INTERNATIONAL
LUNG SOUNDS
ASSOCIATION

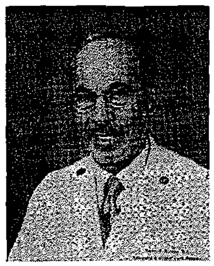
THE 32nd ANNUAL CONFERENCE OF INTERNATIONAL LUNG SOUNDS ASSOCIATION

第３２回肺音(呼吸音)研究会

FINAL PROGRAM AND ABSTRACTS

November 1-2, 2007
International House of Japan
Tokyo, Japan

WELCOME MESSAGE



Welcome to the 32nd annual meeting of the International Lung Sounds Association, held in Tokyo, Japan. Dr. Shoji Kudoh, our host, has arranged a unique experience for the attendees this year with a varied and fascinating program. As usual, the submitted presentations cover a broad range of acoustics that will help ILSA participants find new ways to study and understand respiratory sounds. I look forward to a great meeting and a very enjoyable time for all in Tokyo.

Steve S. Kraman, M.D.
President, ILSA

On behalf of the organizing committee of the 32nd Annual Meeting of International Lung Sounds Association, I am very pleased to welcome all of you to this conference.

This is the third time that the ILSA conference is held in Tokyo, after the ones in 1985 and 1997. In the previous two occasions, we achieved very fruitful results.

It is regrettable that that there are not many theses for presentation this time, but there will be valuable presentations on sound transmission, recording environments, signal processing and sound acquisition, clinical application, and lung sounds nomenclature. Furthermore, we have prepared special lectures on diffuse panbronchiolitis, which is a disease unique to Asia, and on muscle sounds and their applications. I am earnestly hoping that this conference will be an occasion to look back on the origin of the studies on lung sounds, as well as an occasion to discuss possibilities of future progress. The term of the conference is one-and-a-half days, with the remaining half a day secured for a bus-tour of Tokyo.

Let me remind you that, on the day following the Conference, an International Educational Conference on Lung Auscultation will be held in a different hall, which will be organized by the Japanese Lung Sounds Association mainly for young Japanese doctors, and co-medicals such as nurses and physiotherapist. I am looking forward to receiving as many of you as possible.

Thank you.

Shoji Kudoh, M.D.
The 32nd Conference President

ORGANIZATION

ILSA Executives

President: Prof. Steve S. Kraman
Department of Internal Medicine, University of Kentucky, Lexington, KY, USA

Secretary: Dr. Leontios Hadjileotiadis
Department of Electrical and Computer Engineering
Aristotle University of Thessaloniki, Thessaloniki, Greece

Treasurer: Dr. Masato Takase
Department of Pediatrics, Nippon Medical School, Tokyo, Japan

Secretariat of The International Lung Sounds Association

Leontios Hadjileontiadis, Ph.D.
GR 54124 Thessaloniki, Greece
TEL : +30-31-099-6340, FAX : +30-31-099-6312

The 32nd Conference President

Shoji Kudoh, M.D.
Division of Pulmonary Medicine, Infectious Disease and Oncology
Department of Internal Medicine, Nippon Medical School

Local Organizing Committee

Akira Murata, M.D.
Division of Pulmonary Medicine, Infectious Disease and Oncology
Department of Internal Medicine, Nippon Medical School

Masato Takase, M.D.
Department of Pediatrics, Nippon Medical School

Address of Local Organizing Committee

Shoji Kudoh, M.D.
Division of Pulmonary Medicine, Infectious Disease and Oncology
Department of Internal Medicine, Nippon Medical School
1-1-5 Sendagi, Bunkyo-ku, Tokyo 113-8603,Japan
TEL : +81-3-3822-2131 FAX : +81-3-3823-0822
E-mail : kuntonjp@nms.ac.jp

Address of Japan Lung Sounds Association

Akira Murata, M.D.
Division of Pulmonary Medicine, Infectious Disease and Oncology
Department of Internal Medicine, Nippon Medical School
1-1-5 Sendagi, Bunkyo-ku, Tokyo 113-8603,Japan
TEL : +81-3-3822-2131 FAX : +81-3-5685-3075

LIST OF ILSA CONFERENCES

No.	Date	Place	Local Organizer(s)
1.	October 1976	Boston, MA	Raymond L.H.Murphy,Jr.
2.	September 1977	Cincinnati, OH	Robert Loudon
3.	September 1978	New Orleans, LA	William Waring
4.	September 1979	Chicago, IL	David Cugell
5.	September 1980	London, England	Leslie Capel & Paul Forgacs
6.	October 1981	Boston, MA	Raymond L.H.Murphy,Jr.
7.	October 1982	Martinez, CA	Peter Krumpe
8.	September 1983	Baltimore, MD	Wilmot Ball
9.	September 1984	Cincinnati, OH	Robert Loudon
10.	September 1985	Tokyo, Japan	Riichiro Mikami
11.	September 1986	Lexington, KY	Steve S. Kraman
12.	September 1987	Paris, France	Gerard Charbonneau
13.	September 1988	Chicago, IL	David Cugell
14.	September 1989	Winnipeg, Canada	Hans Pasterkamp
15.	October 1990	New Orleans, LA	David Rice
16.	September 1991	Veruno, Italy	Filiberto Dalmasso
17.	August 1992	Helsinki, Finland	Anssi Sovijärvi
18.	August 1993	Alberta, Canada	Raphael Beck
19.	September 1994	Haifa, Israel	Noam Gavriely
20.	October 1995	Long Beach, CA	Christopher Druzgalski
21.	September 1996	Chester, England	John Earis
22.	October 1997	Tokyo, Japan	Masahi Mori
23.	October 1998	Boston, MA	Sadamu Ishikawa
24.	October 1999	Marburg,Germany	Peter von Wichert
25.	September 2000	Chicago, IL	David Cugell
26.	September 2001	Berlin, Germany	Hans Pasterkamp
27.	September 2002	Helsinki, Stockholm	Anssi Sovijärvi
28.	September2003	Cancun, Mexico	Sonia Charleston, Ramón Gonzales Camarena & Tomás Aljama Corrales
29.	September 2004	Glasgow, Scotland	Ken Anderson & John Earis
30.	September 2005	Boston/Cambridge, MA	Raymond L.H.Murphy,Jr.
31.	September 2006	Halkidiki, Greece	Leontios Hadjileontiadis
32.	November 2007	Tokyo, Japan	Shoji Kudoh

GENERAL INFORMATION

Conference venue
International House of Japan
(5-11-16,Roppongi,Minato-ku,Tokyo 106-0032 Japan)
The conference hall will be "Lecture Hall" on the 2nd floor

Official language
English

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

Wednesday, October 31	17:00 -	18:00
Thursday, November 1	8:30 -	18:00
Friday, November 2	8:30 -	18:00

Registration fees
$90 / ¥10000 : (Members/Non-members)
*Note that NO CREDIT CARD will be accepted.
Registration fee includes Ice Melting party, Banquet, and Lunch.

ILSA annual membership fee
$75 / ¥9000
*Note that NO CREDIT CARD will be accepted.
ILSA members are required to pay the membership fee (if it hasn't already paid) followed by the ILSA'07 conference registration fee.

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

Ice Melting party
On October 31st, a wine and cheese reception will be held in the International House of Japan at 6:00 p.m. to welcome the participants and their companions.

Banquet
The banquet will be held at Wadakura Fountain Restaurant at 7:00 p.m. on November 1st.
Bus Departure at 6 p.m.

Sponsor
Japanese Lung Sounds Association
Eisai Co, Ltd.
Department of Pulmonary Medicine, Infectious Diseases, and Oncology, Department of Internal Medicine, Nippon Medical School
Department of Pediatrics, Nippon Medical School

PROGRAM

Wednesday, October 31

17:00	Registration
18:00	Ice Melting Party (International House of Japan)

Thursday, November 1

8:30-	Registration
8:55-	Opening remarks

Session A : Sound Generation & Transmission

Chairmen: Hans Pasterkamp / Yongyudh Ploysongsang

9:00-9:15 Duration of forced expiratory tracheal Noises increases with gas mixture density
Alexander I. D'yachenko, Russia

9:15-9:30 Simulation of sound transmission in humans from trachea to chest wall
Alexander I. D'yachenko, Russia

9:30-9:45 Effect of lung volume on acoustic transmission in normal subjects
John Earis, England

9:45-10:00 Sound transmission (transit time) in the lung in normal subjects appears to be independent of gravity.
Sadamu Ishikawa, USA

-- Coffee Break (15minutes) --

Session B: Signal Processing & Sound Acquisition

Chairmen: Akifumi Suzuki / Alexander I. D'yachenko

10:15-10:30 An examination of a method to detect abnormal sounds from the lung sounds recorded in different environments.
Katsuya Yamauchi, Japan

10:30-10:45 Detection of crackles using an analytic signal representation
Atsushi Fuchita, Japan

10:45-11:00 Further developments in microphone-based contact stethoscopic sensors, and reduction of lead-transmitted noises
Fujihiko Sakao, Japan

11:00-11:15 Auscultation of the chest may be easier when patients are wearing under shirts than on the bare chest
Yukio Nagasaka, Japan

11:15-11:30 Evaluation of the swallowing sound recorded in the auditory canal
Tsunemi Kitagawa, Japan

11:30-13:00 Photo & Lunch

Session C: Clinical Application

Chairmen: Raymond Murphy / Sadamu Ishikawa

13:00-13:15 Assessment of lung auscultation in COPD (Emphysema)
Yongyudh Ploysongsang, Thailand

13:15-13:30 The evaluation of the efficacy of fast Fourier transformation of inspiratory lung sounds by phonopneumograph in a diagnosis of interstitial pneumonia
Hiroshi Ono, Japan

13:30-13:45 Multichannel lung sound analysis before and after mechanically induced lung injury
Raymond Murphy, USA

13:45-14:00 Acoustic analysis of Breath Sounds before and after chest physical therapy
Toshimitsu Suga, Japan

14:00-14:15 Snoring sound intensity and obstructive sleep apnea
Hiroshi Nakano, Japan

-- Coffee Break (15minutes) --

Special Lecture Ⅰ

Chair: Masashi Mori

14:30-15:30	Diffuse panbronchiolitis and anti-inflammatory action of macrolide antibiotics Shoji Kudoh, Japan

-- Coffee Break (15minutes) --

15:45-17:45	Business Meeting
18:00-	Bus Transfer
19:00-	Banquet (Wadakura Fountain Restaurant)

Friday, November 2

Session D: New Technology & Lung Sounds Nomenclature

Chairmen: Steve Kraman / John Earis

9:00-9:15	Vibration response imaging of lung—dynamic images and lung function findings in normal Japanese men Masamichi Mineshita, Japan
9:15-9:30	Non-contact stethoscope for auscultation of neonatal patients Raymond Murphy, USA
9:30-9:45	Changes of lung sound nomenclature in Japan since 1985 World Congress of Lung Sound Yukio Nagasaka, Japan
9:45-10:00	Nomenclature on lung sounds in the world Tadashi Abe, Japan

-- Coffee Break（15minutes）--

Special Lecture Ⅱ

Chair: Shoji Kudoh

10:15-11:15	The basis of mechanomyography and its application Katsumi Mita, Japan
11:15	Closing Remarks
11:20-13:00	Lunch
13:00	HALF-DAY TOUR OF TOKYO (free)

Duration of forced expiratory tracheal noises increases with gas mixture density

Alexander I. D'yachenko[1, 2, 4]*, Vladimir I Korenbaum*[3]*, Elena V. Kir'yanova*[3]*, Irina A. Pochekutova*[3]*, Yury A. Shulagin*[1]*, Antonina A. Osipova*[1]

[1] – State Scientific Center of the Russian Federation – Institute of Biomedical Problems of the Russian Academy of Sciences, Moscow, Russia. [2] – General Physics Institute named by A.M. Prokhorov of the Russian Academy of Sciences, 38 Vavilova Str., Moscow, 117942, Russia, E-mail: alexander-dyachenko@yandex.ru. [3] – V.I. Il'ichev Pacific Oceanologic Institute, Far Eastern Branch, Russian Academy of Sciences 43 Baltiyskaya Str., Vladivostok, 690041, Russia. E-mail: v-kor@poi.dvo.ru

The purpose of this work was to study duration of forced expiratory tracheal noises in different respiratory gas mixtures and normal pressure. We believe that measurement of duration of forced expiratory tracheal noises could be useful in monitoring respiration in divers.

Methods. We studied 20 normal volunteers (13 men, 7 women) aged 20-57 years. All the volunteers performed forced expirations breathing air with 21% O_2 and oxygen-helium mixture (O_2-He) with 21% O_2. Seven volunteers performed forced expirations breathing oxygen-krypton mixture (O_2-Kr) with 21% O_2. With the flow meter we measured flow and volume parameters of the forced expiration including T_s –volumetric duration of forced expiration. Simultaneously with gas flow we registered forced expiratory tracheal noises by virtue of electret microphone with stethoscope nozzle. The volunteer fixed microphone by his hand on the anterior lateral larynx wall. We analyzed digitized flow and sound signals in the following way. The sound signal was filtered (Band Pass; center - 1100 Hz; width - 1800 Hz; steep – slowest). The resulting signal is within 200-2000 Hz band and contains the main part of forced expiratory tracheal noises. We considered signal visually and measured duration of forced expiratory tracheal noises T_a as time interval between start and disappearing of tracheal sounds above the pre- and past-expiration levels. We choose 3 maneuvers with maximal T_a in each gas mixture.

Results. Wilcoxon t-test of group differences of T_a for different gas mixtures demonstrated that T_a is more in O_2-Kr than in O_2-He ($p < 0.02$, Table 1). Differences between all other pairs of T_a are not significant. Analysis of individual T_a revealed that increase of gas mixture density did not result in increase of T_a in some patients. We studied correlation between individual T_a and flow-volume parameters of forced expiration. In all the gas mixtures a maximal correlation (Spearmen coefficient) was obtained between T_a and ratio FVC_1/FVC ($r = -0.64$ in O_2-He; $r = -0.89$ in air; $r = -0.89$ in O_2-Kr; $p < 0.003$). There is no significant correlation between changes in T_a and changes in flow-volume parameters of forced expiration when gas mixture was changed. A significant correlation between T_a and T_s was obtained only in O_2-He ($r = 0.61$; $p < 0.005$) and in air ($r = 0.87$; $p < 0.00001$). Analysis of individual values of T_a shows, that a transition to denser gas mixture was not accompanied by augmentation of forced expiratory noises duration in some subjects.

Table 1. Volumetric duration of forced expiration T_s (average ± SD) and duration of forced expiratory tracheal noises T_a (average ± SD). P - significance of differences of duration of forced expiratory tracheal noises T_a between Gas mixture 1 and Gas mixture 2.

Gas mixture 1	T_s, s	T_a, s	Gas mixture 2	P
Air	3.89±2.41	2.84 ± 1.17	O_2-He	0.073
O_2-He	3.76±2.13	2.43 ± 0.67	O_2-Kr	0.017
O_2-Kr	5.00±2.46	3.90± 1.87	Air	0.090

Conclusions. Mean group acoustical and volumetric durations of forced expiration increased with gas mixture density. Individual reactions on increase of gas density were different.

This work was supported by the State Program of Support for Leading Scientific Schools project NSh - 5616.2006.1, grants of RFBR 06-08-08069-OFI, FEB RAS 06-1-P12-043 (program of RAS Presidium "Fundamental Sciences – to Medicine".

Simulation of sound transmission in humans from trachea to chest wall

A. D'yachenko [a,b], *O. Manyuhina* [c], *A. Mikhailovskaya* [b]

[a] General Physics Institute of RAS, Vavilova 38, 117942 Moscow, Russia. [b] Institute of Biomedical Problems of RAS, Khoroshevskoje shosse, 76a, 123007 Moscow, Russia.
[c] Radboud University/Theoretical Solid State Physics, Toernooiveld 1, 6525ED, Nijmegen, The Netherlands

A sound, generated at the airway opening and transmitted to the chest wall may be used for assessing properties of the respiratory system.

We presented the mathematical model of sound propagation in the respiratory system. This model describes the sound propagation from trachea to alveoli, the sound radiation from trachea to the surrounding tissues and its propagation to the chest wall. The wave equation in pulmonary parenchyma, considered as a multiphase medium, was found on the basis of continuum mechanics.

Two pathways of sound propagation were examined: 1) a sound wave propagating trough airway tree to alveoli; 2) a sound wave generated in pulmonary parenchyma by oscillating airway walls. The relative contributions of components 1) and 2) in the acceleration of the chest wall were examined. Resulting acceleration of the chest wall was found in an approximation of one-dimensional model with radial wave propagation. Two-dimensional model taking into account axial waves was also examined in order to access a role of axial component in the resulting acceleration of the chest wall and to find limitations of one-dimensional model.

We studied two characteristics of sound propagation from mouth to chest wall for frequencies between 0 and 1500 Hz: 1) contributions of 3 components of sound energy flow in each generation of airways: (a) transmission within the airway lumen, (b) emission of sound energy to parenchyma by vibrating airway walls, (c) dissipation in airways; 2) transfer function, i.e. magnitude of chest wall acceleration normalized by the acceleration over external trachea.

The simulation results demonstrate:

1) At low frequencies from 0 to 30 Hz the main part of acoustic energy travels into the branching structure and is transmitted to alveoli along airway tree. Between 40 and 600 Hz the main part of acoustic energy is emitted to parenchyma by walls of trachea and main bronchi. Emission from small airways to parenchyma increases with frequency and becomes significant at frequencies more than 600 Hz.

2) The model predicts reduction of transfer function with frequency (Fig. 1). Sound attenuation at the chest wall increases from 20 dB at 200 Hz to 60 dB at 600 Hz. The main component of the chest wall acceleration between 100 and 600 Hz is produced by a sound generated by oscillations of walls of trachea and main bronchi and transmitted through pulmonary parenchyma. At higher frequencies a sound generated in parenchyma by vibrations of walls of large airways attenuates due to the tissue effective viscosity.

This work was supported by the State Program of Support for Leading Scientific Schools project NSh - 5616.2006.1. E-mail: alexander-dyachenko@yandex.ru.

Effect of lung volume on acoustic transmission in normal subjects

A. Key[1], P.P. Pompilio[2], R.L. Dellaca[2], S. Jack[1], D. Davies[3], J. Earis[1].

[1]University Department of Medicine, University Hospital Aintree, Liverpool, England.
[2]Dipartimento di Bioingegneria, Politecnico di Milano University, Milano, Italy
[3] University of Salford, Manchester, UK

Introduction:
Sound transmission through the chest is much slower than through air, is highly frequency dependent and there is a complex relationship between lung volume and sound transmission. In this study we examine the relationship between lung volume and sound transmission using a new non-invasive method of optoelectronic plethysmography (OEP) and FFT to measure phase angle of the input and output signal and measured sound over the anterior and posterior chest wall.

Methods:
8 healthy non-smoking male subjects were studied (age 35.6-12.9) Sounds between 100 Hz and 1 kHz generated by a loudspeaker were introduced at the mouth and recorded on the chest wall surface by 7 miniature electret microphones attached by elastic rubber belts. (1 tracheal, 2 anterior upper zone, 2 posterior upper zone and 2 posterior lower zone). All the signals were sampled at 10KHz. Chest wall volumes were assessed by placing 89 retro-reflective passive markers on the chest and measuring their 3D position by specially-designed infrared cameras. During each test, the subject was asked to breath spontaneously for ~30 secs, to perform an inspiratory and an expiratory Slow Vital Capacity, separated by 1 min of quiet breathing.

Results:
The results had the first and last values removed because of artefact thought to be due to glottic closure and in addition the coherence of the signal was unacceptable above 300Hz. There was frequency dependence of transmission, higher frequencies showing faster transmission speed. Inspiratory and expiratory results showed similar trends. The Wilcoxon test for differences show a negative correlation ($p<0.001$ to <0.003) between residual volume and total lung capacity in 7 manoeuvres at 200 and 300Hz and in one at 100Hz there was a positive correlation. Correlating the mean transmission at each of the eight measurement points of vital capacity also gave a negative correlation during inspiration in all locations at 300Hz values and all the 200Hz apart from a positive correlation in one posterior microphone. The 100Hz results were more variable.

Discussion and Conclusions
These data clearly demonstrate the frequency dependence of sound transmission. This may be due to higher frequencies penetrating further into the airways before coupling to the parenchyma. The negative correlations between lung volume and transmission is likely to be associated with changes in the density of lung tissue as the lungs expand. Further work is being undertaken to see if density changes in disease (e.g. Emphysema and Interstitial Pulmonary Fibrosis) have an effect on sound transmission which could be used for monitoring such disease processes.

Sound transmission (transit time) in the lung in normal subjects appears to be independent of gravity.

S. Ishikawa, M. Shturman, C. Vassaux, K.F. MacDonnell, B. Celli

Pulmonary& Critical Care, Caritas St Elizabeth's Medical Center, Boston MA.
Dept. of Medicine, Tufts University School of Medicine. Boston MA., U.S.A.
Email: sishikawa@copdnet.org

We studied whether the gravity may have an influence on Sound transmission(transit time) through the lung. To study Sound Transmission(transit time) throughthe lungs, we introduced monophonic 150 Hz sound at the mouth of twenty normalsubjects at Total Lung Capacity with the glottis open. In order to ensure the glottis is fully open each subject was instructed to hold the speaker chamber(sound generator) next to their mouth and take a full inspiration, then close the lips around the mouthpiece and expire very slowly through a plastic straw which is attached to the mouthpiece. Lung sound signals were recorded over the neck near the trachea(reference) and 14 sites on the chest surface with contact microphones using Murphy's STG 16 system at Sitting and Supine positions. Sound signals were digitized and time expanded wave forms displayed. Sound Transmission(transit time) was measured by Cross Correlation technique. We found the Sound Transmission(transit time) were, in milliseconds : In Sitting Position

	proximal zone	middle zone	distal zone
Right lung	1.54 +-0.134	1.72+-0.828	1.35+-0.231
Left lung	1.56 +-0.134	1.51+-0.244	1.42+-0.188

In Recumbent (supine)

	proximal zone	middle zone	distal zone
Right lung	1.56+-0.331	1.62+-0.451	1.42+-0.189
Left lung	1.38+-0.245	1.43+-0.473	1.44+-0.231

The Sounds Transmission(transit time) through the Lungs appears not to be influenced by Gravity.

An examination of a method to detect abnormal sounds from the lung sounds recorded in different environments.

Katsuya Yamauchi, Masaru Yamashita*, Shoichi Matsunaga*, Sueharu Miyahara* and Hiroshi Nakano***

(*Faculty of Engineering, Nagasaki University, ** Fukuoka National Hospital)

Representative address
Katsuya Yamauchi,
Dept. of Computer and Information Sciences, Faculty of Engineering, Nagasaki University
1-14, Bunkyo-machi, Nagasaki 852-8521, Japan
tel. +81-95-819-2701
fax. +81-95-819-2575
email. yamauchi@cis.nagasaki-u.ac.jp

Abstract:
We have examined a procedure to detect the adventitious sounds from lung sounds using a stochastic approach. In previous research, an novel procedure to to detect the adventitious sounds using a stochastic approach was proposed. The architecture of the proposal method is composed of the training process and the test process. Each recorded lung sounds is divided into several respiratory phase segment, and labeled according to the respiratory phase and diagnostic states (normal or abnormal). Acoustic models of each phase segment unit are generated for every kind of diagnostic state in the training process. The hidden Markov models (HMMs) are used to this modeling. Likelihood of an input phase segment is calculated using acoustic models which are generated for each diagnostic state, and the diagnostic state achieving the highest likelihood is derived as a recognized result.
Although the more lung sounds are required to get more reliable recognition results, the lung sounds recorded in different environments are not easily combined for the training. This paper proposes an examination of a method to detect abnormal sounds from lung sounds recorded in different environments and conditions. The lung sounds recorded through a condenser microphone attached to subjects' chest wall and through a electronic stethoscope were used.
The experimental results showed that the difference of noise mixing were diminished by the noise suppression with the cepstrum mean subtraction (CMS) in the acoustic feature extraction. Experimental results using the states and the mixture of segment HMMs were compared. The comparison showed that increasing states of HMMs, which made the models responsive to the time series variation of lung sounds, were effective.

Keywords:
Maximum likelihood detection, Hidden Markov models (HMMs), Cepstrum mean subtraction (CMS), Acoustical signal processing, Recording condition

Detection of crackles using an analytic signal representation

A.Fuchita and A.Suzuki

Division of Medical Imaging, Graduate School of Health Science,
Suzuka University of Medical Science, Mie, Japan

For monitoring respiratory condition with lung sounds, it is important to accurately detect adventitious lung sounds. In this work a new method of detecting crackles is proposed.

The analytic-signal representation of lung sound is employed. The analytic signal is a complex signal; its real part is the lung-sound signal itself and its imaginary part is the Hilbert transform of the lung-sound signal. The envelope, instantaneous frequency and instantaneous bandwidth of the lung sound are determined on the basis of the analytic signal. Using the envelope local peaks of the lung sound are searched as candidates of positions of crackles. Crest factor for each peak is then calculated. The lung sound at each peak is examined with the crest factor, time derivative of instantaneous frequency and instantaneous bandwidth of the lung sound.

The experimental result of detection of coarse crackle is shown in Fig. 1. The instantaneous frequency is stable in the section where a crackle occurs, whereas it fluctuates in the background. The instantaneous bandwidth is narrow in the section where a crackle occurs and it approaches zero at the peak of the crackle, whereas it is wide in the background.

The result shows that the proposed algorithm well detects crackles. We conclude that the analytic-signal based analysis of lung sounds is effective for detecting crackles.

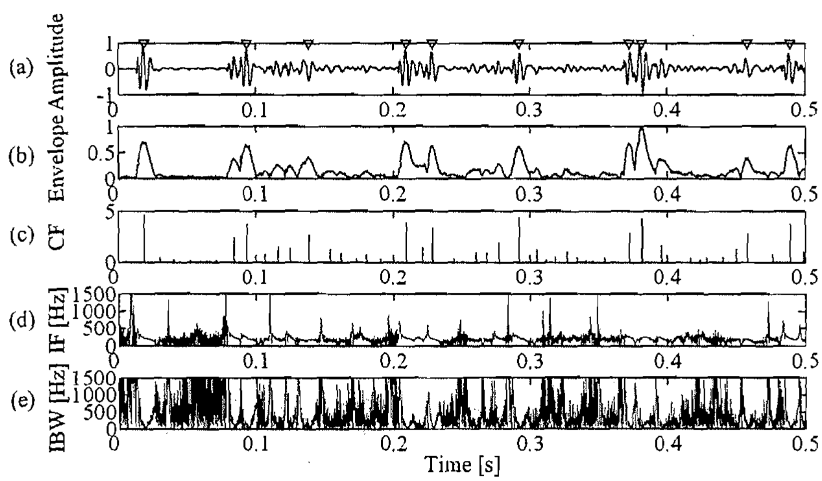


Fig. 1. The experimental result of crackle detection. (a) Recorded lung sound of a patient with bronchiectasis. Detected crackles are shown as triangles. (b) The envelope, (c) crest factor, (d) instantaneous frequency and (e) instantaneous bandwidth of the lung sound.

Further developments in microphone-based contact stethoscopic sensors, and reduction of lead-transmitted noises

Fujihiko SAKAO
Home : Ajina 3-6-20, Hiroshima-ken, Japan 738-0054
e-mail : sakao-f@lime.ocn.ne.jp

I. New composition of Contact Sensors

So far in our sensors, a microphone cartridge was fixed inside a tubuler case with injected silicon (or so) resin which also provides air-tight sealing (Fig. 1). The resin had to be selected from a limited group, with insufficient damping characteristics. Fig. 2 (A) presents an example of frequency response.

In the new method, a thin sheat of rubber is wrapped around cartridge and cemented instead of resin. Then the whole thing is put inside a tubuler case and cemented to it, to form air-tight sealing. Fig. 2 (B) is an example of the results. It gives a remarkably flat resoponse over wide range of frequency.

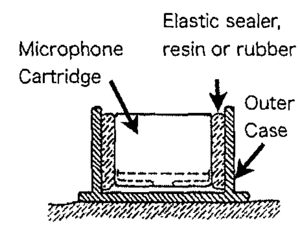


Fig. 1. The sensor

2. A Lead with Reduced Lead-Travelling Noises

Noises caused by rubbing the lead wire(s) and intruding into the sensor along the lead can be very annoying. The author presented some results on preventing it. This time a new, very simple way for noise reduction is described below.

Inside many business machines such as a printer, flexible lead belts are utilized. A lead belt is a thin, smooth plastic belt with thin copper-layer paths on it. From one of such lead belts, a lead belt with two (or, if possible, three) parallel electric paths is obtained by cutting off unnecessary part. Noises caused by (accidentaly) rubbing such a lead is found much less than with a conventional coaxial lead cable, or twisted pair lead. So far the cause is not known, Noises originated in the mains (so called "hum") is found not serious. Detailed results will be presented at the Congress.

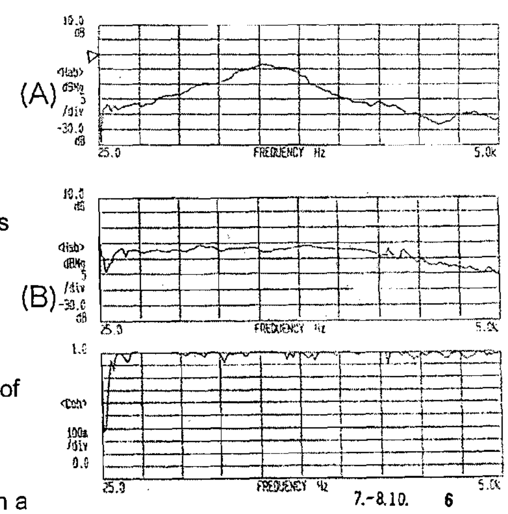


Fig. 2. Frequency characteristics of sensors, (A): Previous type, (B): New type. Abscissas 0 to 5 kHz, ordinates 5 dB/div. The botom is coherence for B, 0 to 1.

(As for references, confer previous abstracts in ILSA Conferences by Sakao)

Auscultation of the chest may be easier when patients are wearing under shirts than on the bare chest

Yukio Nagasaka, Syohei Yasuda, Yasuhiro Ieda, Takamune Sugiura
Department of Pulmonary Medicine, Kinki University Sakai Hospital
*Yoshikazu Takatera, Takanori Kawashima**
*NI Teijin Shoji, * Teijin*

Although wearing under shirts during physical examination is more comfortable than exposing bare chest for the patients, under shirts cause friction noise and attenuate breath sound. We recorded breath sounds on bare chest and while wearing shirts made from seven different materials, including commercial underwear. On a shirt made of a new material, there was little noise and breath sound transmission was comparable to bare chest. We conclude that auscultation of the chest above the commercial under shirts was difficult because of friction noise and attenuation of the breath sounds. However, newly developed shirt material was promising as patients ware during chest auscultation.

Evaluation of the swallowing sound recorded in the auditory canal

Tsunemi KITAGAWA[1] *Hiroshi KIYOKAWA*[2] *and Tatsuhiko HARADA*[3]

International University of Health and Welfare Atami Hospital
[1]Department of Rehabilitation Medicine [2]Department of Internal Medicine
[3]Department of Otolaryngology

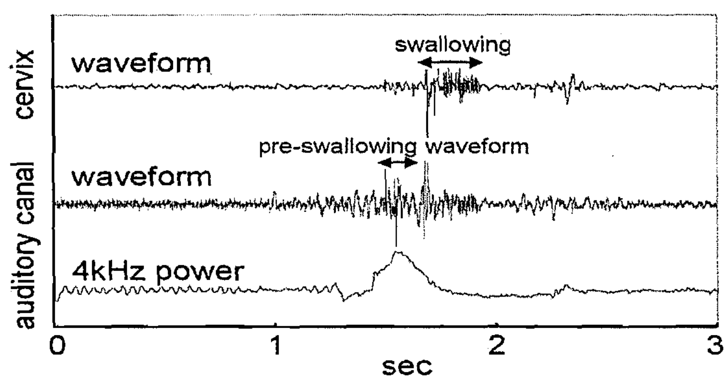
【Purpose】 Monitoring swallowing sound on the surface of neck (cervical sound: C-sound) is important to examine the swallowing function. We considered that the recording of the swallowing sound in the auditory canal (auditory canal sound: A-sound) has advantages including; 1. firm installation of the sensor, 2. less annoying for longer period of recording, and 3. better sound insulation from ambient noise. In this research, we tested the usability of the A-sound in comparison with the C-sound for recording the swallowing sound.

【Investigation of sensors】 We obtained four different auditory canal sensors from the market (Etymotic Research, Temco Japan, Primo and SONY) and tested the performances. All sensors except for SONY were capable to record the A-sound. We adopted a pair of ER sensors for this study.

【Recording】 One of the ER sensors was put in the auditory canal and the other was put on the ipsilateral neck surface. From these sensors, the swallowing sounds were recorded simultaneously. Comparison of the signals was done by observation of the waveforms. The Eustachian tube (E-tube) may have some effect on the A-sound as it opens during swallowing to control air pressure. To detect the E-tube opening, we injected 4000Hz sine wave through ipsilateral nostril to be recorded with the A-sound. The power of 4000 Hz was isolated by FFT, which intensify according to the opening of the E-tube (sonotubometry).

【Outcomes】 Although minor variations were observed in amplitudes and timings, the A- and C-sound were similar. In auditory canal, characteristic waveform was observed just before swallowing (we call it as pre-swallowing waveform: PSWF). Augmentation of the 4000Hz power was accompanied with PSWF.

【Conclusion】 The A-sound can be recorded in substitution for the C-sound, even though these are not exactly the same. The PSWF is observed only from the A-sound, which may originate from the E-tube.



Assessment of lung auscultation in COPD (Emphysema)

by Yongyudh Ploysongsang, MD, Bumrungrad International Hospital.

Introduction

COPD (Chronic Obstructive Pulmonary Disease) or emphysema is characterized pathologically by destruction of lung parenchyma and physiologically by inhomogeneity of regional ventilation and perfusion, leading to severe ventilation/ perfusion inequality and hypoxemia. Due to inhomogeneity of disease in small airways and inequality of regional time constants it is expected that regional ventilations will be inhomogeneous and variable from breath to breath. If regional breath sound intensities reflect regional ventilations in emphysema, we anticipate that regional breath sound intensities will also be different from normal pattern, vary from breath to breath, as well as inhomogeneous the whole range of vital capacity.

Experiments

We set forth to prove our hypothesis by doing our experiments. Eight patients with emphysema were studied in upright posture. Breath sound intensities (Ib) were recorded from 4 positions on the right anterior chest wall just lateral to the midclavicular line at 5, 10, 15 and 20 cm from the top of the lung by microphone amplifier systems as previously described. White noise transmission characteristics (Tn) of the lung and chest wall were also recorded from the same locations. Regional ventilations from the same areas were studied by the ^{133} Xenon techniques on the same day. Regional Ib and Tn were correlated with regional ^{133} Xenon ventilation indices.

Results

The following results are found:

1. Breath sound intensities and transmission characteristics of lung and chest wall in emphysematous subjects tend to follow the same pattern on repeated breaths, but the degree of reproducibility of Ib is not as good as it is in normal subjects. If regional ventilations are related to regional breath sounds, the data suggest that regional ventilations in emphysematous lungs vary from breath to breath.
2. Regional breath sound productions and transmissions are altered in emphysema, leading sometimes to a decrease or increase in breath sounds heard by clinicians.
3. The distribution of breath sounds and, hence, probably regional ventilation is also deranged.
4. In subjects with emphysema, objective breath sound intensities (uncompensated, Ib; and compensated, Ib/Tn) correlate with regional ventilations as measured by xenon inhalation technique.

Conclusion

Breath sound intensities and transmission characteristics of lung and chest wall in emphysematous subjects vary from breath to breath, but trend to follow the same pattern on repeated breaths. They are altered when compared to those in normal subjects. The distribution of breath sound is also deranged. In emphysematous subjects, objective breath sound intensities correlate with regional ventilation as measured by xenon technique.

The evaluation of the efficacy of fast Fourier transformation of inspiratory lung sounds by phonopneumograph in a diagnosis of interstitial pneumonia

Hiroshi Ono[(1)(2)] *Akira Murata*[(2)] *Yasuyuki Taniguchi*[(1)(2)] *Kinya Shinoda*[(1)(2)] *Torakazu Muratake*[(3)] *and Shoji Kudoh*[(2)]

(1) Jiseikai-Tojun Hospital

(2) Department of Pulmonary medicine/Infection and oncology, Nippon Medical School

(3) KenzMedico CO.

(Aim and subjects) We evaluated whether the analysis by fast Fourier transformation (FFT) of inspiratory lung sounds with phonopneumograph is useful in a diagnosis and a judgment of severity of interstitial pneumonia (IP).

(Methods) I . We divided the 31 cases into two groups; the group of ten cases of normal volunteer (the normal group) and that of twenty-one cases of IP(the IP group). Then we made the averaged power spectra by FFT from 10 breathes during inspiratory phase in each cases, gained the frequency of maximum intensity (peak frequency; PF) and that of half intensity of maximum (F50), and compared between the two groups. And we made the receiver operating characteristic curves (ROC), evaluated the capacity of discrimination. II . In the IP group, we evaluated whether PF or F50 relates to lung function tests (%VC, $FEV_{1.0}$%, %DLCO), serological tests (KL-6, SP-D) and the fibrosis score in HRCT (FS)[(1)]

(Results) I . The PF in the IP group was 456.7±137.1 and that of the F50 was 876.7±222.7〔Hz〕, which were significant higher than them in the normal group which were 246±42.5、518±150.8. And the area under ROC of the PF and the F50 were 0.914 and 0.912 which meant excellent capacity of discrimination. II .There were positive correlations between F50 and FS (r=0.613, p=0.003), and between F50 and KL-6 (r=0.468, p=0.038)

(1) Kazerooni EA, Martinez FJ, Flint A, et.al. Thin-section CT obtained at 10-mm increments versus limited three-level thin-section CT for idiopathic pulmonary fibrosis: correlation with pathologic scoring.; AJR Am J Roentgenol. 1997 Oct;169(4):977-83.

Multichannel lung sound analysis before and after mechanically induced lung injury

R. Murphy, A.Vyshedskiy, P. Quinn*, S. Van Albert*, M. Milendorf, & A. Wong-Tse
Faulkner Hospital, Boston, MA and *Walter Reed Army Institute of Research

Introduction

For the purpose of testing different types of protective gear to shield personnel from injury due to explosions on the battlefield, sheep were subjected to mechanically induced injury. We studied lung sounds in these sheep before and after these injuries. Our hypothesis was that abnormal sounds, not present before the injury, would likely be detected in damaged lungs. Detection of these acoustic abnormalities could have the potential of providing a rapid, noninvasive means of detecting lung injury in sheep undergoing such studies. It also could have implications for the diagnosis and monitoring military personnel who experience chest trauma.

Materials and Methods

Sheep were examined with a 16 channel lung sound analyzer (Stethographics Model 302) (STG System) before and after mechanically induced chest trauma. The system uses miniature electret microphones (Gentex, 3301-0) mounted in commercially available stethoscope chest pieces to amplify, filter, and multiplex lung sounds to an analog-to-digital converter (Keithley, DAS-1801ST) and then stores the data on a PC. A custom designed circuit board is used for the amplification and filtering of each channel employing a 1 pole high-pass and low-pass filter with cutoff frequencies 80 and 2,000 Hz respectively. For ease of application 14 microphones are incorporated into a soft foam pad as shown on Figure 1. The microphone pad is covered with a custom made single use, disposable interface to prevent transmission of pathogens to the pad. The side microphones were held in place by lycra straps. One microphone was used to record tracheal sound and one microphone was used to record heart sounds. The STG System software was custom developed to collect data and automate data analysis including calculation of acoustic amplitude as well as automated identification of wheezes, rhonchi and fine and coarse crackles. Time expanded waveform analysis can be performed instantaneously on each channel to verify the automated analysis. The amplitude, i.e. root mean square values (RMS), is calculated at each site.

Results

Table 1 presents the results of the acoustic analyses done prior to and after the mechanically induced injury.
Table 1. *Computerized lung sound analysis before and after mechanically induced lung injury in 9 sheep.*

		Crackle	Right	Left	Wheeze
Pre Injury		Rate	RMS	RMS	Rate
		1.1	21.0	21.5	6.5
		0.7	23.5	30.0	0.0
		0.0	26.7	34.0	0.0
		0.9	19.0	23.5	10.5
		0.3	18.0	28.0	4.5
		1.5	42.3	36.3	1.0
		2.8	32.0	24.7	3.7
		3.5	92.8	101.2	11.0
		3.3	35.3	37.5	2.8
	avg	**1.6**	**34.5**	**37.4**	**4.4**
	std	**1.3**	**23.3**	**24.6**	**4.2**
Post Injury		4.9	172.0	57.3	33.0
		3.5	90.2	69.6	14.0
		0.4	53.3	31.3	1.0

		2.9	130.9	238.7	52.4
		2.2	149.4	116.5	34.2
		2.4	82.8	79.5	5.8
		8.7	55.1	138.1	37.8
		3.8	115.9	121.1	27.3
		3.0	51.9	48.1	11.8
	avg	**3.5**	**100.2**	**100.0**	**24.1**
	std	**2.3**	**44.3**	**63.2**	**17.0**
P values Pre vs Post	**<0.01**	**<0.004**	**<0.008**	**<0.004**	

Prior to the injury the sound amplitude was relatively uniform at all microphones and few adventitious sounds were noted. After the injury was induced there were numerous abnormalities in lung sound patterns. Crackles, wheezes and rhonchi all increased in number.

A score was developed for each of these parameters to normalize them so that the effects of combining them could be assessed. This was done after inspection of the histogram of each parameter. Prior to injury the total score mean was 1.89 (SD 1.83). Post injury the total score mean was 6.89 (SD 1.90) The results were statistically significant -$p<0.0001$ (Friedman's ANOVA).

Summary

The sounds detected in these 9 sheep after mechanically induced damage, were louder and contained more crackles, wheezes, and rhonchi than they did prior to the injury. There were also abnormal patterns seen in the waveforms not previously present. A squeak-like sound (we call a CUSS) was detected that to our knowledge has not been previously described. A score based on acoustic paramters was statistically significantly increased after as compared to before the injury ($p<0.0001$). The correlation of the location of the acoustic abnormalities with the areas of damage needs further investigation.

Conclusion

Lung sound analysis appears to have promise in detection of contused lung.

Limitations

Computerized technology developed for humans was used. More specific algorithms for sheep sounds might improve the analysis. The sounds collected were from fifteen sites. Increasing the number of sites is likely to improve the localization capabilities of multi-channel lung sound analysis.

Implications

These observations provide evidence that lung sound analysis could help in monitoring sheep for the presence and progression of injury in contusion studies. Sound analysis devices could be available in war zones, in medical evacuations, and operating rooms to improve non-invasive diagnosis.

Acoustic analysis of Breath Sounds before and after chest physical therapy

Toshimitsu Suga, Akira Okii, Mayumi Sasaki, Seiko Shibata, Kiyokazu Yshida, Yoshihiro Imai, kwangho Kim, Nobuyuki Iwata

Department of Rehabilitation medicine, Kansai Medical University

Abstract:
Introduction: The use of acoustic analysis has been reported in internal medicine and pediatrics. However, no evaluation using acoustic analysis has been reported in the field of rehabilitation medicine. We speculated that since acoustic analysis shows sounds as pictures, we would be able to objectively evaluate the effects of chest physical therapy(CPT).

Methods: The subjects were three adult patients and two pediatric patients with acute respiratory failure. Adult patients were pulmonary disease, spinal cord injury and postoperative respiratory failure. In postoperative case, we used mechanical Insufflator-Exsufflator in addition to CPT. Two of three pediatric patients had a congenital cardiac disease and all three patients required intratracheal intubation/artificial ventilation. We did an acoustic analysis and compared their breath sounds before and after CPT. Acoustic analysis converts the breath sound to sound spectrograph.

Results and discussion: In patients, a sound spectrogram before CPT revealed an abnormal shadow which had a harmonic structure. After CPT, the shadow disappeared. Abnormal shadows on the sound spectrogram were considered to show a continuous rale accompanying the retention of secreta and these disappeared or decreased after CPT because expectoration of secreta was facilitated by CPT. We analyzed the time course of breath sounds, so that we could understand changes in breath sounds not only by an auditory findings but also visual findings. Also, it is possible to evaluate an effect of mechanical Insufflator-Exsufflator by a sound spectrogram .

If we can accurately establish the change of breath sound using acoustic analysis, it will be useful to effectively a position for drainage as well as to establish the time interval for changing position and to advance auscultation techniques. Moreover, acoustic analysis is invasive. We think that analysis of breath sounds can be an index of the respiratory state.

Snoring sound intensity and obstructive sleep apnea

Hiroshi Nakano, Kenji Hirayama, Tomokazu Furukawa, Sankei Nishima

Fukuoka National Hospital, Fukuoka JAPAN

Objectives

Snoring is the most common manifestation of obstructive sleep apnea (OSA). Snoring severity measured by a questionnaire has been used as a surrogate parameter for OSA in many epidemiological studies. However, there have been only a few studies that focus on the relationship between objectively measured snoring sound and OSA. In the present study, we measured snoring sound intensity during polysomnography and described the relationship between snoring sound intensity and OSA severity as well as various clinical factors.

Methods

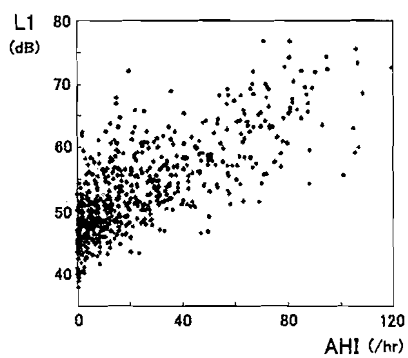
The records of 646 patients who underwent polysomnography for suspected OSA were retrospectively reviewed. Sound intensity (A-weighted sound pressure level) at 1.2m above the surface of patient's bed was assessed by the highest one percentile ambient sound pressure level (L1) while asleep during polysomnography.

Results

1) L1 correlated with apnea-hypopnea index (AHI) (r=0.682), and body mass index (BMI) (r=0.501). A multivariate regression analysis indicated that both AHI and BMI contributed independently and determined about 60% of the L1 variation (R^2=0.597).

2) L1 correlated with subjective sleepiness measured by the Epworth sleepiness scale (r=0.194; p=0.000004). The relationship was preserved after adjustment for confounding factors including the AHI and age.

3) L1 correlated with daytime diastolic blood pressure (r=0.342;p<0.00000001). The relationship was preserved after adjustment for confounding factors including the AHI, age and BMI.



Discussion

The present study demonstrated that the snoring sound intensity is a measure of OSA severity. Moreover, the intensity related to subjective sleepiness and blood pressure independently of AHI, suggesting that measures of snoring might have information about OSA pathophysiology which is not fully evaluated by ordinary polysomnography.

We believe measurement of snoring is an important part of OSA monitoring.

Diffuse panbronchiolitis and anti-inflammatory action of macrolide antibiotics

Shoji Kudoh (Japan)

Diffuse panbronchiolitis (DPB) is a chronic disease of the airways involving diffuse inflammation of the respiratory bronchioles. DPB occurs primarily in East Asia with few cases identified in the western world. According to a recent investigation, it was suggested that an HLA-associated major susceptibility gene for DPB is located within the 200 kilo-base in the class I region on the short arm of chromosome 6.

Before our discovery of low-dose long-term erythromycin (EM) therapy, the prognosis of patients with DPB was extremely poor. However, the EM therapy remarkably improved the prognosis of patients with DPB. The investigation on the mechanisms of EM therapy has resulted clarifying the novel actions, especially anti-inflammatory action of 14-membered (erythromycin and clarithromycin) or 15-membered ring (azithromycin) macrolides.

These drugs reduce the inflammatory response by decreasing the recruitment and infiltration of neutrophils, inhibiting expression of IL-8 through inhibiting expression of transcription factors (NF-*k*B, AP-1), as well as decreasing mucus secretion by inhibiting water secretion through chrolide channel block and inhibiting mucin secretion. Because of these anti-inflammatory effects, there is significant interest in the efficacy of macrolides in the treatment of other chronic inflammatory diseases of the airways such as cystic fibrosis in Western. Recently, usefulness of macrolides for prevention of acute exacerbation of COPD by inhibiting rhinovirus infection and therapeutic effect on influenza virus infection were reported.

Vibration response imaging of lung –dynamic images and lung function findings in normal Japanese men

Masamichi MINESHITA, *Junko SAJI, Hirotaka KIDA, Fuzuki ISHIKAWA, Hiroki NISHINE, Miho NAKAMURA, Masahiro OHSHIGE, Atsuko ISHIDA, Yuka MATSUOKA, Takeo INOUE, Makoto HOSHINO, Taeko SHIRAKAWA, Teruomi MIYAZAWA*

Division of Respiratory and Infectious Disease, Department of Internal Medicine, St.Marianna University School of Medicine, Kawasaki, Japan

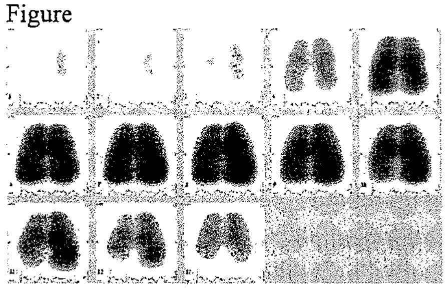
Introduction: The VRI™ (Deep Breeze™, Or-Akiva, Israel) is an imaging modality that records energy generated by vibrations of the lungs during respiration cycle and creates images that can be viewed dynamically or sequentially.

Methods: The VRI images of 25 normal Japanese male subjects (age 33.9±7.3 yrs, 13 non-smokers, 3 ex-smokers, 9 current-smokers) were recorded. Subjects were defined as normal according to medical history, lung function test and physical exam. The images were assembled from frames of 0.17sec of energy recorded by 34 or 40 sensors depending upon the subject's height, during deep breathing (Figure). We defined the darkest point of each lung in every frame as the maximal energy point. We have visually evaluated the VRI images according to the movement of the maximal energy point of each lung along the breathing cycle and the difference in the timing of energy development between both lungs.

Results: The excessive movement of maximal energy point along the breathing cycle was observed in 6 subjects ("moving group"). Four subjects had >2 frames (≥ 0.34sec) difference in the timing of maximal energy development between both lungs ("lagging group"). 2 subjects had both findings while 17 subjects did not have these findings and were considered to be normal ("normal group"). FEV_1% of the moving group was significantly lower than that of normal group (Table).

Conclusions: Apparent movement of maximal energy point was thought to be the sign of uneven intrapulmonary airflow, and this uneven airflow might be the reason for lower FEV_1%.

Figure



Table

group	n	age	%FVC	%FEV1	FEV1%	%V25
moving	6	37.0±4.1	101.2±5.6	91.4±8.3	78.9±5.4*	58.7±13.7
lagging	4	29.3±7.9	105.1±3.7	96.8±8.8	91.5±6.3	76.4±31.5
normal	17	33.8±7.3	99.0±8.4	95.3±9.4	84.7±5.2	79.5±23.5

*: $p<0.05$ (compared with normal; Mann-Whitney U test)

Non-contact stethoscope for auscultation of neonatal patients

Murphy, R., MD, Vyshedskiy, A., PhD, Klebanov L., Brigham and Women's/Faulkner Hospital, Boston, MA

Introduction: Premature babies in neonatal intensive care units (NICU) require monitoring for signs of lung congestion and heart murmurs. Currently NICU medical personnel use acoustic stethoscopes. The use of acoustic stethoscope has a number of highly undesirable side effects including withdrawal response, flinching, apnea, hypoxemia, change in sleep state, and possibility of contamination. The ability to share auscultatory findings among medical personnel is also a problem because of observer variability.
Purpose: To develop a non-contact optical stethoscope.
Methods: Light has long been considered a perfect tool for measuring vibrations of the surface. One of the most precise methods of vibration measurements is based on two-beam interference – one being the beam reflected from the surface of interest and the other called reference beam. The surface movements cause changes in the distance the reflected beam travels. The corresponding changes in the two-beam interference can be detected as changes in the intensity of the detected light.
Results: We have developed a prototype optical stethoscope, capable of detecting heart sounds from 1 meter away. The comparison of heart sounds recorded by the non-contact stethoscope to those recorded by a contact sensor demonstrated clear heart sounds, no signal clipping, and similar waveform and frequency characteristics between two recordings.
Conclusions: It is possible to develop a non-contact stethoscope that can be mounted on an incubator cover. Lung sounds can potentially be detected with this interferometric approach and this could have applications in monitoring patients in the ICU settings.

Supported by a grant from NSF #0610636.
R. Murphy has a financial interest in Stethographics, Inc., a manufacturer of single and multichannel lung sound analyzers.

Changes of lung sound nomenclature in Japan since 1985 World Congress of Lung Sound

Yukio Nagasaka, Syohei Yasuda, Yasuhiro Ieda, Takamune Sugiura
Dept. of Pulmonary Medicine, Kinki U. Sakai Hospital
Shoji Kudoh
Dept. of Pulmonary Medicine, Nippon Medical School

In 1985, International Symposium on Lung Sounds was held in Tokyo and a proposal of new terminology was announced by Professor Mikami, the president of the Symposium. We investigated the terms on lung sounds used in 200 case reports in J Jpn Resp Soc in each period, before and after the Symposium, before 1984, 1994-1993 and 2004-2003. Before 1984, "Nenpatsuon" = hair twisting sound and "Velcro rales" were popular terms to describe fine crackle. For coarse crackle, "Sissei Raon" = moist rale had been the popular term. "Kansei Raon" = dry rale was popular but wheeze or "Zeimei"=wheeze is used more frequently in 2004. Although terminology in lung sounds has been changing, diverse terms have been used onto the same sound. Consensus and message on unification of the nomenclature of lung sound will be mandatory to extend the knowledge and skill of lung auscultation.

The thoracic system acts like a low-pass filter and vesicular lungs sounds originate differently from tracheal sounds.

Yanjiao Zheng, Master Candidate
Tel: 011-86-755-26036355
E-mail: zhen-yj02@mails.thu.edu.cn
Address: 303B, Building L, Tsinghua University, Xili University Town, Nanshan District, Shenzhen, Guangdong 518055, China

Background Lung auscultation is a basic procedure for clinical diagnosis of respiratory diseases. The traditional method of auscultation is based on a stethoscope and the human auditory system which associated to the physician expertise. However, the poor response of the human auditory system to low-frequency sounds let the most information of lung sounds pass away. And the mechanism of production of lung sounds and the characteristics of thoracic transmission system are not exactly known. So many physicians turn to rely on other new complicated instruments instead of this long-history tool. Fortunately, with the growth of computer technology and signal processing technique, lung sounds research have become a new focus and it is worth more and more attention. Normal breath sounds include tracheal sounds, vesicular sounds, bronchial sounds, and bronchovescicular sounds.

Objective To investigate the mechanism of production of respiratory sounds and the characteristics of thoracic transmission system.

Methods Recorded respiratory sounds of healthy persons at normal breath with one stethoscope over the proximal trachea below the larynx and another over the posterior right lower lung.

Recorded tracheal sounds and vesicular lung sounds from the same person while he is breathing air at high flow rates and while he is breathing a low density gas mixture (80% helium, 20% oxygen: $He\text{-}O_2$) at the same flow rates.

Results Tracheal sounds are somewhat like the white noise with a broad range of frequencies up to 1000 Hz and more. Tracheal sounds have a harsh, noisy character. The simultaneous vesicular lung sounds are more muffled whose frequency range is much more limited with little noise above 400 Hz. Lung sounds have lost much of the higher frequency components on the passage through lung and chest wall.

Tracheal sounds' intensity drops and also changes in pitch with low density gas. Vesicular lung sounds become less loud at higher frequencies but low frequencies don't change as much.

Conclusion Air-filled lung acts like a low-pass filter through which low frequency sound passes more readily through similar to the effect of electronically filtering high frequency noise.

The normal tracheal sounds originate from turbulences of air (largely gas density dependent) in large central airways and are affected by resonances in central airways. Vesicular lung sounds are contributed by sources such as noise from muscles and from cardiovascular system at low frequencies besides turbulent air flow.

The Basis of Mechanomyography and Its Applications

Katsumi Mita
Kawasaki University of Medical Welfare

Contents:

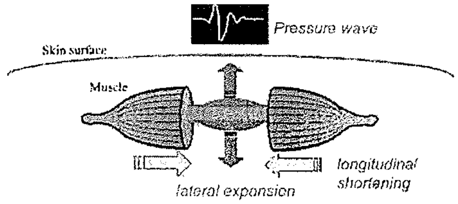
1. What is the mechanomyogram (MMG) ?
2. Who discovered the MMG, and when and where ?
3. What are basic characteristics of the MMG ?
4. How can we use the MMG ?

1. What is the mechanomyogram (MMG) ?

I have been led to infer the existence of these alternative motions from a sensation perceptible upon inserting the extremity of the finger into the ear. (Wollaston H.W. 1810)

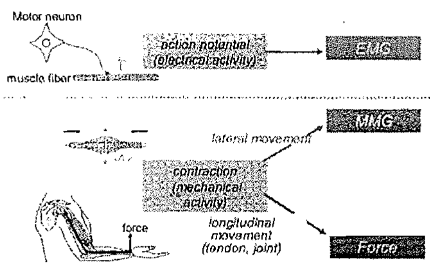
We can hear a small low-frequency sound like the rumbling of thunder. This is a sound generated from muscle.

The mechanomyogram (MMG) is recording of - - -



Pressure waves resulting from the dimensional changes (lateral movement) of the fibers of the active motor units
Gordon & Holbourn (1948); Brozovich & Pollack (1983)

Relationship between the electromyogram (EMG), mechanomyogram (MMG) and force

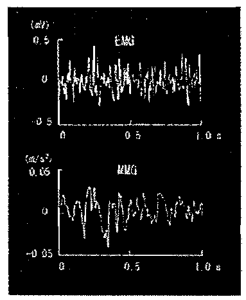


Typical recordings of the EMG and MMG

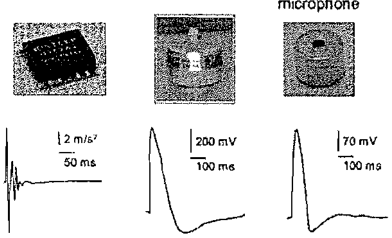
The MMG signal during voluntary contractions is a random signal similar to the EMG.

The frequency components are lower than those of the EMG.

The MMG is considered as the mechanical counterpart of the myoelectrical activities.



Different types of MMG transducers

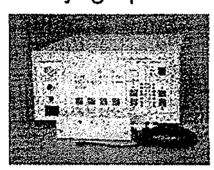


(Each MMG signal is elicited by single electric stimulation)

Standard Mechanomyograph

The specifications are determined on the basis of a number of previous papers.

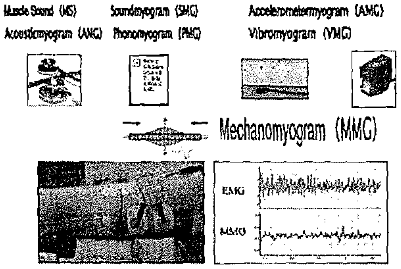
The MMG equipment is commercially available only in Japan.
(http://www.medicons.co.jp)



Transducer (accelerometer)	Rang	±5 G
	Sensitivity	500 mV/G
Amplifier & Filter	How Pass Filter	0.1, 1 Hz (-30 dB/oct)
	Low Pass Filter	250, 1000 Hz (-70 dB/oct)
	Pre-amplifier Gain	x 1, 10
	Main-amplifier Gain	x 1, 2, 5, 10, 20, 100
	Maximum output voltage	±3 V
	Maximum output current	±3 mA

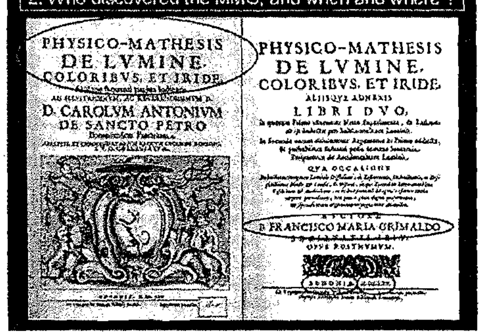
Various terms for the mechanomyogram

Muscle Sound (MS) Soundmyogram (SMG) Accelerometermyogram (AMG)
Acousticmyogram (AMG) Phonomyogram (PMG) Vibromyogram (VMG)



日本語では、筋音図あるいは筋音と名付けられた（赤滝、三田：医用電子と生体工学，1994）

2. Who discovered the MMG, and when and where ?



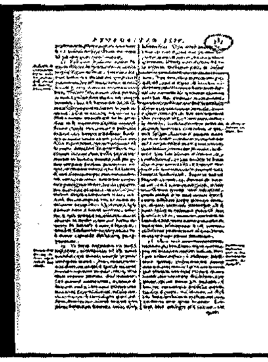
Francesco Maria Grimaldi (1618～1663)

He was professor of mathematics and physics in University of Bologna as well as priest of "Societas Iesu" in Italy

The picture of Grimaldi is cited from Mach E (English translated by Anderson JS & Young AFA): The Principles of Physical Optics (1926)

Physico-Mathesis de Lumine, Coloribus, et Iride.
pp. 383 (1665)

Physical Science of Light, Color, and Rainbow (1665)



The first description of the mechanomyogram

aure. Vera itaq; ratio experimenti prę-
dicti est, quia in digito, & brachio, to-
tóq; corpore continuato fiunt multi mo-
tus, ac tremores ob spirituum agitatio-
nem huc illuc perpetuò accurrentium.

noted by Grimaldi (1665) & cited by Wollaston (1810)

the explanation of the previous experiment result is that, because of the continuous hurried motion of the spirits, tremor and movements occur in figure, arm and in the whole body

translated by Orizio (1993)

3. What are basic characteristics of the MMG ?

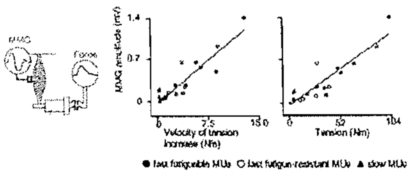
(1) The MMG reflects mechanical activity in muscle contraction.

(2) Fast twitch fibers produce greater MMG than slow twitch fibers.

(3) The MMG amplitude increases with increasing the number of active muscle fibers (i.e., the number of recruited motor units).

(4) The MMG amplitude decreases with firing rate of muscle fibers due to fused tetanus.

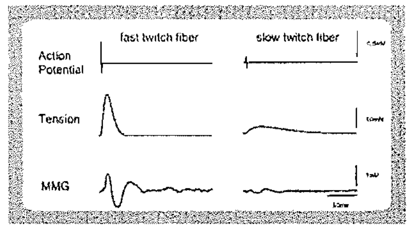
(1) The MMG reflects mechanical activity in muscle contraction.



Linear correlations between the MMG amplitude and the velocity of tension increase, and between the MMG amplitude and tension for the motor unit twitches (Bichler 200)

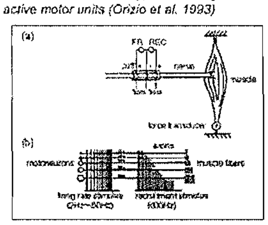
(2) Fast twitch fibers produce greater MMG than slow twitch fibers.

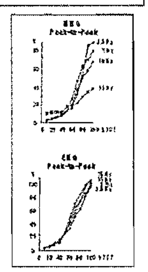
The records were made during the twitch contraction of different motor units by ventral root filament stimulation of rat (Bichler 2000)



(3) The MMG amplitude increases with the number of active muscle fibers.

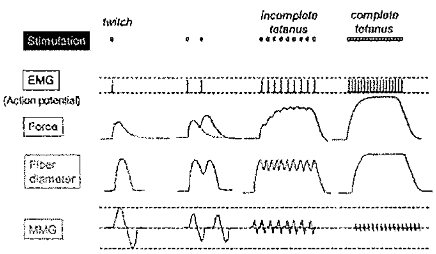
The tripolar nerve cuff electrode method enables to control the number, type, and firing rate of the active motor units (Orizio et al. 1993)





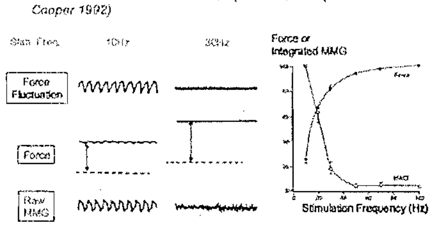
(4) The MMG amplitude decreases with firing rate of muscle fibers due to fused tetanus.

Changes in force, EMG, fiber dimension, MMG with tetanic contractions



(4) The MMG amplitude decreases with firing rate of muscle fibers due to fused tetanus.

Relationships between stimulation frequency and force and MMG and force fluctuation from adductor pollicis muscle (Stokes and Cooper 1992)



4. How can we use the MMG ?

Typical applications of MMG:

- Can contractile property of diaphragm in muscular dystrophy be non-invasively assessed by the MMG ? (1)
- How is motor unit activation strategy in force production estimated by the MMG ? (2, 3, 4)
- Can age-related change in muscle function be reflected by the MMG ? (2, 3, 4)

Basic characteristics of MMG:
(1) The MMG reflects mechanical activity in muscle contraction.
(2) Fast twitch fibers produce greater MMG than slow twitch fibers.
(3) The MMG amplitude increases with increasing the number of active muscle fibers (i.e., the number of recruited motor units).
(4) The MMG amplitude decreases with firing rate of muscle fibers due to fused tetanus.

Special Lecture II

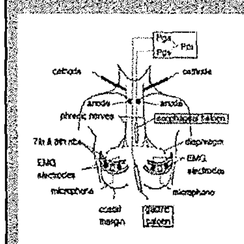
Application of the basic characteristics (1)

Can contractile property of diaphragm in muscular dystrophy be non-invasively assessed by the MMG ?

by Akataki, Mita, Sonoda, Arimura (Clinical Pharmacology and Therapy 2004)

Basic characteristics of MMG:
(1) The MMG reflects mechanical activity in muscle contraction.
(2) Fast twitch fibers produce greater MMG than slow twitch fibers.
(3) The MMG amplitude increases with increasing the number of active muscle fibers (i.e., the number of recruited motor units).
(4) The MMG amplitude decreases with firing rate of muscle fibers due to fused tetanus.

Balloon-catheter technique and EMG and MMG measurement of diaphragm

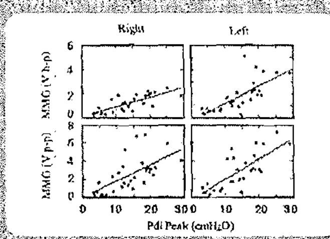


$P_{di}=P_{ga}-P_{es}$
(an index of diaphragm force output)

P_{di}: transdiaphragmatic pressure
P_{ga}: gastric pressure
P_{es}: esophageal pressure

(Petitjean et al. 1994)

Linear relationships between amplitude of right and left MMG and P_{di} peak values



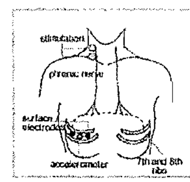
(Petitjean et al. 1994)

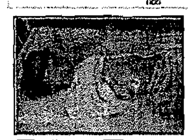
MMG and EMG measurement

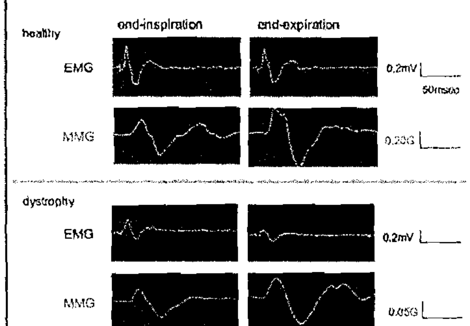
Subjects :
dystrophy 6 males (20.1 ± 7.0 yr)
healthy 8 males (24.4 ± 3.0 yr)

Stimulation :
The phrenic nerves were stimulated transcutaneously in the neck with supramaximal intensity at end-expiration and end-inspiration.

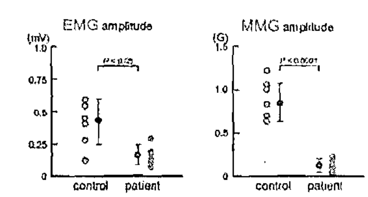
Recordings :
The MMG and EMG were derived with an accelerometer and bipolar electrodes placed over the seventh and eighth intercostal space, respectively.







EMG and MMG amplitude at end-expiration



The MMG seems to be useful for the assessment of diaphragm function.

Application of the basic characteristics (2),(3),(4)

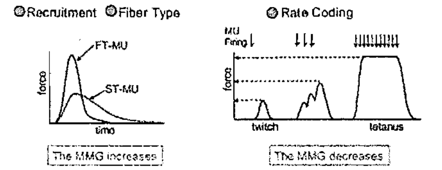
How is motor unit activation strategy in force production estimated by the MMG ?

by Akataki, Mita, Watakabe, Itoh (Eur J Appl Physiol 2001, 2003)

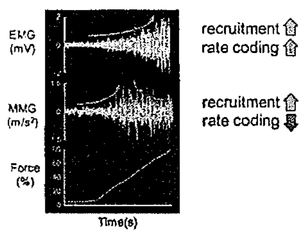
Basic characteristics of MMG:
(1) The MMG reflects mechanical activity in muscle contraction.
(2) Fast twitch fibers produce greater MMG than slow twitch fibers.
(3) The MMG amplitude increases with increasing the number of active muscle fibers (i.e., the number of recruited motor units).
(4) The MMG amplitude decreases with firing rate of muscle fibers due to fused tetanus.

Motor unit activation strategy controlling force output

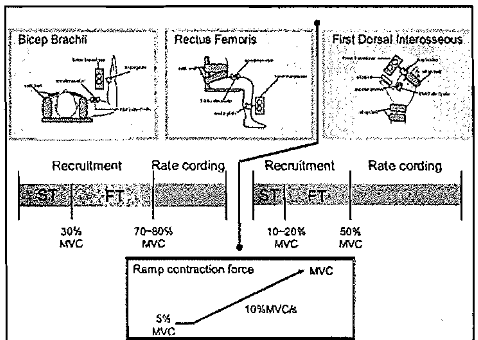
1. Recruitment : How many motor units are activated ?
2. Fiber Type : Which types of motor units are activated ?
3. Rate Coding : How frequent are motor units activated ?



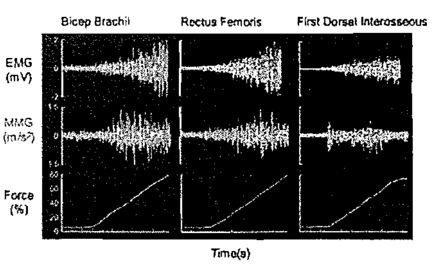
Different patterns between the EMG and MMG during ramp contraction

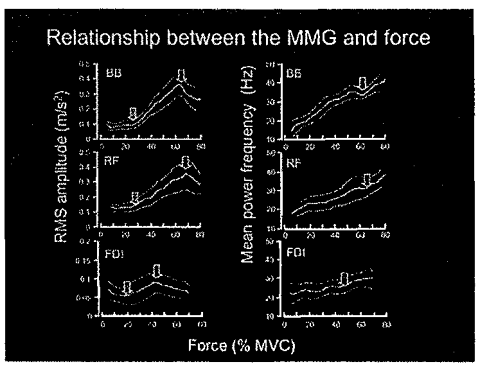


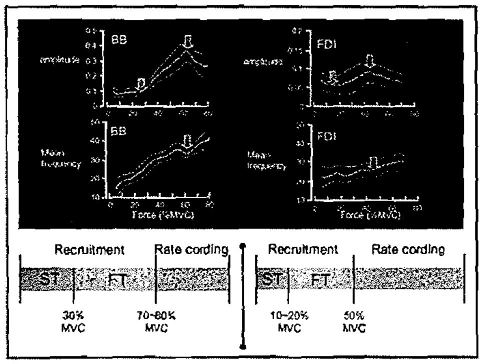
Fusion in the MMG is effective to determine the motor unit activation strategy

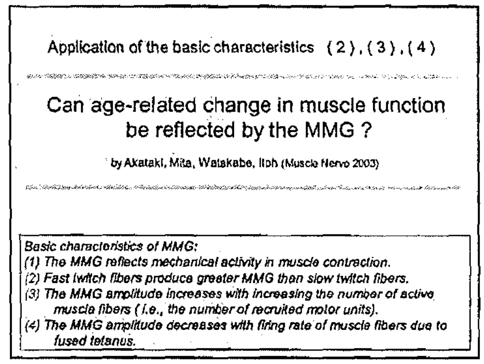


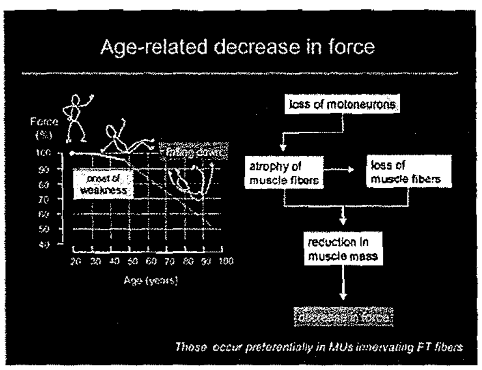
The EMG and MMG in different muscles during ramp contraction

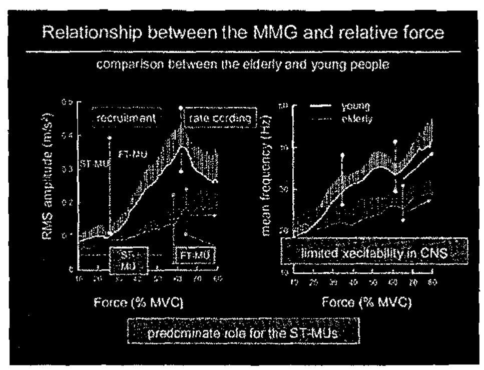


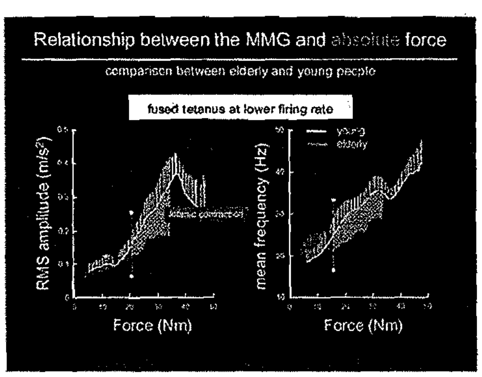


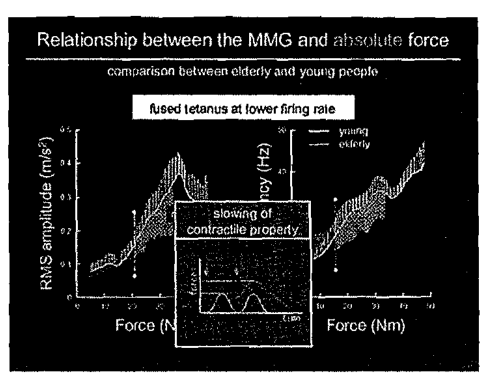

BB
FDI
amplitude
Mean frequency
Force (%MVC)
Recruitment
Rate cording
ST
FT
30% MVC
70~80% MVC
10~20% MVC
50% MVC


Application of the basic characteristics (2),(3),(4)
Can age-related change in muscle function be reflected by the MMG ?
by Akataki, Mita, Watakabe, Itoh (Muscle Nerve 2003)
Basic characteristics of MMG:
(1) The MMG reflects mechanical activity in muscle contraction.
(2) Fast twitch fibers produce greater MMG than slow twitch fibers.
(3) The MMG amplitude increases with increasing the number of active muscle fibers (i.e., the number of recruited motor units).
(4) The MMG amplitude decreases with firing rate of muscle fibers due to fused tetanus.


Age-related decrease in force
Force (%)
onset of weakness
falling down
Age (years)
loss of motoneurons
atrophy of muscle fibers
loss of muscle fibers
reduction in muscle mass
decrease in force
These occur preferentially in MUs innervating FT fibers


Relationship between the MMG and relative force
comparison between the elderly and young people
recruitment
rate cording
ST-MU
FT-MU
young
elderly
RMS amplitude (m/s²)
mean frequency (Hz)
limited excitability in CNS
Force (% MVC)
Force (% MVC)
predominate role for the ST-MUs


Relationship between the MMG and absolute force
comparison between elderly and young people
fused tetanus at lower firing rate
young
elderly
RMS amplitude (m/s²)
mean frequency (Hz)
Force (Nm)
Force (Nm)


Relationship between the MMG and absolute force
comparison between elderly and young people
fused tetanus at lower firing rate
young
elderly
RMS amplitude (m/s²)
slowing of contractile property
Force (Nm)

Can age-related change in muscle function be reflected by the MMG ?

In conclusion:

The MMG is useful for investigating modification of the motor unit control mechanism resulting from age-related deterioration in muscle function.

The motor unit activation strategy in the elderly is characterized by a predominant role for the slow-twitch motor units and a decrease in the number of the fast-twitch motor units, and by an effective fused tetanus induced even at low firing rate.

The MMG is still a developing signal.

Further investigations are expected not only in neuromuscular function but also in respiratory function.

I sincerely appreciate for your kind attention.

MEMO