

A Synchronous Dynamic Vibration Response Image (VRI) of the Lung in Emphysema

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Background: Loss of lung parenchyma, shown by CT scan and loss of function, as confirmed by limited CO diffusion, DL_{CO}, are the only sensitive correlates of emphysema. The VRI* system constructs a dynamic lung image from vibrations produced by airflow. The vibrations, hence the image, are altered by the airway and parenchymal abnormalities in emphysema.



Figure 1: The VRI system

Objective: To describe the lung VRI in emphysema.

Methods: 9 adults (1 F) with mean age 60 ± 13 yrs, FEV₁ $37 \pm 29\%$, DL_{CO} $50 \pm 14\%$ and RV $185 \pm 69\%$ P, underwent VRI testing during tidal breathing.

One breath image was assembled from frames of 0.17 sec of energy recorded by 40 sensors.

Analysis included the dynamic VRI, the peak inspiratory signal, and the frame by frame signal all were compared with the normal variability.

Findings:

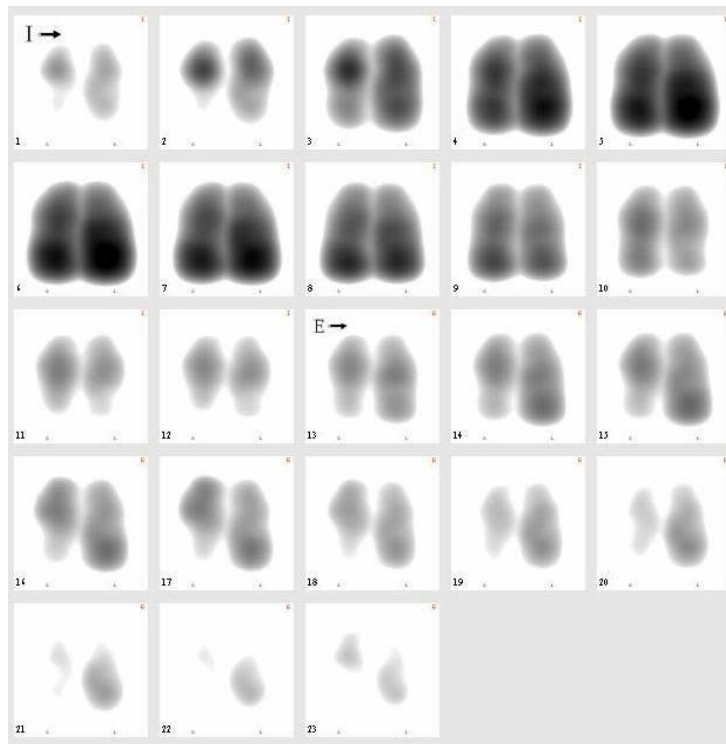


Figure 2: A sequence of 23 frames representing 1 breathing cycle (3.91 sec) from a patient with emphysema

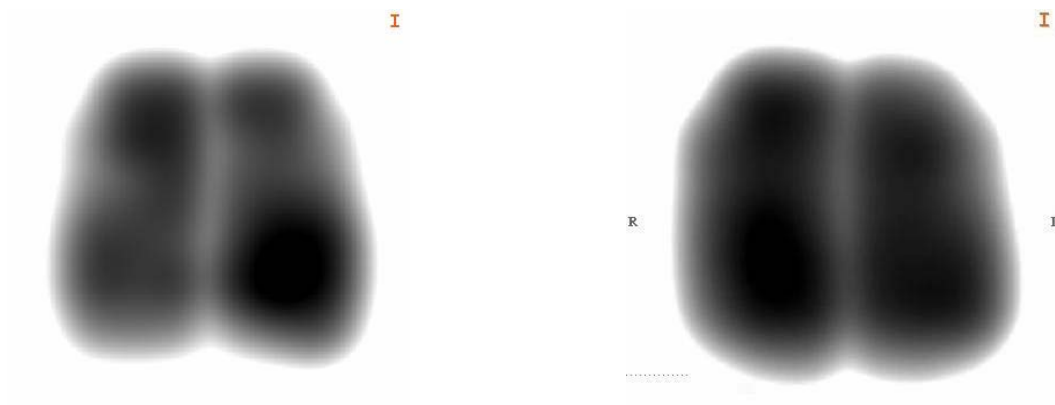


Figure 3a & 3b: Maximal inspiratory image of a (a) patient with emphysema as compared with the maximal inspiratory image of a healthy male (b).

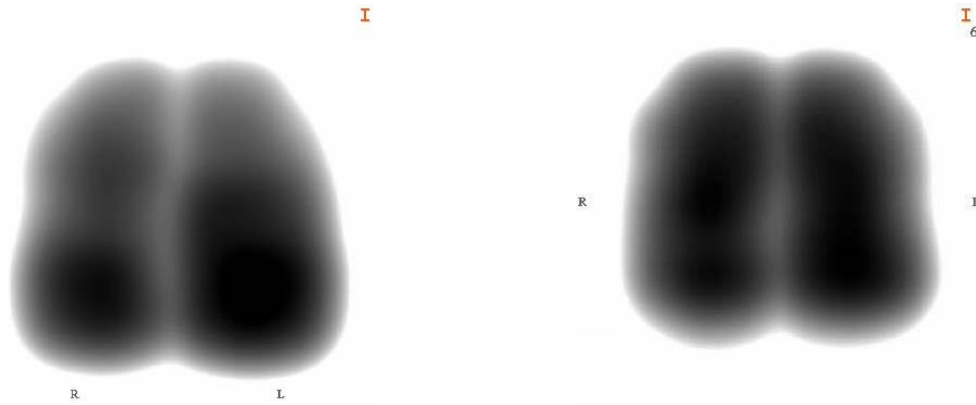


Figure 4a & 3b: Maximal inspiratory image of a (a) patient with emphysema as compared with the maximal inspiratory image of a healthy male (b).

Images were relatively similar, but differed dramatically, in all aspects, from the normal. The dynamic images were elongated, but markedly asymmetric, and with irregular borders. The signal started as indistinct foci (1-2) of different size, intensity and location, usually in the upper or lower third of the lungs. The intensity of the foci increased in a chaotic pattern, but they never unified. During progression, foci of signal were abruptly formed at remote areas, leading to focal deformation of the border, as if the lungs were twisted and squeezed. Even at peak inspiratory signal, some areas of the chest remained with low or no signal. The signal faded (but never disappeared) until it expanded during expiration, at which point its intensity and distribution were smaller and its dynamics were similarly random.

Conclusion: The dynamic VRI is radically altered in emphysema; probably reflecting erratic distribution of ventilation. The consistency of these pattern forms the basis for controlled quantitative studies of the VRI in emphysema.

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