakayama, Japan
9:20 - 9:40	Combination of crackle analysis with flow-volume display -A new tool in the assessment of pulmonary disease P. Helisto, J. Vanderschoot, P. Lipponen, P. Piirila, J. Makila, A.Sovijarvi, Finland
9:40 - 10:00	Effects of finite-stiffness support on the frequency characteristics of an accelerometer-type stethoscope F. Sakao, H. Sato, M. Mori, Japan
10:00 - 10:20	Network / pc / mac requirements and formats for archiving and interchange of lung sounds files C.Druzgalski, United States
10:20 - 10:40	Coffee Break
10:40 - 11:00	Utilizing wave audio files for lung sound archiving,telemedicine and case review C. Irving, N.Gavriely, Israel
11:00 - 11:20	Continuous monitoring system of respiratory sound for the patient in ICU M. Hosomura, T. Yamahata, M. Nakayama, K. Kikuchi, N. Furuta, H. Tsubakiyama, Japan
11:20 - 11:40	Correction of sound amplitude calculations for adventitious sound contribution in chronic obstructive lung disease patients M. Murphy, K. Bergstrom, P. Krumhansl, L. Mylott, R. Murphy, United States

CHARACTERISTICS OF THE LUNG-SOUND TRANSDUCER

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It is important to characterize the response of the lung-sound transducer, however, the absolute response, when it is coupled to the chest wall, is not fully analyzed yet. We studied the relationship between the unloaded vibrating velocity of the chest wall and the sound pressure measured by an air-coupled microphone. The vibrating velocity was measured by a laser vibrometer. Uniform viscoelastic material (Kitecko, 3MN) was used as a chest-mimicking medium. The transfer function from the sound source pressure to the sound pressure measured by an air-coupled microphone placed on the surface of the medium was measured. The transfer function from the sound source pressure to the unloaded vibrating velocity of the surface was also measured. The ratio of these two transfer functions is the transfer function from the vibrating velocity to the measured sound pressure, and corresponds to the mechanical impedance of the medium for the coupling area in parallel with the impedance of the microphone air cavity. The results well agreed with the theoretical prediction. In the frequency range below the resonance, the ratio was independent of the cavity depth and showed the impedance of a viscoelastic medium. In the frequency range above the resonance, the ratio was determined only by the air-cavity dimension.

COMBINATION OF CRACKLE ANALYSIS WITH FLOW -VOLUME DISPLAY - A NEW TOOL IN THE ASSESSMENT OF PULMONARY DISEASES

P. Helisto [1], J. Vanderschoot[2] . Lipponen [1], P. Piirila [3], J. Makila [1] and A.R.A. Sovijarvi [4]

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Crackles have been traditionally recorded with reference to their timing within each respiratory phase or as a function of air flow. However, individual breath cycles may vary greatly, making a direct comparison of crackle timings between different cycles misleading. There are also indications that occurrence of crackles depends much more on the instantaneous lung volume or transpulmonary pressure than on the flow signal.

In this work, crackles occurring in different pulmonary diseases are analyzed in terms of their location in the flow-volume (F-V) plane. Two-dimensional F-V plan analysis eliminates many problems associated with other crackle analysis methods. In addition F-V representation is more familiar to chest physicians than many previous techniques to present lung sounds.

The patients studied here had crackles due to pneumonia, bronchiectasis, chronic obstructive pulmonary disease, heart failure or cryptogenic fibrosing alveolitis.

The patients were asked to breath at a target peak flows level of 1 l/s during both inspiration and expiration. The lung volume was obtained from the flow by integration. The sound signals were recorded with an air-coupled sensor. The crackles were detected from the sound signals with a modified HeLSA crackle detector and their occurrence was indicated in the F-V plan accordingly.

Substantial differences between the diseases and between different stages of a disease can be observed with the F-V analysis of crackles. It is visually informative, complements spirometry and can yeild quantitative results about the occurrence of the crackles. The method appears to be a promising tool in the assessment of various pulmonary diseases with crackling sounds.

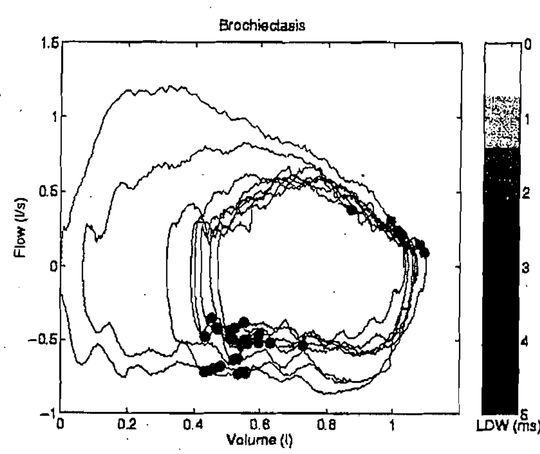

Fig. 1. Crackles on the flow volume plan from a patient suffering from bronchiectasis.

EFFECTS OF FINITE-STIFFNESS SUPPORT ON THE FREQUENCY CHARACTERISTICS OF AN ACCELEROMETER-TYPE STETHOSCOPE

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Abstract

A simple model for a stethoscope (or sensor) of air-coupled-microphone type held by fingers onto the skin has been devised by the authors. Using this model we predicted that the frequency characteristics would be seriously influenced by the way the microphone is supported.

This time we investigated an accelerometer type sensor attached to the skin. The model is simpler than that of an air-coupled-microphone.

The higher frequency limit of the sensor is determined, as expected, by the mass of the sensor and the elastic characteristics (stiffness and damping) of the skin contacting the sensor. It is observed that a resonance peak appears there, if the skin damping is poor.

When the sensor is held onto the skin by e.g., double-sided adhesive tape only, we find flat response over a wider frequency range until the higher end limit is approached. When, however, other auxiliary method such as taping is applied, a lower frequency limit is introduced.The limit frequency is determined by the sensor mass and the stiffness of the additional support. There may a resonance peak if the damping is poor.

It is to be noted that the frequency characteristics of sensors attached to the skin are influenced by the way the sensors are supported irrespective of the sensor used, though with differences.

Experimental results seem to confirm the above conclusion.

Key Words: Accelerometer-type stethoscope, Frequency characteristics, Stiffness of taping

NETWORK/PC/MAC REQUIREMENTS AND FORMATS FOR ARCHIVING AND INTERCHANGE OF LUNG SOUNDS FILES

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A continuous trend toward standardization of medical information and electronic flow of patient data necessitates consideration of acquisition formats for an electronic linkage and interchange of digitized audio files representing auscultatory data. As auscultatory findings and the need for their storage and transmission might become a part of telemedicine, it is important to consider technical requirements for teleauscultation. The standardization of recording, digital media and format, as well as definition of preprocessing will contribute to uniformity in quantitative and also qualitative characterization of auscultatory findings, including their long term quantitative follow up.

The aim of these studies was to provide guidelines and a comparative analysis of different platforms, MPC-compatible sound cards, plug-ins available and extension of their capabilities to lung sounds acquisition as digital media or their Internet based exchange. Specifically, this work deals with suitability of a variety of sound file formats and their applicability to lung sounds' documentation within the network/PC/Mac platforms. There is no firm cross-platform standard for digital audio files. A few Web sites having samples of lung sounds provide data in Wav (Windows based) and AU (Unix based) formats. The digital media users face many different audio file formats, including Apple AIFF, Sun Workstation AU (only format supported by Java) with its European equivalent A-law, and Windows WAV files. Digital audio files can also include VOC format that offers lower sampling rates suitable for lung sound recordings thus reducing restriction on needed memory space, MPEG, Real Audio, and other formats with different compression schemes. However, the file format conversion capabilities provide a versatile tool for documentation of auscultatory events. A crossplatform exchange has to take into account the fact that in HTML audio data is treated as a hyperlink. The sound files tend to be large and most limit audio clips of lung sounds to 10 seconds. An eight-bit sound sample at a sampling rate of 11kHz requires approximately 11kB of disk space per second while a 30 seconds sample of 16-bit sound at the sampling rate to 22kHZ may take 1.3MB or almost entire high-density floppy disk. Zip drives and future DVD-R's will elevate this problem. However, the limitations of the downloading time will remain unless one opts for streamed audio.

Common criteria of digitized audio clips or extended files, with accompanied spectral characteristics, and a compromise between audio quality and file size which reflects on transfer time, will allow uniform representation of auscultatory information in a fashion that no other forms can convey.

UTILIZING WAVE AUDIO FILES FOR LUNG SOUND ARCHIVING, TELEMEDICINE AND CASE REVIEW

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The increasing availability of Internet and multimedia tools present interesting opportunities in lung sound research for exchanging, reviewing and archiving sound files. The purpose of this presentation is to demonstrate how the Windows WAVE audio file format can be used for integrating patient and data acquisition information into the sound file, as well as marking, describing and indexing interesting acoustic features. Readily available, low cost, shareware sound analysis programs were used to write into the WAVE file header and later read information about subject, protocol and study ID's, sensor type, anatomical acquisition site and filter characteristics. Pairs of cue marks were added to identify the locations of the start and finish of sound segments of particular interest and single cue marks were used to identify the location of acoustic features, such wheezes, crackles, rhonchi and honks. Cue mark labels and short descriptions were added, along with indexing key words for use in file retrieval. Annotated WAVE files were exchanged as E-mail attachments between collaborators, who reviewed and commented on the highlighted features. Similar procedures were used for preparing teaching files. The use of audio file features for standardizing the exchange of lung sound information among researchers and the medical community will be discussed.

CONTINUOUS MONITORING SYSTEM OF RESPIRATORY SOUNDS FOR THE PATIENT IN ICU

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Norihiko Furuta, Hidetoshi Tsubakiyama [2]

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83, Roppou-cho, Inage-ku, Chiba-shi, Chiba 263 Japan

It is necessary for us to carefully observe the cardio-pulmonary conditions of patients in the ICU (Intensive Care Unit). We usually monitor the condition of the heart by ECG (Electro-cardiogram) but only ausculatation is used to monitor pulmonary function. We therefore tried to analyze patient's respiratory sounds with a computer in ICU.

First, we attached a microphone to the patient's chest and recorded the patient's respiratory sounds; next we analyzed this sound with a computer. Consequently, we had recorded patient's respiratory sound and, at the same time, we had recorded the ECG and respiratory sound. So we were not able to analyze the patient's respiratory sound. In this trial, we recorded respiratory sound about ten minutes in one hour, but we think it is better to monitor from five to ten respiratory cycles. Because, in recording that sound for a short time, we had also recorded patient's cough sound, and we must consider a change of respiratory frequency in his sleeping and walking.

CORRECTION OF SOUND AMPLITUDE CALCULATIONS FOR ADVENTITIOUS SOUND CONTRIBUTION IN CHRONIC OBSTRUCTIVE LUNG DISEASE PATIENTS

Margaret A. Murphy, Kirsten Bergstrom, Peter Krumhansl, Laura Mylott and Raymond L.H. Murphy

Differentiation of normal subjects from those with Chronic Obstructive Pulmonary Disease is based on spirometry and clinical features. Efforts to differentiate these 2 populations based on intensity of lung sounds is confounded by the contribution of adventitious sounds to measures of breath sound intensity. The contribution of the adventitious sounds to the overall sound amplitude decreases the expected difference between the low amplitude of the COPD patients and normals, assuming that more adventitious sounds are present in the COPD patients. In a previous study we observed no significant difference between groups in the ratio of the sound amplitude over the chest to the sound amplitude at the trachea.

We investigated 2 methods of separating out the contribution of crackles to the intensity of the breath sounds measured at 20 sites over the chest wall in 25 patients with COPD and 25 elderly volunteers with normal spirometry and without history of lung disease.

Method 1 involved assigning a qualitatively derived value for the contribution of crackles to the RMS (Root Mean Squared) over the chest wall.

Method 2 utilized measures of intensity over the chest wall (RMS) in subjects who had at least one grouping of 5 microphones in which no adventitious sounds were visible on waveform. This intensity measure divided by the RMS over the trachea provided a mean ratio of amplitude without adventitious sounds present.

Results of Method 1 showed no significant difference in corrected mean ratios of RMS over the chest wall to RMS over the trachea in COPD (m=0.37) versus healthy volunteers (m= 0.34)

Results of Method 2 showed a significant difference between COPD patients and healthy volunteers.

Further investigations and new methods are needed to determine the role of adventitious sounds in measures of amplitude over the chest wall.

FRIDAY, October 17

Session D: Clinical science

Chairmen : R. Murphy, M.D. / A. Sovijarvi, M.D.

13:00 - 13:20	Lung sounds frequencies are increased in patients with asthma-like inflammation A.Sovijarvi, A. Saarinen, P. Malmberg, T. Helin, B. Pekkanen, P. Helisto, E. Varsila , T. Haahtela, L.Laitinen, Finland & England
13:20 - 13:40	Effect of the depth of inspiration on expiratory flow and lung sounds in COPD - A video demonstration H. Melbye, Norway
13:40 - 14:00	Changes in lung sounds following bilateral thoracotomy lung volume reduction surgery in patients with emphysema S. Ishikawa, V, Pinto-Plata, I. Kogan, J. Rassulo, J. Stetz, K. MacDonnel, B. Celli, United States
14:00 - 14:20	Characteristics of lung sounds in patients with pneumonia and congestive heart failure R. Murphy, United States
14:20 - 14:40	Coffee Break

LUNG SOUND FREQUENCIES ARE INCREASED IN PATIENTS WITH ASTHMA-LIKE INFLAMMATION

R.A. Sovijarvi*, A. Saarinen*, P. Malmberg**, T.Helin**, L. Pekkanen*, P. Helisto***, E. Varsila**, T.'Haahtela** and L.A. Laidinen*,
Helsinki University Central Hospital, Dept Of Medicine, Division of Pulmonary Medicine and Clinical Physiology* and Skin and Allergy Hospital** and Helsinki University of Technology, Lab. Biomed Eng.***

Median frequencies (F50) of breath sounds are shown to be higher in asthmatic patients with normal FEVI than in healthy subjects (1). We,studied 10 patients with asthma-like inflammation who did not meet ATS criteria for asthma. They suffered from episodic dyspnea and chronic cough. They had the concentration of sputum eosinophilic cationic protein (ECP) over 800 mcg/l, normal FEVI, MEF 50 and FVC and PD 15/FEV1 over 0.6 mg in a dosimetric histamine challenge test (2). Thirteen healthy subjects with no respiratory symptoms were studied as a control group. Lung sound analysis was performed by using a PC-based analyzer (HeLSA, Pulmer, Ltd, Helsinki). Sound signal samples of 35 seconds were recorded during tidal breathing with air coupled micophones placed on the right lung and trachea. Averaged Fast. Fourier Transform analysis with a flow gate of 1.0 - 1.25 l/s was used for calculation of inspiratory and expiratory F50. There were no significant differences in FEV1, MEF 50 and FVC between the groups. F50 of the inspiratory lung sounds was significantly higher in patients than in healthy subjects ($p = 0.03$) with mean frequencies (SD +) 212 + 13 Hz and 193 + 20 Hz, respectively. Expiratory lung sounds and tracheal sounds were not significantly different between the groups. No wheezes were detected. Changes in airflow dynamics due to bronchial inflammation may be a reason for the differences in lung sound spectra. The results suggest that lung sound spectral analysis may be a more sensitive method than flow-volume spirometry to assess bronchial changes in patients with asthma-like inflammation,

1) Schreur HJW et al. Chest 1994; 106:91-99

2) Sovijiirvi ARA et al. Chest 1993; 104:164-170

Grants: Helsinki University Central Hospital Research Funds, No TYHOO33, Paulo Foundation

Effect of the depth of inspiration on expiratory flow and lung sounds in COPD - a video demonstration

Hasse Melbye, Institute of Community Medicine, University of Tromso, 9037 Tromso, Norway

In healthy subjects increased depth of inspiration followed by relaxed and unforced expiration, is associated with increased inspiratory and expiratory flow, and accordingly, a distinct increase in the intensity of the breath sound in both respiratory phases. This is not the case for patients with chronic obstructive pulmonary disease (COPD). With deeper respiration only a very slight increase in expiratory flow and breath sound intensity may be found, which is recognized by the clinician as diminished breath sound. If expiratory wheezes are elicited after maximal inspiration, these wheezes are not associated with increased expiratory flow. This is demonstrated by HiFi-videorecordings , with live volume-time and flow-time-curves shown as overlay on the images of the auscultated patients. Possible mechanisms behind the observed flow and sound phenomena will be discussed.

CHANGES IN LUNG SOUNDS FOLLOWING BILATERAL THORACOTOMY LUNG VOLUME REDUCTION SURGERY IN PATIENTS WITH EMPHYSEMA

S. Ishikawa*, V. Pinto-Plata, I. Kogan, J. Rassulo, J. Stetz,
K. MacDonell and B. Celli
Tufts Lung Station, St. Elizabeth's Med. Ctr. and Dept of
Med. Tufts Univ. School of Med., Boston Ma. U.S.A.

Lung sound changes were studied on seven patients before and 3 months after bilateral thoractomy lung volume reduction surgery. With a contact microphone, lung sounds were recorded at the neck and 6 sites on the chest surface. At the time of lung sound recording, pulmonary physiology studies of the patients were carried out. Lung volume reduction surgery achieved reduction of total lung capacity of the patient from 7.15+2.26 to 6.18+2.09, residual volume from 4.86+1.86L to 3.55 +1.17L and increase of FEV1 from 0.84 +0.29L to 0.97+0.27L, Pimax from 58.5+26.9 to 66.4+20.76 cmH20. Vesicular lung sounds intensity increased 82% on upper zones of the lung while lower zone increased 27%.Tracheal sounds intensity increased 21%. There were no significant changes noted in the period of inspiration or expiration on either tracheal and vesicular lung sounds.

CHARACTERISTICS OF LUNG SOUNDS IN PATIENTS WITH PNEUMONIA AND CONGESTIVE HEART FAILURE

Murphy R, Bergstrom K

In a pilot study, we noted that patients with congestive heart failure (CHF) had some lung sound patterns that differed from those observed in patients with pneumonia (PN). To examine this further, we studied 10 patients with PN and 10 patients with CHF using a multichannel lung sound analyzer. Sounds were analyzed from the trachea and 20 sites over the chest. Crackles were classified into fine, medium and coarse, based on their waveform characteristics and classified by their timing in the respiratory cycle as early, mid or late. Results of the analysis appear in Table I.

Table I

	PN n=10	CHF n=10
Average Length of Inspiration (msec)	1059	1204
Average Length of Expiration (msec)	1448	1765
Ratio of I/E	.731	.682
Inspiration Crackles (total # all sites)		
Fine	3	10
Medium	36	33
Coarse	25	60
Total	64	103
Expiratory Crackles (total # all sites)		
Fine	22	3
Medium	8	8
Coarse	57	36
Total	87	47
Inspiratory Rhonchi (# of occurrences)	2	2
Expiratory Rhonchi (# of occurrences)	3	6
Total Rhonchi	5	8
Inspiratory Wheeze (# of occurrences)	2	2
Expiratory Wheeze (# of occurrences)	7	3
Total Wheeze	9	5

There was considerable overlap in the findings between the two disease categories, but significant differences were found in crackle counts. Total inspiratory crackles were more common in CHF ($p=.021$). Medium and/or coarse crackles in early or mid inspiration occurred more commonly in CHF as compared to PN (98 vs. 42; $p=.006$) (Table II).

Table II

PN	Early	Mid	Late	CHF	Early	Mid	Late
Fine	0	3	1		3	5	0
Medium	5	19	16		13	34	8
Coarse	9	9	6		22	29	11

FRIDAY, October 17

Poster Discussion Session

Chairmen : P. Piirila, M.D. / S. Ishikawa, M.D.

14:40 - 15:40 Poster Presentation : Presentation 5 minutes, Discussion 7 minutes

A sonogram-based real time lung sound analyzer and algorithm for real time wheeze detection

J. Makila, P. Lipponen, P. Helisto, Finland

Wheeze originated from the opening of sub-carinal bronchial cyst into main bronchus

T. Takahashi, S. Ohizumi, S. Ogura, M. Munakata, Y. Homma, Y. Kawakami, Japan

Simulation of coarse crackles by simple experimental arrangements

K. Tanaka, Japan

A new computer system to detect snoring and apnea/hypopnea by tracheal sounds analysis

H. Nakano, Y. Ohnishi, K. Matsuzawa, J. Maekawa, N. Narita, Japan

Intensity and frequency content of breath sounds in patients with emphysema

K. Sano, H. Nakano, J. Maekawa, N. Narita, Japan

15:40 - 15:50 Closing Remarks - Raymond L.H. Murphy, M.D.

A SONAGRAM-BASED REAL TIME LUNG SOUND ANALYZER AND ALGORITHM FOR REAL TIME WHEEZE DETECTION

J. Makila, P. Lipponen, P. Helisto
Laboratory of Biomedical Engineering, Helsinki University of Technology
P.O.Box 2200, FIN-02015 HUT, Finland

Introduction: A sonagram is a very informative method to display the respiratory sound signal and several types of adventitious sounds can easily be recognized from it. To analyze respiratory sounds in real time, a PC-based system and a fast wheeze detection algorithm were developed in this work.

Real-Time Analyzer: The developed real time analyzer was implemented with a National Instruments AT-DSP2200 digital signal processing caxd and a Pentium PC running Windows NT. The respiratory sound signal and air flow signals axe detected with an electret microphone and a pneumotachometer. The DSP -caxd has steep digital anti-aliasing filters and samples both signals at 6 kHz with 16 bit resolution. The AT&T DSP32C-processor on the DSP-caxd was programmed to calculate the FFT-spectrum of 256-point sound signal segments overlapping 50%. The input channels and the calculated spectra axe then transferred to the PC using DMA. A device driver was developed to enable the communication between the DSPcard and the Windows NT user interface. The user interface displays the signal as a scrolling sonagram simultaneously with the measured air flow and the sound signal envelope. The delay from analog signal to the spectrum on the screen is under 50 ms and can thus not be noticed. The analyzer has been tested on a 150 MHz Pentium with Windows NT 3.51. About 50% of processor time is still available to be used for further real time signal processing and feature extraction.

Wheeze Detection: A simple sonagram based wheeze detection algorithm for real time use was developed. The spectrum of each segment is filtered with a peak detection filter which subtracts a smoothed spectrum from the original. The local maxima above a specified threshold level are taken for further consideration. Temporal continuity of these maxima in at least three successive columns of the sonagram is used as a criterion for detecting a wheeze. This method is both causal and fast to calculate. It obtains a sensitivity of over 90% simultaneously with about 65% predictivity. Most of the 35% wheezes that were found but not validated by the doctor were audible but could not be confirmed by examining the mere waveform.

Conclusion: The developed analyzer enables the doctor to view the signal sonagram in real time during patient recordings. This provides a method to immediately verify the adventitious sounds heard. Combined with real-time detection, the system is a useful instrument in a wide range of applications related to pulmonary sounds.

WHEEZE ORIGINATED FROM THE OPENING OF SUB-CARINAL BRONCHIAL CYST INTO MAIN BRONCHUS

Toru Takahashi, Satoshi Ohizumi, Shigeaki Ogura, Mitsuru Munakata, Yukihiko Homma, Yoshikazu Kawakami
The First Depatment of Medicine, School of Medicine, Hokkaido University, Sapporo, Japan

Wheezes are usually considered to be a sign of diffuse or localized airway obstruction. We experienced a rare case in whom the origin of wheeze was airflow from sub-carinal bronchial cyst into main bronchus. Sixty-six year old man has been complaining of wheezing at supine position for several years. In auscultation, wheeze during mid-expiratory phase was audible on the right-side of the sternum at supine and right decubitus position. Chest computed tomography scan of inspiratory phase revealed cystic air space beneath the carina. The air space volume assumed by the computed tomography scan changed greatly, increased during inspiratory phase and decreased during expiratory phase. Bronchoscopic findings showed small hole which connected peribronchial cyst to right main bronchus. The size of hole was increased during inspiration phase and decreased during expiratory phase. Furthermore, after the injection of local anesthetics, an outflow of air bubbles from the cyst was detected during expiratory phase, suggesting air-outflow from the cyst through the hole. The wheeze was audible with a stethoscope on the surface of the chest wall just above this hole. These results suggest that the wheeze in the patient is derived from the airflow through the opening of sub-carinal bronchial cyst into main bronchus.

SIMULATION OF COARSE CRACKLES BY SIMPLE EXPERIMENTAL ARRANGEMENTS

KOJI TANAKA

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Bubble eruptions of lung surfactants were closely related to the generation of crackles. Present experimental simulation were planned to clarify the relations between surfactants and crackles. In the experiment, egg-shaped blower and fine tube were used as respiratory system. The respiratory cycles of the airflow were realized by compression and expansion of the blower. Lecithin solution diluted by physiological saline was supplied into the tube as the lung surfactants. One of the recorded signals of the bubbling sounds showed that the wave form was quite similar to that of coarse crackles audible in a patient with pulmonary edema (fig. 1 and Fig. 2). The Fourier analysis of the simulated data showed that the contribution of the lower frequency components was dominant. Simulated coarse crackles were sensitive to the density of the solution. These analogous sinusoidal wave motions were observable in a range of 4 to 6 times dilution. Outside this range, small size eruptions happened frequently and the contribution of the higher frequency components was correspondingly dominant. For example, sharply edged triangular wave form was observed in two times dilution.

A NEW COMPUTER SYSTEM TO DETECT SNORING AND APNEA/HYPOPNEA BY TRACHEAL SOUNDS ANALYSIS

Hiroshi Nakano [1], Yoshinobu Ohnishi [1], Kuniaki Matsuzawa [1], Junko Maekawa [1] and Nobuhiro Narita [2]

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2)Second Department of Internal Medicine, Nara Medical University,
840 Shijou-chou Kashihara, Nara 634 Japan

We developed a computer system to detect snoring and apnea/hypopnea by night tracheal sound analysis. Hardware of this system consisted only of a Windows95 personal computer and a microphone. Tracheal sound was inputted to the computer and dizitized by Win32 waveaudio function. Every 0.2 second the waveform data was transformed to short time power spectra using FFT. The data size of calculated spectra time series during 9 hours was about 10MB. To detect snoring our system was designed to note peak power spectrum(100Hz to 300Hz) of more than 80dB/10Hz and then validate it visually by inspection of compressed sound spectrogram. To evaluate disordered breathing, moving averages(duration;18 sec) of the power spectra(dB) within bandwidth of 400 to 600 Hz were calculated every 2 second, and the number of transient falls of more than 12dB(TS-DIP) were counted. In 33 patients of possible sleep apnea/hypopnea syndrome tracheal sound recoding and polysomnograph were done. The numbers of TS-DIP per night were well correlated with numbers of apnea/hypopnea episodes per night on polysomnographs(n=33,r=0.95). This system may be very useful tool for evaluation of snoring and sleep disordered breathing.

INTENSITY AND FREQUENCY CONTENT OF BREATH SOUNDS IN PATIENTS WITH EMPHYSEMA

Kimihiko Sano [1], Hiroshi Nakano [2], Junko Maekawa [1], Nobuhiro Narita [2]

1) Depatment of Internal Medicine, Tenri City Hospital,
Tenri, Nara 632 Japan
2) Second Department of Internal Medicine, Nara Medical University,
Kashihara, Nara 634 Japan

We compared the intensity of breath sounds between fifteen patients with pulmonary emphysema and normal controls. The signals of breath sounds at four sites on the chest wall were passed through an amplifier and a band-pass filter (0.1 to 2000 Hz), and digitized to be recorded on personal computer with the signal of air flow rate. Power spectra of the breath sounds for inspiratory blocks of 102.4msec when the flow rate was 0.7L/sec was obtained using fast Fourier transform. We calculated F25, F50, F75, F95 and H/M power ratio (H:400-800 Hz, M:200-400Hz) as parameters to quantify distribution of frequency spectra of breath sounds. There was no difference in total power (sum of power spectra within bandwidth of 100 to 2000Hz) of breath sounds between patients with emphysema and normal controls. In patients with emphysema F75, F95 and H/M ratio were higher than in the normal controls, especially on upper lung fields.

In conclusion, the breath sounds in patients with emphysema do not decrease in intensity but may increase in frequency content.

THE 22ND INTERNATIONAL LUNG SOUNDS CONFERENCE

ANNUAL MEETING ANNOUNCEMENT

The 22nd International Conference on Lung Sounds will be held in Tokyo, Japan on October 15 -17, 1997.

The 22nd Conference Chairman
Masashi Mori, M.D. Tokyo National Chest Hospital

Executive committee of ILSA

Robert Loudon, M.D.	Cincinnati, Ohio	Chairman
Raymond L.H. Murpy, Jr. M.D.	Boston, Massachusetts	Cochairman
Noam Gavrielly, M.D.	Haifa, Israel	
Shoji Kudoh, M.D.	Tokyo, Japan	
Stephen Kraman, M.D.	Lexington, Kentucky	
Hans Pasterkamp, M.D.	Winnipeg, Canada	
Anssi Sovijarvi, M.D.	Helsinki, Finland	

CALL FOR ABSTRACTS

Papers for presentation during the Conference will be selected by the Program Committee. Abstracts should not exceed 200 words in length and should be submitted by June 30, 1997. Submission of abstracts on disks is encouraged. Notification of acceptance will be mailed out by July 15, 1997. Abstracts may relate to any aspect of lung sounds; examples are studies of mechanisms of production, clinical implications, phisiological correlations, methods for recording, analysis or representation.

Abstracts should be typed on an 8 1 /2" x 11"sheet of bond paper.
Please allow a 1 1 /2" margin on all sides. Abstracts should be single spaced, include title in all caps, all authors with presenting author listed first, and name and address of institution where work was completed. Abstracts will be reproduced as submitted. Please check for clarity and accuracy. Please indicate whether oral or poster presentation is preferred and equipment needs. Abstracts should be sent to:

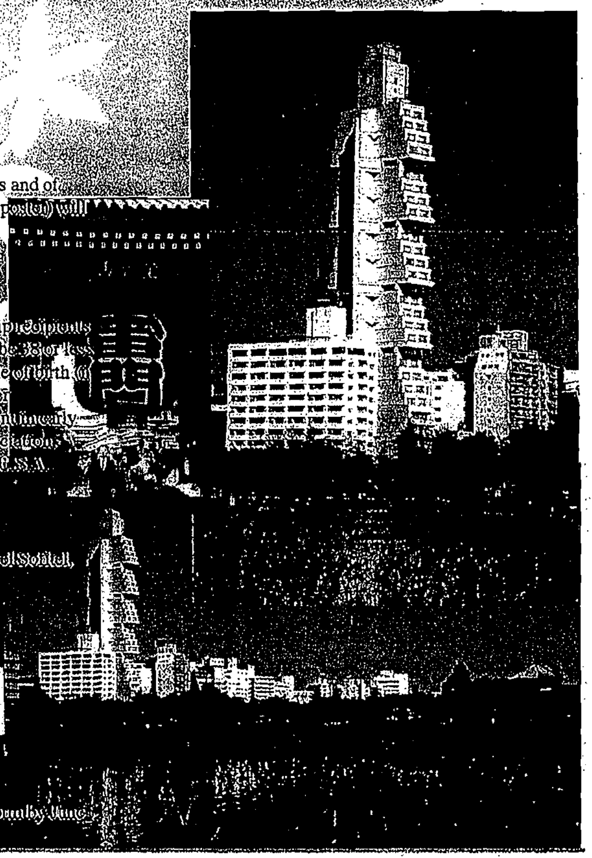
Raymond L. H. Murphy, Jr., M.D.
Faulkner Hospital/Pulmonary
1153 Centre street, Boston, MA 02130 U.S.A
Telephone: 1(617)522-5800; ext 1968
Fax: 1(617)522-4156

POSTER SESSION

Posters will be displayed throughout the meeting. Presentation of recordings and of video posters will be possible. A poster discussion (5 minutes, 3 slides per poster) will be held.

REGISTRATION

Registration fee of $200.00 for regular members and $100.00 for scholarship recipients and spouse/companion. To be eligible for the scholarship, candidates must be 38 or less years of age; ie., born after October 1, 1959. A legal document showing date of birth (i. e., passport, birth certificate, etc.) is required for acceptance of oral or poster presentation and scholarship eligibility. Notification of eligibility will be sent in early July. The registration fee should be sent to International Lung Sounds Association, Raymond L.H. Murphy, Jr., M.D., 1153 Centre Street, Boston, MA 02130 U.S.A.



HOTEL ARRANGEMENTS

A block of rooms have been reserved for the conference participants at Hotel Sofitel, Tokyo, 2-1-48, Ikenohata, Taito ku, Tokyo 110 Japan.

Hotel Sofitel Tokyo
2-1-48 Ikenohata Taito ku Tokyo 110 Japan
Tel: +81-3-5685-7111 Fax: +81-3-5685-6171

Accommodation fees (October 14-17)
Participants: $100.00 (with one companion $120)/day
Accommodation fees (excluding October 14-17)
One person: $170/day
Hotel applications should be faxed to Shoji Kudoh, M.D. on the attached form by June 30, 1997.