TRANSMISSION OF CRACKLES IN PATIENTS WITH INTERSTITIAL PULMONARY FIBROSIS, CONGESTIVE HEART FAILURE, AND PNEUMONIA

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BACKGROUND
- Patients with Interstitial pulmonary fibrosis (IPF) often have chest roentgenograms that are diffusely abnormal making it difficult to detect evidence of superimposed congestive heart failure (CHF) or pneumonia (PN).
- The crackles of these patients are commonly mistaken for the crackles of CHF. As a result, they frequently are incorrectly diagnosed and prescribed diuretics inappropriately.

OBJECTIVE
The goal of this study was to determine whether the crackles of IPF differed in their transmission characteristics from those of CHF and PN in the hope of improving diagnosis and monitoring of these patients.

METHODS
- A 16-channel lung sound analyzer (Stethographics Model STG180) was used to collect 20 seconds of sound from each crackle.
- Patients with a high number of crackles, i.e. over 20 inspiratory crackles in a 20 second recording, were chosen from a pool of over 500 patients.
- These patients included 25 with IPF, 37 with CHF, and 16 with PN.
- The diagnostic category of each of the patients was that of the clinicians caring for these patients. This was reviewed by the senior author to be sure they were consistent with established criteria.
- This figure shows the soft foam backpad with microphones embedded in chestpieces (A) and method of application (B).

RESULTS
- Figure 1 shows sound waveforms recorded from a CHF patient. The waveforms are superimposed on a body plot. Each waveform is positioned on a part of the body from where the sound was recorded.
- Figure 2 shows the sound distribution in a patient with IPF. Notice the prominent crackle on channel 5 (indicated by a triangle). In contrast to the crackle shown in the patient with CHF, the crackle barely stands above the background noise at channels 3, 4, 5, or 7. In general crackles of IPF are transmitted over smaller area than crackles of CHF and PN.

CRACKLE TRANSMISSION COEFFICIENT
- To quantify the phenomena of the distance a crackling sound spreads or is transmitted, crackle waveforms occurring within the same 5 millisecond interval were considered to be coming from the same crackle source.
- The signal containing the crackle with the highest amplitude was correlated with the corresponding signals on other microphones (source microphones).
- The ratio of the peak of the cross-correlation function to the peak of the source crackle autocorrelation function was calculated.
- This ratio characterizes the degree of sound transmission from the source microphones to the corresponding microphone on the chest surface.
- The crackle transmission coefficient has a value of 0% in the absence of any transmission and 100% when there is equal transmission to all channels.

RESULTS - continued
- Average inspiratory crackle transmission coefficient and average crackle frequency were calculated for every patient in the study.
- Inspiratory crackle CTC averaged 24±5% for pneumonia, 25±4% for CHF, and 14±4% for IPF.
- The difference in CTC between IPF and CHF and between IPF and PN was statistically significant (p<0.0001).
- Inspiratory crackle frequency was also different: the frequency averaged 30±25 Hz for pneumonia, 311±62 Hz for CHF, and 462±50 Hz for IPF.
- The difference in frequency between IPF and CHF and between IPF and PN was statistically significant (p<0.0001).

CONCLUSION
- In this study we have described criteria that differentiate IPF patients from CHF and PN in terms of crackle transmission and frequency.
- The differences that characterize IPF patients from the other two conditions monitored in this study provide evidence that acoustical analysis could be a helpful guide in the management of these patients.