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

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PURPOSE

The goal of this study was to search for acoustic parameters that could reliably differentiate the crackles of IPF from the crackles of CHF.

MATERIALS AND METHODS

A 16-channel lung sound analyzer (Bioacoustics Model STG1602) was used to collect 20 samples of sound from patients with CHF (n=40) and IPF (n=18) during deeper than normal breathing.

CRACKLE TRANSMISSION COEFFICIENT

- Some crackles appear at many microphones and others at only a few.
- To quantify the phenomena of the distance a crackling sound spreads or is transmitted, crackle waveforms occurring within the same 5 milliseconds interval were considered to be coming from the same crackle source.

![Diagram](image)

- The signal containing the crackle with the highest amplitude (the mother crackle) was cross-correlated with the corresponding signal on other microphones (daughter crackles).
- The ratio of the peak of the cross-correlation function to the peak of the mother crackle autocorrelation function was calculated.
- This ratio characterizes the degree of sound transmission from the sound source to the corresponding microphone on the chest surface.

- For every crackle family, the average of ratios over the chest characterizes the degree of sound transmission from the sound source to the chest.
- Crackle transmission coefficient has a value of 0% in the absence of any transmission and 100% when there is equal transmission to all channels.
- Average inspiratory crackle transmission coefficient and average crackle frequency were calculated for every patient in the study.

RESULTS

Figure 1 shows time amplitude plots of a single breath as they appear at multiple sites in a subject with CHF. Twelve microphones are placed on the back; numbers 1 through 6 are on the right side, 9 through 14 are on the left. There is one on each lateral base - microphone numbers 7 and 13 respectively. There is one over the heart (not shown) and one over the trachea - number 16.

Waveforms are presented in both the unexpanded (top) and expanded (bottom) modes. The unexpanded waveform shows one full breath. The unexpanded and expanded waves corresponding to the same channel are shown in the same color. The choice of colors is arbitrary. The solid bars under the unexpanded waves mark respiratory cycle - green bars indicate inspiration and blue bars indicate expiration. The arrow indicates the location of the expanded interval. The duration of the expanded interval is 100 milliseconds.

Figure 2 shows the sound distribution in a patient with IPF. Notice the prominent crackle on channel 6 in the center of the expanded waveform (indicated by a long, thick arrow). 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.

![Diagram](image)

This figure shows that crackling sounds are transmitted through the chest. Consider the most prominent crackle on channel 6 in the center of the expanded waveform (indicated by a long, thick arrow). One can recognize crackles at channels 3, 4, 5, and 7 that occur at the same time (indicated by long thin arrows). These crackles are related. They likely represent the same event of airway opening.

CONCLUSION

We have described criteria that differentiate IPF patients from CHF patients on the basis of crackle transmission coefficient and frequency. As this type of acoustical analysis is readily done at the bedside, it provides the promise of helping guide diagnosis in such patients.