ILSA International Lung Sounds Association

Annual Conference 2011

The Premier Inn, Manchester Central, 22-23 September 2011

CONFERENCE PROGRAMME

gsk GlaxoSmithKline

We are very grateful to GSK for sponsoring the 36th Annual ILSA Conference

HISTORY OF THE INTERNATIONAL LUNG SOUNDS ASSOCIATION

In October 1976, the first International Conference on lung sounds was Held in Boston, MA. The objectives of this conference were defined as follows:

"Studies of lung sounds have been reported with increasing frequency in recent years. This conference is convened to provide an opportunity for exchange of ideas and experience among those who have an active interest in the subject. Clinicians, physiologist, engineers and perceptual psychologists can each contribute towards a better understanding of what lung sounds mean. They will have a better chance of doing so after talking together."

"We hope that comparisons of methods of recording, analyzing and describing lung sounds will reduce ambiguity. We hope that discussions about work in progress may prevent unnecessary duplication of effort. We hope that investigators will save time and avoid some mistakes by learning what others have done."

Enthusiasm generated by this conference has continued, and annual meetings have been held since. These annual conferences have typically occurred over a period of two to three days being devoted to presentation of papers with discussion, and a half day being devoted to a workshop. Attendance at the conferences has averaged about 60. This is the 36th annual meeting.

Co-founders – Robert G. Loudon, MD and Raymond L.H. Murphy, Jr., MD

LIST OF ILSA CONFERENCES

1 **1976 Boston**	2 **1977 Cincinnati**	3 **1978 New Orleans**	4 **1979 Chicago**	5 **1980 London**	6 **1981 Boston**
7 **1982 Martinez**	8 **1983 Baltimore**	9 **1984 Cincinnati**	10 **1985 Tokyo**	11 **1986 Lexington**	12 **1987 Paris**
13 **1988 Chicago**	14 **1989 Winnipeg**	15 **1990 New Orleans**	16 **1991 Veruno**	17 **1992 Helsinki**	18 **1993 Alberta**
19 **1994 Haifa**	20 **1995 Long Beach**	21 **1996 Chester**	22 **1997 Tokyo**	23 **1998 Boston**	24 **1999 Marburg**
25 **2000 Chicago**	26 **2001 Berlin**	27 **2002 Helsinki**	28 **2003 Cancun**	29 **2004 Glasgow**	30 **2005 Boston**
31 **2006 Halkidiki**	32 **2007 Tokyo**	33 **2008 Boston**	34 **2009 Haifa**	35 **2010 Toledo**	36 **2011 Manchester**

Conference Programme…. at a glance

Thursday 22nd September	
COUGH ACOUSTICS	
9.00-9.30	Registration and coffee
9.30-10.40	**Session 1: Opening thoughts**
	Welcome: Ashley Woodcock
	Abstract: Key, et al.
	Lecture: Alyn Morice
10.40-11.00	*Coffee break*
11.00-12.20	**Session 2: Cough Monitoring and Cough Counting**
	Lecture: Surinder Birring
	Lecture: Noam Gavriely
12.20-14.00	*Lunch*
14.00-15.20	**Session 3: Cough Acoustics**
	Lecture: Kevin McGuinness
	Lecture: Antony Barton
15.20-15.40	*Coffee break*
15.40-16.40	**Session 4: Lung Sound Education**
	Abstract: Newnham, et al
	Lecture: Andrey Vyshedskiy
16.40	*End of Day 1*
19.00-20.00	Post-meeting Refreshments
20.00-23.00	Conference Dinner at Gio's Restaurant

Friday 23rd September	
PULMONARY ACOUSTICS	
9.00-9.15	Coffee
9.15-10.40	**Session 1: Pulmonary acoustics Abstracts**
	Abstract: Nagasaka, et al.
	Abstract: Dyachenko, et al.
	Abstract: Sen, et al.
	Abstract: Papdaniil, et al
10.40-11.10	*Coffee break*
11.10-12.30	**Session 2: Clinical Aspects of Lung Sounds**
	Abstract: Vyshedskiy, et al.
	Abstract: Vyshedskiy, et al.
	Lecture: Hans Pasterkamp
12.30-13.45	*Lunch*
13.45-15.05	**Session 3: Clinical Aspects of Lung Sounds cont/d…**
	Abstract: Hervie, et al.
	Abstract: Vyshedskiy, et al.
	Abstract: Oshaug, et al.
	Abstract: Ishikawa, et al.
15.05-15.30	*Coffee break*
15.30-16.10	**Session 4: Respiratory Acoustics**
	Abstract: Quintas, et al.
	Abstract: Vyshedskiy, et al.
16.10-17.15	**Session 5: Discussion and Close**

DAY 1 THURSDAY 22 SEPTEMBER

9.00-9.30	**REGISTRATION AND COFFEE** *(delegate packs can be collected from the ILSA Registration Desk)*
9.30-10.40	**SESSION 1: OPENING THOUGHTS** *(Chaired By Dr. Jacky Smith)*
9.30-9.40	**WELCOME AND INTRODUCTION** ***Professor Ashley Woodcock, University of Manchester***
9.40-10.00	**COUGH DURING COPD EXACERBATIONS** ***Angela Key, et al.***
10.00-10.40	**COUGH MONITORING IN HULL: THE HACC** ***Professor Alyn Morice, University of Hull***
10.40-11.00	***COFFEE BREAK*** *(unlimited Costa coffee or tea will be available outside the Conference Room)*
11.00-12.20	**SESSION 2: COUGH MONITORING AND COUGH COUNTING** *(Chaired By Dr. Jacky Smith)*
11.00-11.40	**THE LEICESTER COUGH MONITOR** ***Dr. Surinder Birring, King's College London***
11.40-12.20	**COUGH COUNTING WITH THE COUGHCOUNT** ***Professor Noam Gavriely, Karmelsonix Ltd***
12.20-14.00	***LUNCH*** *(a hot buffet will be served in the Green Room of the Hotel Restaurant)*

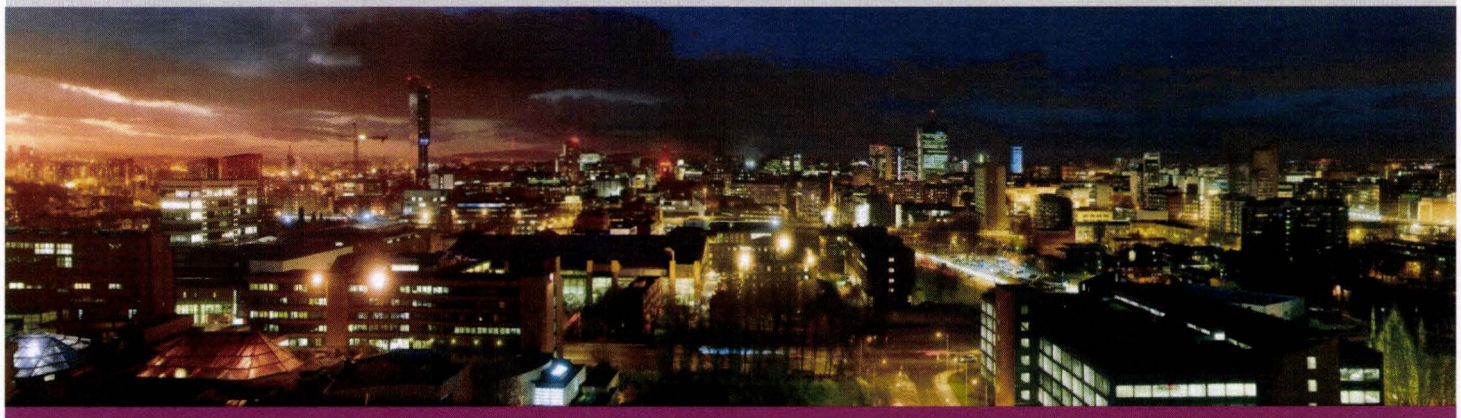
DAY 1 THURSDAY 22 SEPTEMBER

14.00-15.20 **SESSION 3: COUGH ACOUSTICS** *(Chaired By Dr. Jacky Smith)*

14.00-14.40 **RELATIONSHIPS BETWEEN PHYSIOLOGICAL MEASURES AND ACOUSTICS DURING COUGHING**
Dr. Kevin McGuinness, University Hospital of South Manchester NHS Foundation Trust

14.40-15.20 **DATA MINIMISATION OF ACOUSTIC COUGH RECORDINGS**
Mr. Antony Barton, University of Manchester

15.20-15.40 ***COFFEE BREAK*** *(unlimited Costa coffee or tea will be available outside the Conference Room)*



15.40-16.40 **SESSION 4: LUNG SOUND EDUCATION** *(Chaired By Dr. Jacky Smith)*

15.40-16.00 **RELIABILITY OF ELEMENTS OF THE RESPIRATORY EXAMINATION SURVEYED AMONG MEDICAL STUDENTS** ***Mike Newnham & Rahul Mukherjee***

16.00-16.40 **MEASURING CRACKLES**
Dr. Andrey Vyshedskiy, Stethographics Inc and Brigham & Women's/Faulkner Hospitals, Boston USA.

16.40 **END OF DAY 1**

19.00-20.00 **POST-MEETING REFRESHMENTS** *(join the conference organisers for drinks in the Hotel Bar)*

20.00-23.00 **CONFERENCE DINNER AT GIO'S RESTAURANT** *(next door to the Hotel)*

DAY 2 FRIDAY 23 SEPTEMBER

9.00-9.15 **COFFEE** *(Morning coffee or tea will be available before heading into the Conference Room)*

9.15-10.40 **SESSION 1: PULMONARY ACOUSTICS ABSTRACTS** *(Chaired By Prof. Noam Gavriely)*

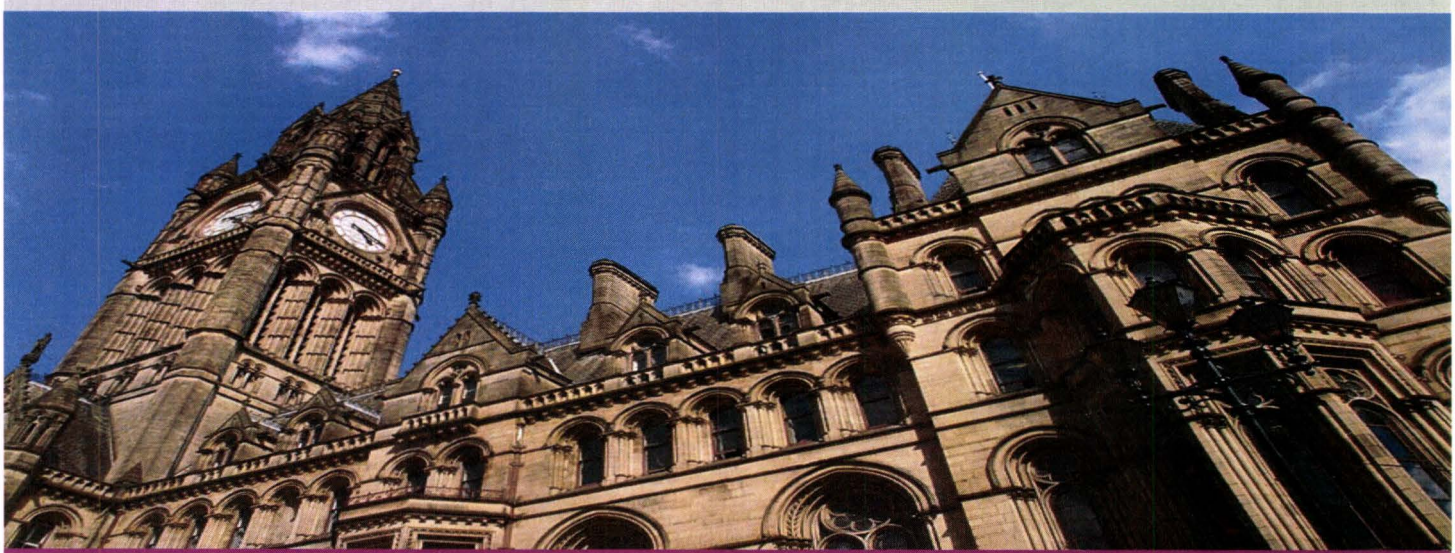
9.15-9.35 **NUMERIC DESCRIPTION OF VESICULAR AND BRONCHIAL BREATH SOUNDS**
Yukio Nagasaka, et al.

9.35-9.55 **MEASUREMENTS OF FORCED EXPIRATORY NOISE OVER TRACHEA AND INFRASCAPULAR REGION**
Alexander Dyachenko, et al.

9.55-10.15 **MULTIVARIATE ANALYSIS OF MULTICHANNEL PULMONARY SOUND DATA**
Ipek Sen & Yasemin Kahya

10.15-10.35 **A HEART SOUND SEGMENTATION METHOD USING ENSEMBLE EMD AND HIGHER-ORDER STATISTICS** *Chrysa Papadaniil & Leontios Hadjileontiadis*

10.40-11.10 ***COFFEE BREAK*** *(unlimited Costa coffee or tea will be available outside the Conference Room)*



11.10-12.30 **SESSION 2: CLINICAL ASPECTS OF LUNG SOUNDS** *(Chaired By Prof. John Earis)*

11.10-11.30 **ASSESSMENT OF ASYMMETRIC LUNG DISEASE USING ACOUSTIC IMAGING**
Andrey Vyshedskiy & Raymond Murphy

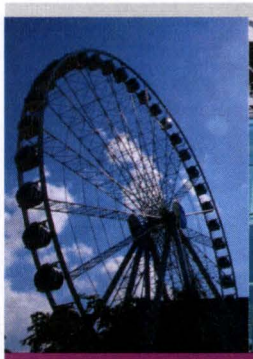
11.30-11.50 **CRACKLE PARAMETER HISTOGRAMS**
Andrey Vyshedskiy & Raymond Murphy

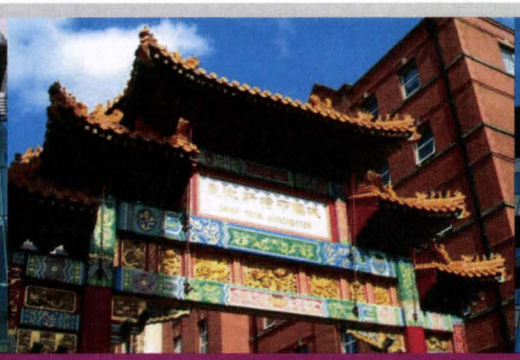
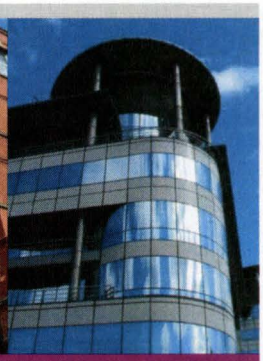
11.50-12.30 **LUNG SOUNDS SINCE FORGACS – WHAT HAVE WE LEARNED IN 33 YEARS**
Professor Hans Pasterkamp, University of Manitoba

12.30-13.45 ***LUNCH*** *(a hot buffet will be served in the Green Room of the Hotel Restaurant)*

DAY 2 FRIDAY 23 SEPTEMBER

13.45-15.05	**SESSION 3: CLINICAL ASPECTS OF LUNG SOUNDS** *cont/d...* *(Chaired By Dr. Sadamu Ishikawa)*
13.45-14.05	**IMPACT OF ACOUSTIC RESPIRATORY MONITORING ON CLINICAL DECISION-MAKING IN THE MANAGEMENT OF ASTHMA PATIENTS IN A PAEDIATRIC ITU (PILOT STUDY)** ***Peter Hervie, et al.***
14.05-14.25	**ACOUSTIC BIOMARKERS OF CHRONIC OBSTRUCTIVE LUNG DISEASE** ***Andrey Vyshedskiy & Raymond Murphy***
14.25-14.45	**HOW SMOKING AFFECT THE PREDICTIVE VALUE OF ABNORMAL LUNG SOUNDS FOR AIR-FLOW LIMITATION** ***Katja Oshaug & Hasse Melbye***
14.45-15.05	**CARDIAC RESPONSE TO RESPIRATION** ***Sadamu Ishikawa, et al.***
15.05-15.30	***COFFEE BREAK*** *(unlimited Costa coffee or tea will be available outside the Conference Room)*
15.30-16.10	**SESSION 4: RESPIRATORY ACOUSTICS** *(Chaired By Prof. John Earis)*
15.30-15.50	**PERFORMANCE OF CRACKLE DETECTORS IN CYSTIC FIBROSIS (PILOT STUDY)** ***Joao Quintas, et al.***
15.50-16.10	**CRACKLE PITCH RISES PROGRESSIVELY DURING INSPIRATION IN IPF, CHF AND PNEUMONIA PATIENTS** ***Andrey Vyshedskiy & Raymond Murphy***
16.10-17.15	**SESSION 5: DISCUSSION**
16.10-17.00	**PRACTICAL USE OF LUNG SOUNDS IN CLINICAL DIAGNOSIS - SELECTION OF CLINICAL CASES** ***Dr. Raymond Murphy, Stethographics Inc and Faulkner Hospital, Boston***
17.00-17.15	**CONCLUDING REMARKS** ***Dr. Raymond Murphy***
17.15	**END OF CONFERENCE**



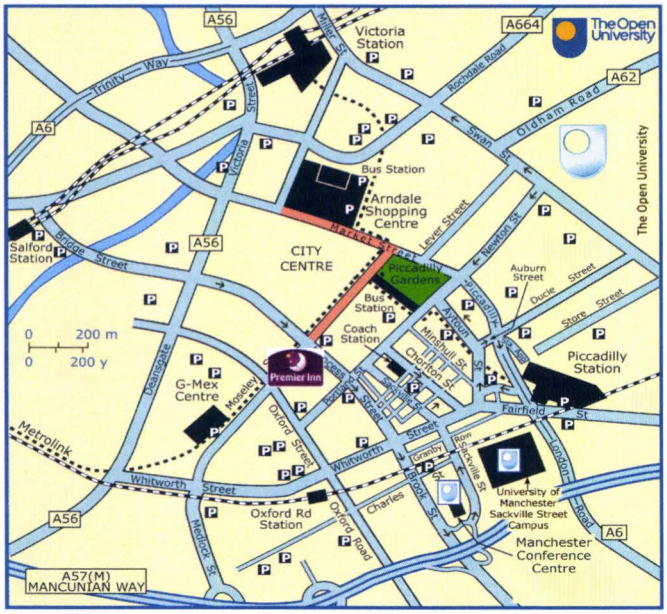
INFORMATION

The Premier Inn *7-11 Lower Mosley Street, Manchester*

We've chosen The Premier Inn for the 36th Annual ILSA Conference as it is conveniently located in the heart of Manchester city centre, and within walking distance of several attractions, city centre shops, bars and restaurants.

We hope you enjoy your stay and get the opportunity to explore Manchester.

Manchester ..... *a big cosmopolitan city with a compact centre*



Manchester is a city famous for its industrial which is evident from its grand Victorian buildings. However, new architectural structures can be seen rising up between regenerated original treasures.

But Manchester is not just about buildings. The culture, food, music, nightlife, shopping and sport are second to none.

You won't have to get three underground trains to get from museum to art gallery, struggle on crowded buses from one shopping area to another, or pay a fortune for taxis on a night out.

Manchester's city centre is made up of closely linked areas making it easy to find your way around.

Travel Information

There a number of ground transportation options from Manchester Airport to Manchester city centre.

TAXIS

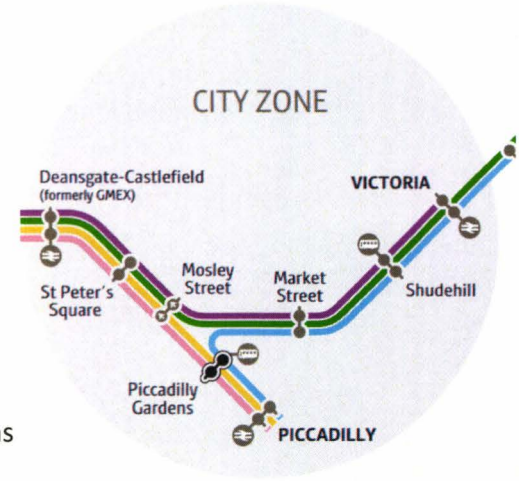
You will find taxi (black cab) ranks outside each Airport Terminal. There are several Premier Inn hotels in Manchester. Advise your taxi driver that you are staying at the Premier Inn, opposite the G-Mex Centre.

TRAIN

There is a direct train from Manchester Airport to Manchester Piccadilly Train Stations. Follows signs for 'The Station' and use the Skylink moving walkways to get there.

TRAM

If you arrive into Manchester via train then the Metrolink (tram) service runs direct from Manchester Piccadilly train station to St. Peter's Square tram stop which is the nearest tram stop to the Hotel. Take the Altrincham (yellow) or Eccles (pink) Line.



ABSTRACTS

COUGH DURING COPD EXACERBATIONS

Angela Key, Grin Tack, Kimberley Holt, Lisa Spencer, Jacky Smith, John Earis.
University Hospital Aintree, Liverpool and North West Lung Centre, University of Manchester, UK

INTRODUCTION:

Cough is a frequently reported and troublesome symptom in COPD and can have a significant impact on quality of life (QOL). COPD patients have been shown to have a similar cough related impairment of QOL to patients with chronic cough. The aims of this study are first to measure objective cough rates during an exacerbation of COPD and on recovery (6 weeks post exacerbation) and second to compare these rates to subjective cough assessments and cough related QOL (St Georges Respiratory Questionnaire (SGRQ) and the Leicester Cough Questionnaire (LCQ)).

METHODS:

Ten patients who met the GOLD criteria for COPD underwent two 10 hour ambulatory daytime cough recordings. The first during exacerbation and the second on recovery. Exacerbation was defined by the Anthonisen criteria and recovery as a period of stability for six weeks. Results are reported as cough rate (number of coughs per hour), a self completed a SGRQ and LCQ. Disease status was graded using GOLD criteria.

RESULTS & DISCUSSION:

Patients showed high cough rates during exacerbation (range 15-56.4), which significantly decreased on recovery (range 0.2-24.8) ($p=0.004$). The LCQ (total) significantly decreased post exacerbation ($p=0.021$) and the SGRQ (total) showed a non-significant improvement ($p=0.051$). Various components of the LCQ also showed significant improvement during recovery. However, there was no overall correlation between cough rates and the LCQ. The SGRQ during exacerbation (total and activity) correlated with overall cough rates only during exacerbation. These correlations are negative (i.e. better health status) were associated with a higher cough rate during exacerbation. Initially this would appear counterintuitive, however, patients with a higher cough may also have better sputum clearance leading them to a improved score on a quality of life questionnaire. Cough rates during exacerbation and recovery were not associated with smoking history, current smoking or GOLD grading. Lung function showed correlations with cough counts during exacerbation, but not during recovery. Higher FEV1 and FVC were associated with higher cough rate during exacerbation.

CONCLUSION:

Despite the relatively small sample size, the correlations between subjective and objective measures of cough in this study were very strong. For the first time this study confirms the change in cough rate during a COPD exacerbation. It also highlights that subjective QOL measures may also be useful for observing change.

RELIABILITY OF ELEMENTS OF THE RESPIRATORY EXAMINATION SURVEYED AMONG MEDICAL STUDENTS

M Newnham and R Mukherjee
Department of Respiratory Medicine, Birmingham Heartlands Hospital & Birmingham Chest Clinic, UK

INTRODUCTION:

We often teach and assess medical students performing the respiratory examination in a traditional ritualistic way, rather than based on evidence. An essential component of the respiratory clinical examination is its precision. The reliability of the examination is a fundamental element of this precision (often expressed by Kappa values, i.e. agreement beyond chance). There needs to be agreement between physicians that a clinical sign can be elicited independently in the same patient when it is present. When learning about the respiratory examination, medical students should have knowledge of the reliability of the different elements. We set out to establish medical students' knowledge of the reliability of different elements of the respiratory examination, which is likely to be a precondition of a scientific understanding of lung sounds.

METHODS:

A cross sectional questionnaire survey of clinical medical students (years 3-5) was undertaken. The questionnaire assessed the reliability of tactile vocal fremitus, tracheal position, auscultation of wheeze, whispering pectoriloquy, auscultation of crackles and chest expansion using a 5 point Likert scale. Demographic data was also collected. The results of the perceived reliability of different elements of the respiratory examination was compared with Cohen's kappa coefficient values; a statistical measure of inter-observer reliability.

RESULTS:

Of 104 questionnaires completed, 33% were male, 36% attached to respiratory firm, 11% graduate entry. Crackles, wheeze and percussion note are all regarded as reliable to very reliable signs by students. Perceived reliability of whispering pectoriloquy decreased as students become more experienced ($p=0.003$). There was no relationship between perceived reliability and graduate entry, previous respiratory attachment or gender. Factor analysis identified that tactile vocal fremitus and whispering pectoriloquy were grouped together separately from the other respiratory signs. Linear regression showed good correlation between students answers and actual kappa values of reliability ($r=0.722$).

CONCLUSIONS:

Students have a good intuition of the reliability of elements of the respiratory examination, generally demonstrating an unconscious facility with a Bayesian tendency. For example, as experience increases, they correctly perceive whispering pectoriloquy as a less reliable sign. The need to make clinical teaching generally more evidence-based has already been discussed (Mukherjee R. Teaching Evidence Based Clinical Skills. *Proceedings of the Association for Medical Education in Europe* (Approaches to Better Teaching) 2002; 9: 4.123). In the teaching of respiratory clinical examination, this can be built on their natural Bayesian reasoning and can be taken further by more objective and scientific analysis of lung sounds.

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NUMERICAL DESCRIPTION OF VESICULAR AND BRONCHIAL BREATH SOUNDS

Yukio Nagasaka[1], Terufumi Shimoda[2], Shohei Yasuda[1], Katsumi Murakami[3] Chizu Habukawa[4]

1. Department of Medicine, Kinki University Sakai Hospital
2. Department of Clinical Research, National Fukuoka Medical Center
3. Department of Pediatrics, Kinki University Sakai Hospital
4. Department of Pediatrics, National Minami Wakayama Medical Center

INTRODUCTION:

We tried to analyze vesicular and bronchial sounds in two different ways, from power and from frequency.

SUBJECTS AND METHODS:

We studied lung sounds in seventy four cases of asthma. We divided lung sounds into vesicular (V, n=43), vesicular/broncho-vesicular (V/BV, n=6), broncho-vesicular (BV, n=14) and bronchial (B, n=5) sounds. We measured lung sound intensity, highest frequency of inspiratory (HFI) and expiratory (HFE) sounds, power of low (LF: 100 to 195 Hz) and middle (MF: 200 to 395 Hz) frequency range.

We compared power of expiratory and inspiratory breath sounds of LF range (E/I LFP) and the ratio of MF and LF power in inspiration (I M/L) and expiration (E M/L) in each lung sounds.

RESULTS:

Both sound power and sound frequency correlated well with auscultation. (Table) E/I LFP appears to be the best indicator. HFE and HFE/HFI were the better indicators than HFI, but their significance were not as much as that of E/I LFP. Sound frequency is a good indicator to image lung sounds, but power ratio will be a better indicator to describe lung sounds numerically.

CONCLUSIONS:

E/I LFP, HFE and HFE/HFI could describe the difference of vesicular and bronchial lung sounds numerically. We are recognizing lung sounds not only from their frequency but also from relative intensity of their sound power.

Table. Sound power and frequency in vesicular and bronchial lung sounds

	Power			Frequency		
	E M/L	**I M/L**	**E/I LFP**	**HFE (Hz)**	**HFI (Hz)**	**HFE/HFI**
Vesicular (n-43)	0.058	0.092	0.266	252	421	0.60
(mean +/- S.D.)	0.0279	0.0479	0.1619	57.2	96.6	0.137
Vesicular/Broncho-vesicular (n=6)	0.079	0.089	0.393	281	443	0.65
(mean +/- S.D.)	0.0683	0.0301	0.2299	21.9	60.9	0.089
Broncho-vesicular (n=14)	0.059	0.116	0.488	410	571	0.69
(mean +/- S.D.)	0.0179	0.0555	0.3992	21.9	110.1	0.166
Bronchial (n=5)	0.117	0.108	0.717	472	492	0.97
(mean +/- S.D.)	0.1327	0.0317	0.5526	68.6	70.0	0.153

MEASUREMENTS OF FORCED EXPIRATORY NOISE OVER TRACHEA AND INFRASCAPULAR REGION

Dyachenko A.[1,2], Korenbaum V.[3], Tagiltsev A.[3]

[1] General Physics Institute named by A.M. Prokhorov of RAS, 38 Vavilova Str., Moscow, 117942, Russia, [2] SSC of RF – IBMP RAS, Moscow, Russia. Tel.: +79036751700. E-mail: alexander-dyachenko@yandex.ru. [3] V.I. Il'ichev Pacific Oceanologic Institute of Far Eastern Branch of RAS, Vladivostok, Russia

Lung sounds always were presented as a ratio of microphone or accelerometer signals to arbitrary chosen referent signals. The referent signals usually were signals of the same microphone or accelerometer at some frequency. Despite of numerous studies of lung sounds in these relative units there are no any data about absolute levels of lung sounds in dimensional physical units. Absolute levels of the basic physical signal – oscillatory displacement or acceleration of tissue surface are important parameters for development of new techniques of lung sounds research. Absence of such data makes difficult comparison of results of different studies.

OBJECTIVE : To fill out this gap in lung sound research by measurement of absolute levels of forced expiratory noise over trachea and infrascapular region while breathing different gas mixtures.

METHODS: We used two contact accelerometers with a mass 8 g. The accelerometers were calibrated on a vibration table so their output was quantified from 8 Hz to 3960 Hz. Twenty five normal subjects in this study were volunteers who had no history of lung diseases. Age range was 20 to 59. Forced expiratory sounds were measured at the ambient pressure 1 atm while breathing the following gas mixtures: room air with 21% O_2, oxygen-helium mixture (O_2-He) with 25% O_2 and oxygen-krypton mixture (O_2-Kr) with 21% O_2. A volunteer performed 3 or 4 vital capacity maneuvers from pneumatic system that contained a gas cylinder with prepared gas mixtures. The volunteer performed forced expirations 3 times in each gas mixture. Accelerometers were glued to the skin surface by double sided scotch tape. One sensor was glued to chest wall in infrascapular region and another to the neck in jugular vein hollow. Accelerometers data were filtered in the following frequency bands: 100-200, 200-400, 400-600, 600-800, 800-1000 Hz. Maximal and root mean squares values (RMS) of signal amplitude were studied. Data analysis by the Shapiro Wilk Test revealed that the respective distributions of all these variables are not normal. We used nonparametric descriptive statistics software *STATISTICA* (StatSoft) for finding medians and quartiles. Comparison of signal amplitudes registered during breathing different gas mixtures was estimated with Kruskal-Wallis ANOVA by Ranks test.

RESULTS: Both maximal and RMS values of signal amplitude were studied for trachea. Only maximal values were studied for infrascapular region because RMS were too close to background noise. Maximal values of forced expiratory sounds in units of maximal oscillatory acceleration of chest wall and neck surfaces are presented in Fig. 1.

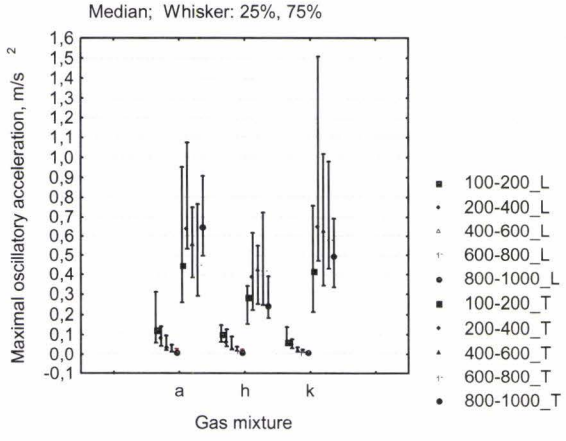

Fig. 1: Maximal values of forced exhalation respiratory sounds at the level of lower right lung's lobe (surface of right infrascapular region of chest wall), (L) and at the level extrathorasic trachea (T) in 100 Hz and 200 Hz intervals between 100 Hz and 1000 Hz.
On x-axis: gas mixtures, a – air, h - O_2-He, k - O_2-Kr. On Y-axis: acoustical acceleration signal: medians, whiskers show 25% and 75 % quartiles for the group of n=25 test subject.

Both RMS and maximal forced expiratory noise over trachea is lower while breathing O_2-He gas mixture in comparison with breathing both air and O_2-Kr gas mixture. This difference is significant ($P<0.05$) in some frequency intervals and is not significant in other intervals. Statistical significance of differences between maximal amplitudes of sounds in infrascapular region while breathing different gas mixtures was estimated by the same Kruskal-Wallis ANOVA by Ranks test. There was no any significant difference between gas mixtures in this estimation.

CONCLUSIONS:

1. This paper presents for the first time absolute levels of respiratory sounds of forced exhalation in units of maximal and RMS oscillatory acceleration over right lower lung lobe and extrathorasic trachea. **2.** RMS and maximal forced expiratory noise over trachea is lower while breathing O_2-He gas mixture in comparison with breathing both air and O_2-Kr gas mixture. **3.** Gas density-dependent mechanism of forced expiratory sounds generation supports the concept that the basic mechanism is generation of vortexes inside trachea or close to trachea.

This work was partially supported by a grant RFBR-10-07-00486

HOW SMOKING AFFECTS THE PREDICTIVE VALUE OF ABNORMAL LUNG SOUNDS FOR AIRFLOW LIMITATION

Ipek Sen and Yasemin P. Kahya, PhD
Bogazici University, Electrical and Electronics Engineering Department, Istanbul, Turkey
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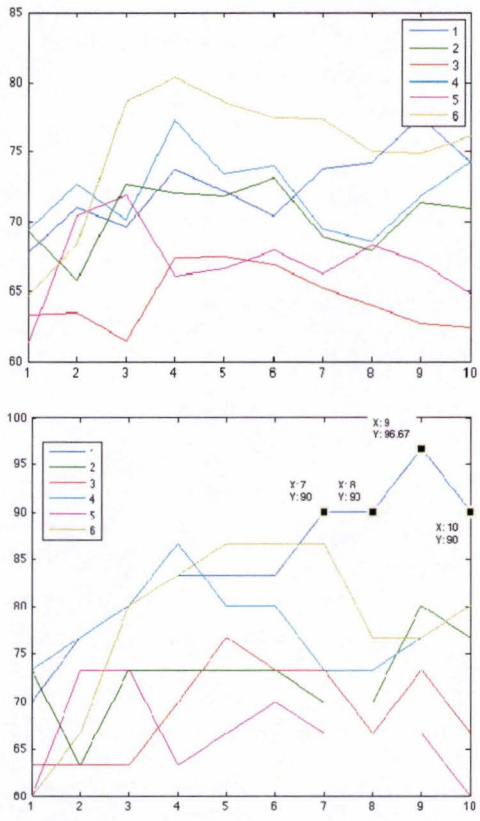
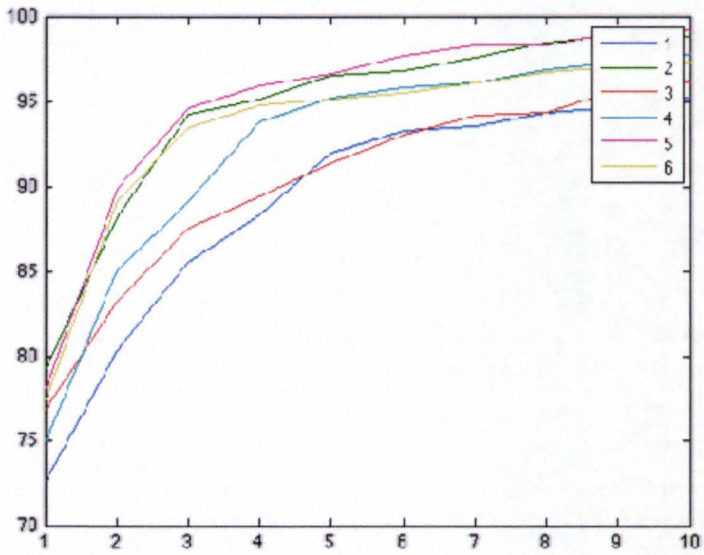
The aim of this study is to investigate multichannel pulmonary sounds in healthy and pathological cases via a multivariate mathematical model. Model parameters are expected to explain the spatial and temporal relationships that the multichannel measurements share. Therefore, the effects of the pathological situation that can be observed in changing pulmonary sound characteristics are also expected to be observed in the model parameters. Quantification of such changes via model parameters further serves the aim of extracting an acoustic map of the chest. For this study, 15 healthy and 15 pathological subjects (bronchiectasis being the common pathology) are selected. 14-channel pulmonary sound data are recorded via microphones attached on the chest wall, simultaneously with the airflow signal for synchronization. The data are segmented into early/mid/late inspiration/expiration sub phases, and each sub phase is further segmented into 250-point, 50 % overlapping parts (the sampling frequency is 9600 Hz and the total recording lasts for 15 seconds). A second order vector autoregressive (VAR) model is fitted on each such part, yielding the estimated model parameters. To examine the differences between the model parameters of healthy and pathological cases, Gaussian mixture models (GMM) are adopted for the parameter likelihoods of the two classes for each sub phase, and classification performances are calculated in the Bayesian framework. Applying GMM with one to ten mixtures for each class, healthy and pathological parameters are classified with high correct rates for early/mid/late inspiration/expiration sub phases. The model parameters that reveal the microphone-to-microphone spatio-temporal relationships are tested using Hotelling's T^2 hypothesis testing. It is shown that the model parameters corresponding to certain microphone pairs are significantly ($p<0.01$) different in case of the pathological subjects of this study as compared to the healthy subjects.





International Lung Sounds Association 36th Annual Conference, 2011

A HEART SOUND SEGMENTATION METHOD USING ENSEMBLE EMD AND HIGHER-ORDER STATISTICS

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Auscultation consists an elemental heart examination method. Visualization of the sounds is achieved by means of the heart phonocardiogram, which serves as a tool for digital analysis of the findings. Segmenting the cardiac cycle into its four components, diastole-first heart sound (S_1)-systole-second heart sound (S_2), is the first step of the analysis. This task becomes complicated when secondary sounds, called murmurs, interfere with the primary ones. Aortic stenosis and mitral regurgitation are two common valve diseases with systolic murmurs. Various methods have been employed to segment the heart cycle, including the Wavelet Transform, (Chebil and Al-Nabulsi, 2007), simplicity features (Vepa *et al.*, 2008), calculation of the Shannon energy (Ari *et al.*, 2008), Neural Networks (Olmez and Dokur, 2002) etc. The present study uses the Ensemble Empirical Mode Decomposition (EEMD) to filter the acoustic signal and an algorithm based on kurtosis' features to detect the primary heart sounds. A dataset of heart sounds, consisting of 43 different subjects, 11 normal, 16 patients with aortic stenosis and 16 patients with mitral regurgitation, was recorded in real clinical conditions and the efficiency of the proposed method was tested on it. Fig. 1 is an example of a segmentation using the proposed algorithm. Experimental results show that the heart sound locations are determined in a percentage of 95.33% and heart cycles are segmented correctly for the 83.64% of the cases. Finally, by applying Ari's *et al.* algorithm to the experimental dataset a comparison was performed, to reveal that the proposed method achieves a higher detectability rate by more than 12%, and points out less false heart sound by more than 13%. The accurately segmented cardiac cycles set the basis for the automated analysis of each cardiac phase's information and thereafter the implementation of a heart sounds based, automated diagnosis tool.

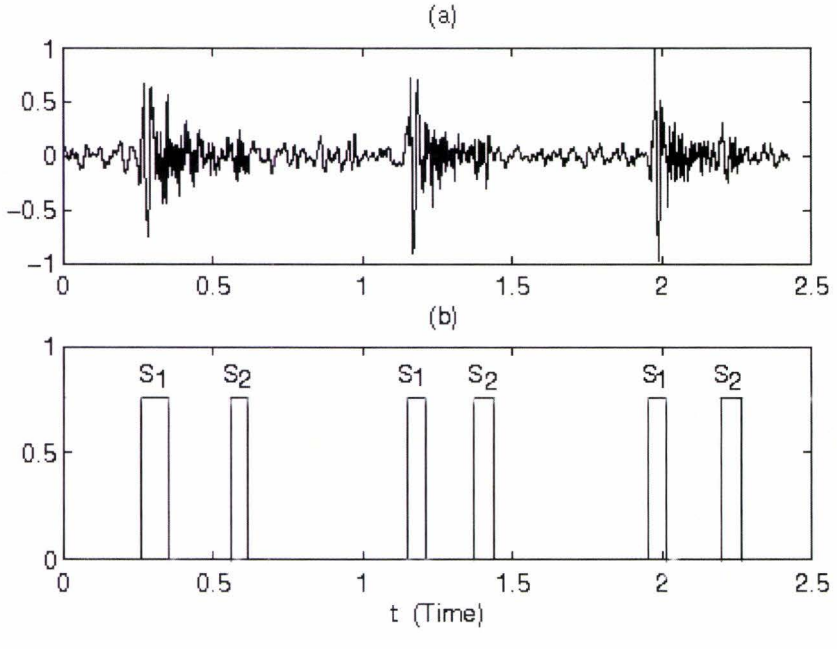

Fig.1
(a) 3 periods of an aortic stenosis heart phonocardiogram with a medium systolic murmur and a faint S_2,

(b) the segmented signal after the application of the suggested method.

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ASSESSMENT OF ASYMMETRIC LUNG DISEASE USING ACOUSTIC IMAGING

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OBJECTIVE:

To examine the correlation of lung sound localization with focal lung disease.

METHODS:

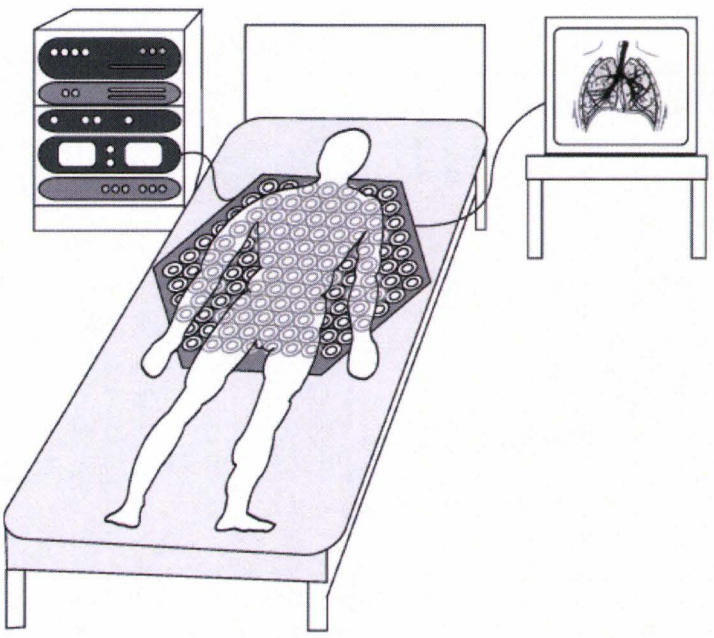
Using a 16-channel lung sound analyzer (STG) we examined three parameters - crackle rate, wheeze rate, and sound amplitude - in 37 patients with focal lung disease as determined by chest X-rays and CT. These patients included 27 with pneumonia, one with radiation pneumonitis, one with pneumothorax, five with pneumonectomy, and two with focal tumors. We also studied a patient who had bronchoscopic documentation of bronchomalacia in a right stem bronchus.

RESULTS:

Example of the histograms we obtain appear in the figures below. The figure on the left shows a normalized histogram of crackle pitch. Crackles in patients with CHF and pneumonia are distributed around a peak of 240Hz. Crackles in patients with IPF are distributed around a peak of 560Hz. Significant overlap is observed. The figure on the right shows the distribution of the crackle transmission coefficient.

CONCLUSION:

While we found clear differences in the distribution of the many crackle parameters we examined, we also found a significant overlap among the four diseases. At this time we have found no single parameter that clearly separates disorders from one another.



CRACKLE PARAMETER HISTOGRAMS

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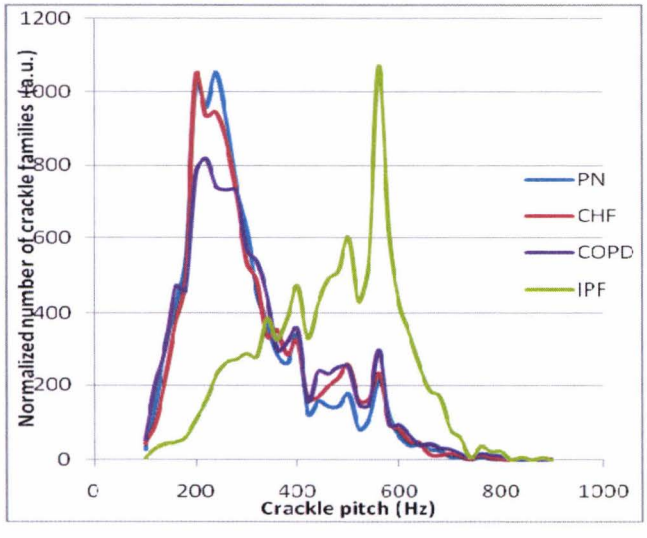
OBJECTIVE: In this study we plotted histograms of multiple crackle parameters to see if we could uncover parameters that could be helpful in diagnosing common clinical illnesses.

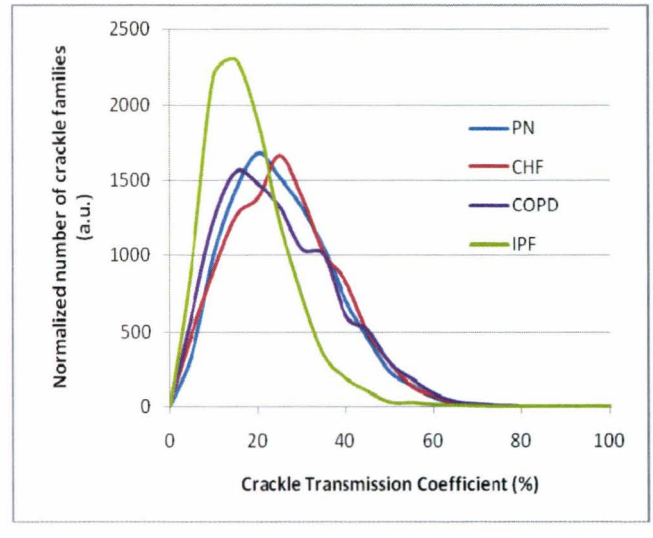
METHODS: From a database of sounds recorded using a multichannel lung sound analyzer from a convenience sample of over 1000 patients we selected those with diagnoses of pneumonia (PN), congestive heart failure (CHF), interstitial fibrosis (IPF), and COPD who had more than two crackles per breath. Table 1 lists the number of patients and the total number of crackles. When using a multichannel analyzer individual crackle events are normally detected by multiple microphones. The group of waveforms corresponding to a single crackle event and recorded by multiple microphones is referred to as a crackle family. Histograms presented in this report show parameters derived by analysis of crackle families - one parameter per crackle family. All histograms were normalized by the total number of crackles.

	Pneumonia	CHF	Interstitial fibrosis	COPD
Number of patients	140	92	40	110
Total number of crackle families	7,738	3,985	8,895	3,114

Table 1. The number of patients and the total number of identified crackles families.

RESULTS: Example of the histograms we obtain appear in the figures below. The figure on the left shows a normalized histogram of crackle pitch. Crackles in patients with CHF and pneumonia are distributed around a peak of 240Hz. Crackles in patients with IPF are distributed around a peak of 560Hz. Significant overlap is observed. The figure on the right shows the distribution of the crackle transmission coefficient.





CONCLUSION: While we found clear differences in the distribution of the many crackle parameters we examined, we also found a significant overlap among the four diseases. At this time we have found no single parameter that clearly separates disorders from one another.

IMPACT OF ACOUSTIC RESPIRATORY MONITORING (ARM) ON CLINICAL DECISION-MAKING IN THE MANAGEMENT OF ASTHMA PATIENTS IN A PEDIATRIC INTENSIVE CARE UNIT – A PILOT STUDY

Peter Hervie MD, Phoebe Yager MD, Brenda Miller RN, Kathryn Beauchamp CNS, Maureen Clark MS, Robert Kacmarek PhD, RPR, Natan Noviski MD

OBJECTIVE: To assess the impact of acoustic respiratory monitoring (ARM) on clinical decision-making in the management of asthma patients in a pediatric intensive care unit (PICU).

METHODS: This was a prospective, single arm study enrolling consecutive patients admitted to the PICU with status asthmaticus or respiratory distress on asthma therapy. Patients were connected to an ARM device for 1-4 hours. The *PulmoTrack®*, is an automatic wheeze monitor (KarmelSonix Ltd) and was previously described in Prodhan et al, Respir Care 2008;53(10). Digital processing of the signals was performed in real time to provide objective and quantitative continuous monitoring of wheeze rate (Wz%), respiratory rate and I:E ratio. Providers (physicians, nurses, and respiratory therapists) were asked to evaluate the patient, indicate his/her physical examination findings, review the patient's current regimen of asthma therapy and record any recommended changes to the regimen. They were then allowed to review the ARM data and reconsider their initial recommendations. Providers were blinded to other providers' decision-making and asked to specify whether the ARM data "changed their initial decision," "reinforced their initial decision," or was "neutral" (e.g. had no impact on the decision making.) The impact on the clinical decision making based on review of the ARM data was evaluated.

RESULTS: Nineteen patients, 2-17 years of age, were enrolled in the study. Data collected included 205 pairs of decisions regarding asthma therapy. Asthma therapy for patients enrolled included: Albuterol (100%), Ipratropium bromide (53%), Terbutaline drip (11%), Magnesium sulfate (63%), and Steroids (100%). Twenty-three percent of providers felt the ARM data changed their initial decision; 71% felt it reinforced their initial decision; 6% felt it had no impact on their initial decision. Thirty percent of physicians, 50% of nurses and 14% of respiratory therapists indicated ARM changed or reinforced their decision.

CONCLUSIONS: By providing an objective, continuous assessment of the patient's wheezing, ARM data was shown to impact clinical decision-making in toddlers and children admitted to the PICU for asthma therapy. Further studies are needed to identify how ARM data can be incorporated into the clinical assessment and medical management of asthma patients in a PICU setting.

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ACOUSTIC BIOMARKERS OF CHRONIC OBSTRUCTIVE LUNG DISEASE

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OBJECTIVE:

The goal of this study was to determine lung sounds-derived biomarkers that distinguished Chronic Obstructive Pulmonary Disease patients from age-matched controls.

METHODS:

We used a multichannel lung sound analyzer (Stethographics Model STG-1602) that provides acoustic data from multiple sites on the chest wall to study patients diagnosed by their physicians as having Chronic Obstructive Pulmonary Disease (90 patients). The acoustic findings in these patients were compared to those in 90 age matched controls who presented to an internist for an annual physical examination.

MEASUREMENTS:

Parameters based on timing, frequency, amplitude and adventitious sound analysis were derived from lung sounds.

MAIN RESULTS:

Eleven parameters were statistically different between COPD and control patients, Table 1.

		Control	COPD	p-value
1	Ratio of the duration of inspiration to the duration of expiration (%)	85 16	70 17	<0.0001
2	Lead - the difference in timing between the start of inspiration at the trachea and the start of inspiration at each chest wall site (% of inspiration duration)	4 5	14 13	<0.0001
3	Lag - the difference in timing between the end of inspiration at the trachea and the end of inspiration at each chest wall site (% of inspiration duration)	13 12	28 25	<0.0001
4	Lead time-integrated amplitude (a.u.)	51 70	249 360	<0.0001
5	Lag time-integrated amplitude (a.u.)	236 304	535 1055	<0.01
6	Maximum ratio of low frequency energy (between 10Hz and 80Hz) to high frequency energy (80Hz to 500Hz) among chest microphones	1.0 1.1	2.6 2.9	<0.0001
7	Inspiratory crackle rate	0.6 0.5	4.9 6.5	<0.0001
8	Expiratory crackle rate	0.5 0.5	1.9 2.1	<0.0001
9	Inspiratory wheeze and rhonchi rate	0.1 0.5	1.3 3.4	<0.0001
10	Expiratory wheeze and rhonchi rate	0.0 0.2	2.3 4.3	<0.0001
11	Ratio of peak inspiratory amplitude to peak expiratory amplitude.	4.8 3.3	3.1 2.9	<0.0001

CONCLUSION:

This study showed that measurable differences exist between the lung sound patterns of Chronic Obstructive Pulmonary Disease patients as compared to age-matched controls. Lung sounds derived biomarkers are helpful in diagnosing COPD.

HOW SMOKING AFFECTS THE PREDICTIVE VALUE OF ABNORMAL LUNG SOUNDS FOR AIRFLOW LIMITATION

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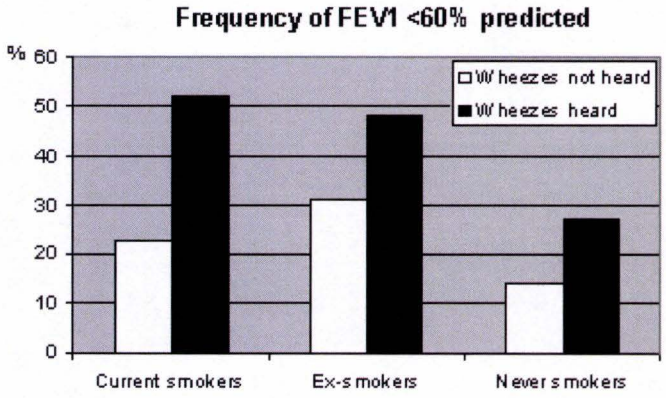
BACKGROUND: Crackles and wheezes are known features of obstructive pulmonary diseases, and hearing such sounds on auscultation of the lungs of a patient, makes bronchial airflow limitation more likely. Crackles and wheezes are more frequently heard in current smokers than in people who do not smoke. This may be partly explained by increased prevalence of obstructive pulmonary disease in smokers, but it is also likely that irritation of the bronchial mucosa may bring about abnormal lung sounds also in subjects with normal lung function. If this is the case, the specificity of crackles and wheezes in the diagnosis of airflow limitation may be lower in smokers than in non-smokers, and the predictive value may be lower as well. This study was carried out to find out how current smoking affects the value of crackles and wheezes in the diagnosis of airflow limitation.

METHODS: 377 patients aged 40 year or more with a diagnosis of asthma or COPD in their medical record were examined by a GP, during stable phase of their disease. The GPs recorded the presence of wheezes and crackles on auscultation, and spirometry was carried out. FEV1<60% predicted was chosen as evidence of significant airflow limitation.

RESULTS: FEV1<60% predicted was found in 27.6% of the study sample. Current smoking was registered in 27.3%, whereas 45.4% were previous smokers and 27.3 % never smokers. FEV1<60% predicted was found with similar frequency in smokers and ex-smokers, in 30.1% and 33.3%, respectively. Wheezes were recorded in 16.7%, crackles in 9.8%. The sensitivities and positive predictive values of crackles and wheezes were higher in current smokers than in ex-smokers and never smokers, see table and figure.

	Sensitivity	Specificity	Likelihood Ratio	Positive predictive value
Crackles				
Current smokers	0.16	0.89	1.45	38.5%
Ex-smokers	0.11	0.90	1.09	33.3%
Never smokers	0.06	0.93	0.91	14.3%
Wheezes				
Current smokers	0.42	0.83	2.51	52.0%
Ex-smokers	0.23	0.88	1.85	48.1%
Never smokers	0.19	0.91	2.04	27.3%

The association between wheezes and airflow limitation was statistically significant in current smokers, p=0.006.



CONCLUSION:
The diagnostic value of wheezes in detecting airflow limitation were shown to be better in current smokers than in ex-smokers, in spite of decreased specificity.

This can be explained by increased sensitivity of the finding in smokers compared to ex-smokers.

CARDIAC RESPONSE TO RESPIRATION

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OBJECTIVE:

It has been known that the heart beat becomes slower on Inspiration. When one takes a deeper breathe, more negative pressure within the chest is generated, which leads to more blood return to the Left Ventricle, hence a delay of the next heart beat.

METHODS:

Utilizing Murphy's STG-1, we recorded 1st and 2nd heart sounds, superimposing breath sounds recording. Measurements of 1st heart sound interval of 2 beats during Inspiration, and 2 beats just before the Inspiration, were made. All recordings were done, at sitting position, with a Diaphragm Stethoscope's Head with a microphone built in the middle, which was placed by the subject, over the anterior chest surface, where, the subject thought heart was located. By simply signaling let subject to take good deep breathe, twice, at few seconds interval for data collection.

RESULTS:

30 Nonsmoking subjects showed longer 2 beasts interval during Inspiration (1.467 msec) comparing to shorter 2 beats interval before Inspiration (0.719 msec), and the ratio, was 2.121 + 0.949.

10 subjects who were known to have C.O.P.D, there were no significant differences of the 2 intervals during Inspiration (0.834 msec) and before the Inspiration (0.928 msec), and the ratio was 0.879 + 0.383.

CONCLUSION:

There was a clear evidence of slowing of the heart beat during deep inspiration in a healthy non smoking subject, which was not observed in a subject with C O P D.

PERFORMANCE OF CRACKLE DETECTORS IN CYSTIC FIBROSIS AND PNEUMONIA: A PILOT STUDY

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PURPOSE: Computer aided lung-sound analysis (CALSA) [1] characterising adventitious lung sounds (ALS) can be an objective and reliable method of identifying crackles [2], which are important indicators of lung disease severity. However, it is still unclear which automatic detection algorithm offers the best performance; further validation is required to regularly apply this method in clinical practice across different populations and respiratory pathologies. The main objective of this pilot study was to test the behaviour of different crackle-detection algorithms in cystic fibrosis and pneumonia.

METHODS: Four crackle-detection algorithms were implemented based on methods described in the literature: (A) Hadjileontiadis and Rekanos [3]; (B) idem using Sevcik's fractal dimension algorithm [4]; (C) Vannuccini et al. [5] and (D) Lu and Bahoura [6]. Digital respiratory sound recordings were obtained following the CORSA guidelines [7] from four adult outpatients in a clinical setting. Ten of these recordings (five of cystic fibrosis and five of pneumonia) were analysed using the implemented algorithms. The recordings were independently annotated for crackles by three experienced respiratory clinicians. A reference annotation (*gold standard*) was obtained through agreement by majority. The accuracy of the algorithms was assessed against this *gold standard*. The chosen performance index was the harmonic mean (*F-measure* [8]) of sensitivity and precision. The criterion applied to identify *true positives* (TP) was the coincidence of crackle maximum magnitude peak [9]. The assessment of performance was completed by measuring the average computation time of each algorithm.

RESULTS: The best performance (i.e. best compromise between *F-measure* and computation time) was obtained with algorithm B, as shown in table 1. The sensitivity and precision achieved with this algorithm were 91.5% and 72.1%, respectively. Table 2 presents the breakdown of the results obtained for cystic fibrosis and pneumonia. The algorithm performs better in cystic fibrosis when compared to pneumonia, with sensitivity, precision and F-measure parameters higher by 15.7%, 7.0% and 14.2%, respectively.

Table 1: Processing time and F-measure of the four tested algorithms.

	Algorithm A	Algorithm B	Algorithm C	Algorithm D
Processing time* (s)	72.0	10.9	103.5	12.5
F-measure (%)	81.0	79.4	78.7	77.4

Table 2: Performance of algorithm B in cystic fibrosis vs. pneumonia.

	Sensitivity (%)	Precision (%)	F-measure (%)
Cystic Fibrosis	98.0	74.6	84.7
Pneumonia	84.8	69.7	74.2

CONCLUSIONS: This study involved more demanding performance tests than usually reported in the literature, since the *gold standard* was obtained through multi-annotator agreement to reduce annotation bias. It still confirmed the idea that computer-based crackle detection can be an objective and reliable tool to assess and monitor different pulmonary diseases. Therefore, crackle detector validation effort must be continued based on credible (multi-annotator) references obtained from very large respiratory sound repositories covering a wide range of pathologies. While method B appears to be the most promising, further work is also needed to determine which algorithm offers the best performance in terms of detection accuracy and speed.

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CRACKLE PITCH RISES PROGRESSIVELY DURING INSPIRATION IN IPF, CHF, AND PNEUMONIA PATIENTS

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OBJECTIVE:

Although crackles are frequently heard on auscultation of the chest of patients with common cardiopulmonary disorders, the mechanism of production of these sounds is inadequately understood. The goal of this research was to gain insights into the mechanism of crackle generation by systematic examination of crackle pitch as a function of its timing during inspiration.

METHODS:

Patients with a significant number of crackles were examined using a multichannel lung sound analyzer. These patients included 34 with pneumonia, 38 with heart failure and 28 with interstitial fibrosis. Individual crackle events are normally detected by multiple microphones located on the chest surface. The group of waveforms corresponding to a single crackle event and recorded by multiple microphones is referred to as a crackle family. The channel with highest crackle amplitude is called the mother crackle and the corresponding deflections at other channels are called daughter crackles. In this study crackle pitch of the mother crackle was used for analysis.

RESULTS:

Crackle pitch increased during inspirations in 82% of pneumonia patients, 74% of CHF patients, and 82% of IPF patients, Table 1.

	Pneumonia	CHF	Interstitial fibrosis
Increased	28	28	23
No change	2	6	2
Decreased	4	4	3

Table 1. Crackle pitch increases progressively during inspiration in most patients.

CONCLUSION:

Airways with progressively smaller diameter are recruited during inspiration. Therefore crackles recorded during beginning of inspiration are expected to be generated by larger diameter airways than the crackles generated at the end of inspiration. If crackle pitch is determined by airway diameter we should be able to observe a difference in pitch between crackles generated at the beginning and at the end of inspiration. In fact we observed a progressive pitch increase during inspiration. This observation is consistent with the hypothesis that crackle pitch is determined by an airway diameter.