AUTOMATED LUNG SOUND ANALYSIS IN PATIENTS WITH PNEUMONIA
R. Murphy, A. Vyshedsky, V-A Power, D. Bana, P. Marinelli, A. Wong

BACKGROUND
<> Observer disagreement for the physical findings used to diagnose pneumonia is large.
<> To circumvent this problem we have developed a computerized multichannel lung sound analyzer that detects and provides objective quantification of sounds from 16 sites simultaneously.

OBJECTIVE
To determine the sensitivity and specificity of objectively detected lung sounds in the diagnosis of pneumonia.

MATERIALS AND METHODS
<> A convenience sample of 62 patients, age 726±38 (mean 53), in a community teaching hospital who had a clinical diagnosis of pneumonia and 62 controls, age 71±5, were examined with a 16 channel lung sound analyzer (Stethographs, Inc, Model 1602).
<> An Acoustic Pneumonia Score (APS) was generated based on individual acoustic findings detected by the system including rates of wheezing and rhonchi, automatic counts of fine and coarse crackles as well as amplitude measurements of inspiration and expiration.

ACOUSTIC PNEUMONIA SCORE
<> The adventitious sounds and the amplitude information were used to generate an “acoustic pneumonia score” (APS).
<> Each score ranged from 0 to 10.
<> A total score was calculated for each subject by adding each of the individual scores.

ADVENTITIOUS SOUNDS
<> The wheeze rate was defined as the proportion of the breath cycle occupied by a wheeze or a rhonchus. It was calculated separately for inspiration and expiration. We have included rhonchi in the wheeze rate as the precise frequency that divides wheezes and rhonchi is not known. The wheeze score was calculated by dividing the wheeze rate by 10.
<> The crackle score was calculated separately for inspiration and expiration and was defined as a number of crackles per breath, except that the maximum crackle score assigned was 10. In other words all patients with scores of 10 or more were assigned the score of 10.

SOUND AMPLITUDE
<> As we had no direct method for computerized detection of bronchial breathing, we employed the ratio of the expiratory to inspiratory amplitude as a surrogate. Our assumption was that bronchial breathing would tend to make expiration louder either diffusely or locally.
<> Accordingly, we calculated the ratio of the expiratory RMS to the inspiratory RMS for each chest recording site.
<> The average of this ratio over 14 chest sites was calculated for each patient (A1).
<> The A1 score was and assigned as follows:

EXAMPLE OF DATA COLLECTION
PNEUMONIA PATIENT

CLINICAL SUMMARY
42 year old white male presents with a chief complaint of increased shortness of breath starting the previous night.
Past Medical History - GERD, positive PPD, history of pneumonia.
Present Illness - five day history of weakness, cough and fever of one day’s duration. Denies any GI symptoms.
Review of systems - otherwise unremarkable.
Social History - denies any tobacco use.

PHYSICAL EXAM
General appearance - alert, oriented male with slightly labored breathing.
Vital signs - temperature 94.6, heart rate 82, RR 22, O2 saturation - 98%, BP - 110/80.
HEENT - no evidence of inflammation, no masses, trachea is midline, thyroid not enlarged.
Chest - symmetrical, slightly labored breathing.
Heart - regular rhythm, no murmurs, rubs or gallops.
Abdomen - soft, no tenderness, masses or hepatosplenomegaly, normal bowel sounds.
Extremities - no clubbing, cyanosis or edema.

LABORATORY STUDIES
CBC - WBC 7000: 59% neutrophiles; 32% lymphocytes; 4 bands, Sputum culture - Staph Aureus.
Comprehensive Medical profile - within normal limits.

RESULTS
<> Inspiratory crackles were present in 76% of these patients as compared to 29% of controls.
<> Expiratory crackles were more common in patient with pneumonia - 57% as compared to 5% in controls.
<> Eighty two percent of patients with pneumonia and 24% of controls had over 2 crackles either during inspiration or during expiration.
<> Fifty percent of patients with pneumonia and 4% of controls had over 2 crackles both during inspiration and during expiration.
 <> Seventy percent of patients with pneumonia had more than 4 crackles per breath (including inspiration and expiration) as compared to 13% of controls.
<> Wheezes and rhonchi were more common in the patients with pneumonia. Thirty six percent had wheezing or rhonchi in inspiration and 48% in expiration. In the controls those rates were 5% and 9% respectively.
<> Only 5% of patients with pneumonia were wheeze, rhonchi and crackle free as compared to 74% of controls.
<> The inspiratory crackles in the pneumonia patients were classified by the computer as coarse in 43% and both coarse and fine in 57%.
<> Seventy six percent of the expiratory crackles were classified as coarse, the remainder were a mixture of fine and coarse crackles.
<> The presence of crackles in the control group was age related. None of the controls with crackles was younger than sixty.
<> The average of expiratory RMS to inspiratory RMS ratio over 14 chest sites (A1) was 0.9±1.2 as compared to 0.5±0.2 in controls (p<0.0001).
<> The pneumonia score based on all the 5 values was 21±16 in the pneumonia patients and 3±4 in the controls (p<0.0001). Figure 4 shows the pneumonia score frequency distribution. The acoustic pneumonia score had a sensitivity of 0.87 and a specificity of 0.90. The positive predictive power of a score higher than 6 was 0.90.

ACOUSTIC PNEUMONIA SCORE

CONCLUSION
Lung sound analysis can provide objective evidence supporting the diagnosis of pneumonia. The method is noninvasive and easy to perform even in severely ill patients.