

# Decreased spatial distribution of vibration energy in lungs with acute heart failure

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## Introduction

The purpose of this study is to compare lung vibration distribution in acute heart failure (AHF) patients to healthy subjects with normal chest radiographs.

## Methods

We performed vibration distribution analysis in 24 consecutive AHF subjects in the emergency department (ED) and compared them to 16 healthy subjects. Recordings were performed over 20 second periods of respiration using vibration response imaging (VRI) device, a novel technology using sophisticated software and 34 surface skin sensors placed on the back to record, analyze and display vibration energy of lung sounds during the respiratory cycle. Respiratory cycles free of noise or artifacts were chosen for analysis and images were analyzed. The images at maximum vibration energy during inspiration were chosen for analysis and areas were compared. Areas of both lungs were calculated digitally using the program Image J. Statistical t-test was used to compare total mean lung areas.

## Chest radiograph and vibration distribution image

Figure 1.  
Healthy volunteer

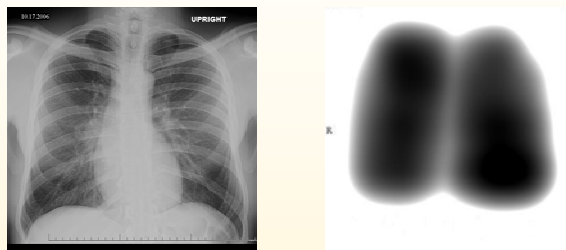
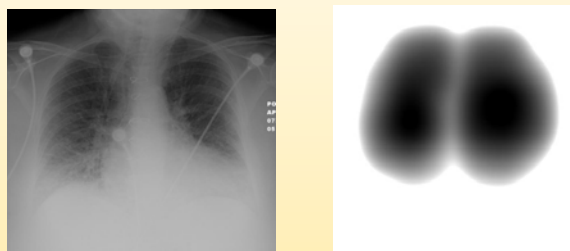
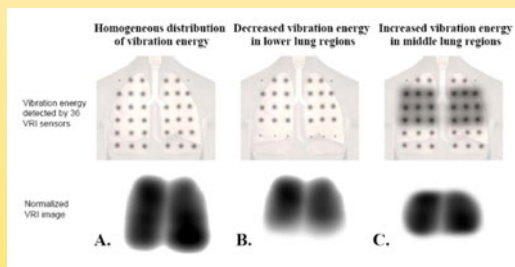


Figure 2.  
Acute heart failure patient



## Normalization of VRI image



36 VRI sensors are spaced over the patient's back and detect vibrations during respiration. The size of the dots is a cartoon representation of the amount of vibration energy detected by that sensor. When the detected vibrations are uniform, the resulting VRI image will be large (A). When the detected vibrations are less homogeneous, i.e. if the lower sensors have decreased vibrations (B) or if the middle sensors detect increased vibration (C), a smaller VRI image results. The visual geographic area is therefore determined not by intensity of vibration but by the distribution of intensity.

## Results

The total mean areas of both lungs were  $56757 \pm 8231$  and  $76170 \pm 3843$  (mean  $\pm$  SD) in AHF patients and healthy volunteers, respectively ( $p = 0.01$ ).

## Conclusions

Compared to healthy volunteers (Fig 1A), there was less homogenous distribution of lung vibration energy in acute CHF exacerbations, as demonstrated by the decreased geographical area of the VRI image. We have demonstrated an association between geographical area of the VRI image with acute heart failure. This is likely due, in part, to decreased airflow in the lower lung regions due to edema and pleural effusion.