AUTOMATED ANALYSIS OF SQUAWKS

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BACKGROUND

Squawks are short, isolated, end-inspiratory wheeze-like sounds, which are associated with pneumonia as well as hypersensitivity pneumonitis and other fibrotic disorders. We have previously demonstrated that squawks can provide relatively specific although not very sensitive evidence of pneumonia[1] .

PURPOSE

To develop a computer algorithm for automated squawk analysis. To assess sensitivity and specificity of this algorithm as compared to human observers.

MATERIALS AND METHODS

Seven hundred and fifty nine patient were included in the study.

We used a 16 channel lung sound analyzer (Stethographics model 1602) to record their lung sounds.

Three experienced observers, blinded to the clinical diagnosis, used playback and video displays to identify squawks.

Patients with at least one squawk as defined by 2 out of 3 observers were considered squawk positive.

The auscultatory findings were confirmed by inspection of the time-amplitude plots of the sound showing the characteristic waveform patterns of squawks as previously described[1].

MICROPHONE LOCATION

FIGURE 1.

RESULTS

	Pneumonia	IPF	Asthma	COPD	CHF	Normals	Total
# patients	137	27	51	109	80	381	785
Squawks determined by auscultation							
# patients with squawks	12	3	4	7	1	0	27
% patients with squawks	9	11	8	6	1	0	3
Squawks determined by computer algorithm							
# patients with squawks	14	6	4	6	3	0	33
% patients with squawks	10	22	8	6	4	0	4

- The sensitivity of the algorithm for detection of squawks heard by auscultation was 0.89
- The specificity was 0.99;
- The positive predictive power was 0.76
- The negative predictive power was 0.996
- Most false negatives are due to failure of the algorithm to identify very weak squawks.
- Most false positive are due to the presence of fine crackles of long duration misidentified as squawks by the algorithm.

Acoustic Characteristics

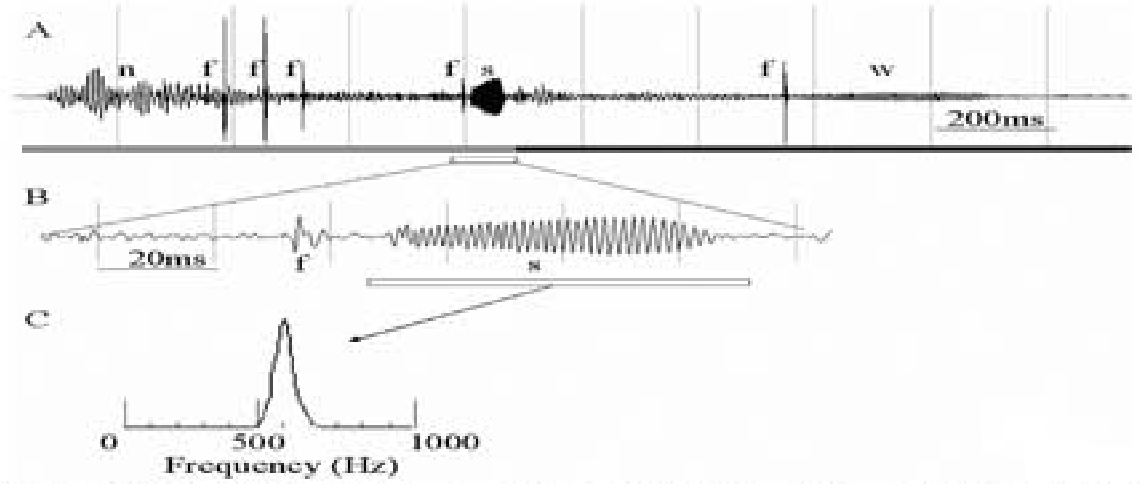


Figure 2. The time-amplitude plot of a sound recorded at lung bases posteriorly (channel 14) in a patient with pneumonia. Waveforms are presented in both the unexpanded (A) and expanded (B) modes.
A: The unexpanded waveform shows one full breath. The solid bars under the unexpanded wave mark the respiratory cycle – the light bar indicates inspiration and the dark bar indicates expiration. Abnormal sounds are indicated as follows: 'f' stands for fine crackle, 's' indicates squawk, 'w' stands for wheeze; 'n' stands for normal inspiratory sound.
B: The squawk waveform is shown expanded.
C: The squawk in the frequency domain. The squawk sound was end-inspiratory with a frequency peak at 600Hz. In this patient similar squawks appeared in 3 consecutive breaths during the 20 seconds of deeper than normal breathing.

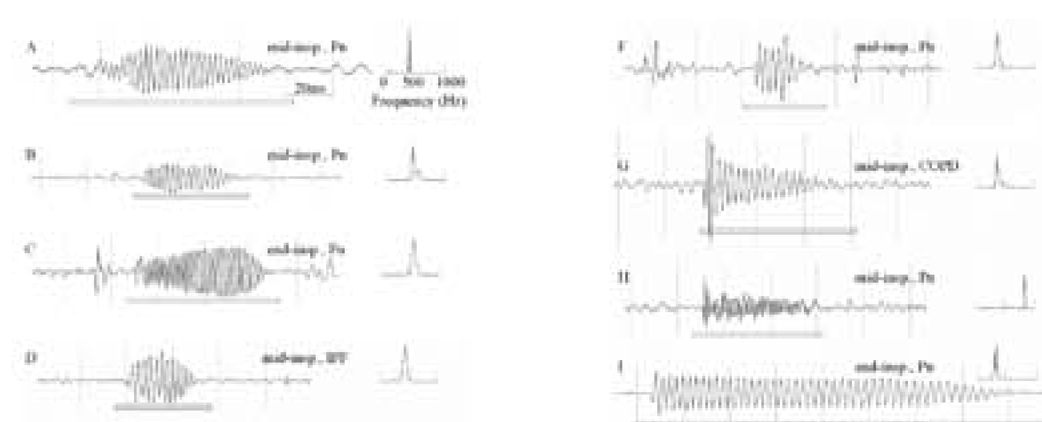


Figure 3. Typical squawk waveforms. Bars under the waveforms indicate intervals that were used to calculate the respresentation of the squawk in the frequency domain (insets on the right).

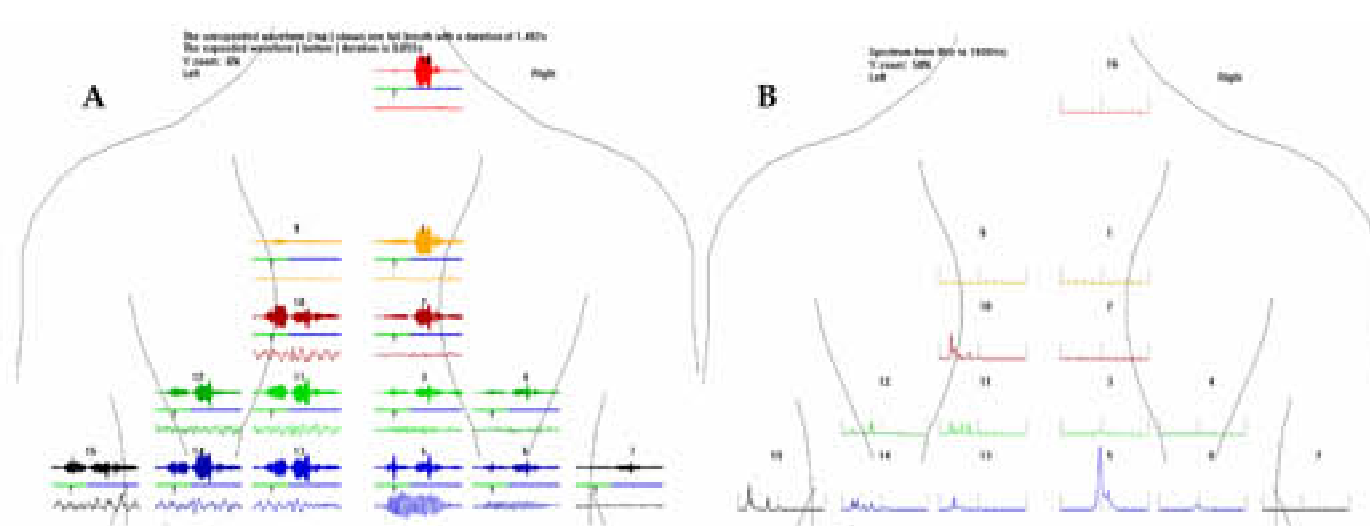
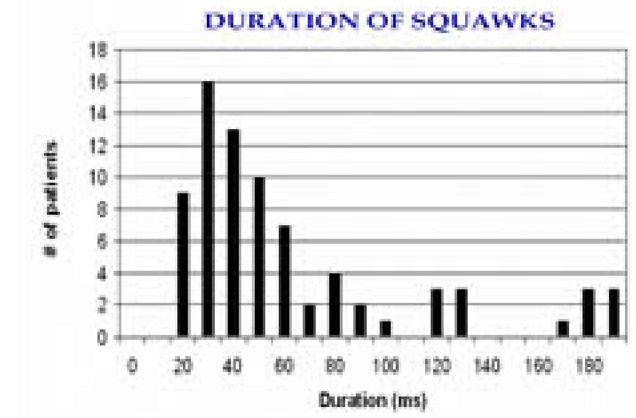
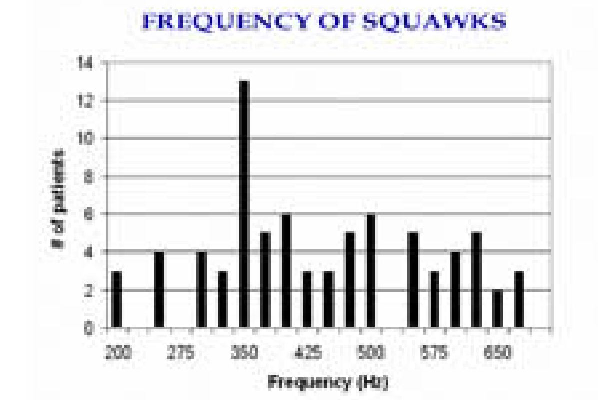


Figure 4. Example of transmission of a squawk through the chest. Time-amplitude plots of a single breath are displayed as they appear at multiple sites. Waveforms are presented in both the unexpanded (top) and expanded (bottom) modes. The unexpanded waveform shows one full breath. The solid bars under the unexpanded waves mark the respiratory cycle - light bars indicate inspiration and dark bars indicate expiration. The arrow indicates the location of the expanded interval. The duration of the expanded interval is 50 millisecond.
A: In this subject with pneumonia, the squawk is most prominently detected on channel 5. Note that the squawk sound is also present on channels 3, 4, and 6. A similar squawk in the same location was heard on every breath we examined.
B: The same squawk as in A is shown in the frequency domain. The squawk frequency was 444Hz.





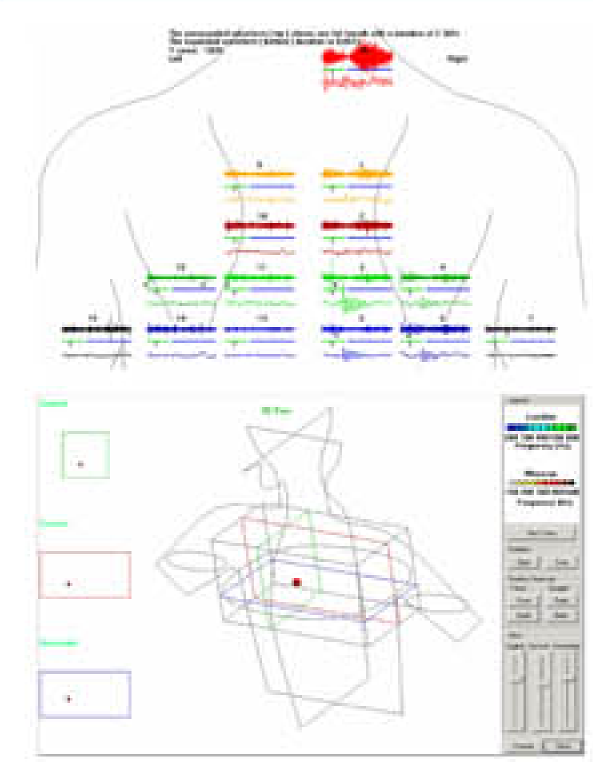
CONCLUSION

- We have developed a computerized algorithm that is relatively sensitive and highly specific for the detection of squawks.
- As squawks are indicative of significant illness we believe that automated analysis by providing objective documentation of their presence has the promise of aiding clinicians in the diagnosis of theses conditions.

Case Report

Squawk leading to the correct diagnosis.
- 69-year-old female presented to the emergency room with acute shortness of breath
- General good health, physically active
- 20 pack-year history of cigarette smoking, stopped 18 years previously
- Cough of 2 month duration with progressive dyspnea
- Negative allergy tests, but started on bronchodilators for a presumptive diagnosis of new onset asthma
- Physical exam in ER - Cyanotic female in acute respiratory distress, T 99.8, Pulse 107, Respiratory rate 22
- Chest auscultation - mild wheezing, few inspiratory crackles
- Chest Xray interpreted as normal
- Diagnosis acute bronchial asthma
- Rx steroids IV, bronchodilators
- Automated lung sound analysis - 3 hours after admission to ER - 4 crackles per breath, squawks present
- Because of the squawks antibotic Rx instituted
- Rereading of chest Xray - small patch of opacification consistent with pneumonia - cleared on follow-up exam

Squawk localized to area of Xray abnormality



Ref. 1. R Paciej, A Vyshedskiy, D Bana, R Murphy, Squawks in pneumonia, Thorax 2004; 59:177-179.