Vibration Response Imaging (VRI) of the Lungs in Pediatric Patients

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Background:
Pediatric chest imaging such as chest radiology and computed tomography largely contribute to the diagnosis and management of pediatric pulmonary disorders [1]. However, these technologies emit radiation [2] and cannot detect the whole range of pulmonary complaints [3,4]. Vibration Response Imaging (VRI) is a novel technology providing a non-invasive, radiation free dynamic image of the lungs. A sensor array that is suitable for pediatric patients has now been developed with the intention of extending the clinicians ability in the diagnosis and management of pediatric pulmonary disease.

Objective: To describe the lung VRI in pediatric subjects.

Description of Device
The VRI system constructs a dynamic lung image from vibrations produced by airflow. Vibration energy is detected by two arrays of acoustic contact sensors, which are coupled to the subjects back by a low computer controlled vacuum (Fig 1). The sensors' signals are processed by the VRI software, which incorporates an algorithm to convert the vibration energy to a sequence of images that is viewed on the computer screen. The VRI also detects and analyzes crackles and wheezes, which are presented in the display as blue and red dots, respectively, superimposed on the VRI image.

Figure 1: The VRI system

Methods: Thirty-eight patients (age 5 to 12 years, mean 8.8 years) with various respiratory pathologies and 10 normal subjects (age 5 to 12 years, mean 8.9 years) underwent VRI procedure. The vibration energy was collected by 34 sensors that were adhered to the subjects back and an image was assembled from frames of 0.17 seconds of energy. Analysis included the dynamic VRI and the frame by frame signal, as compared with the normal distribution.

Results

Images of Normal Lungs: The dynamic image, comprised of the left and right lungs, develops bilaterally, simultaneously and almost symmetrically. Normal dynamic energy patterns have vertical movement of energy in a synchronized fashion. The maximal energy frame (MEF) image of normal subjects appears smooth, rounded with narrowing towards the top and slight widening below midsection (Fig. 2).

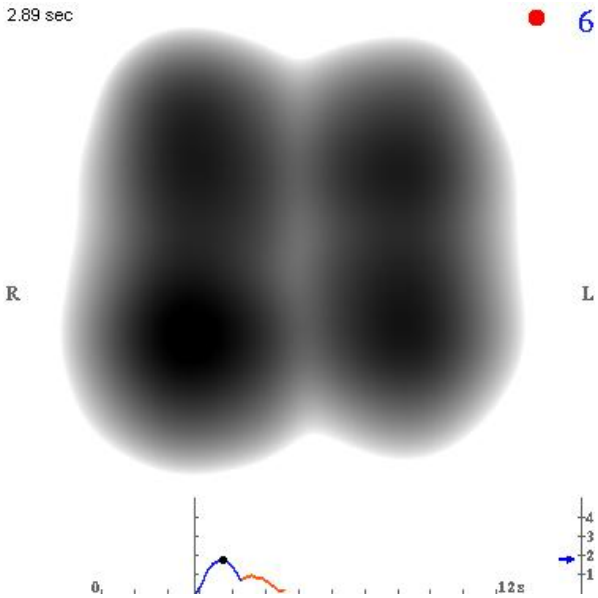

Figure 2: Normal Image (male, 12 years)

Images of Lung Pathology: The VRI images of pediatric patients having various lung pathologies such as asthma and bronchiectasis, differed from normal images in symmetry, intensity and time sequence. In 15 asthma patients the VRI showed an asymmetrical vibration response (VR) distribution between lungs and lung regions (Fig. 3). In 5 bronchiectasis patients the VRI revealed disturbed VR which affected the time sequence and symmetry (Fig. 4). The VRI of a patient with chest X-ray negative for a foreign body was modified and had a reduced airflow (Fig. 5). Further bronchoscope testing revealed a plastic object in the patient's left main bronchus.

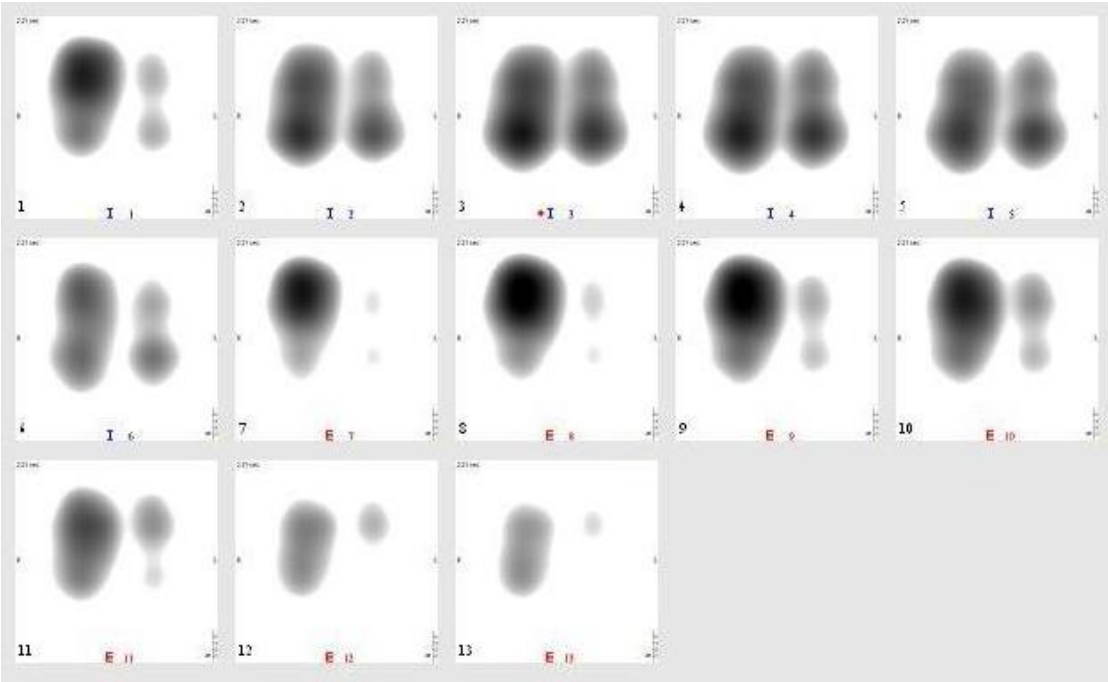

Figure 3: Sequence of 13 frames of a single dynamic image of a patient (male, 7.5 years) diagnosed with asthma. There are disturbances in the dynamic image development and a constant asymmetry between the left and right lungs.

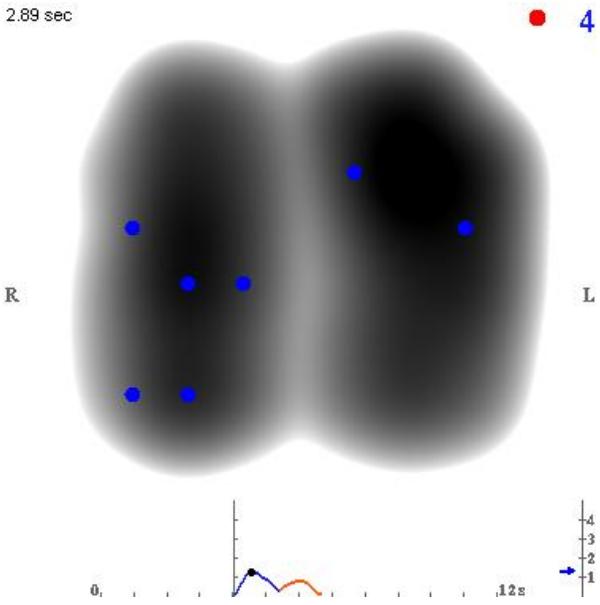

Figure 4: The VRI-MEF image of a patient (female, 12 years) diagnosed with bilateral bronchiectasis and pulmonary hypertension is asymmetrical. Blue dots indicate presence of crackles confirmed by chest auscultation.

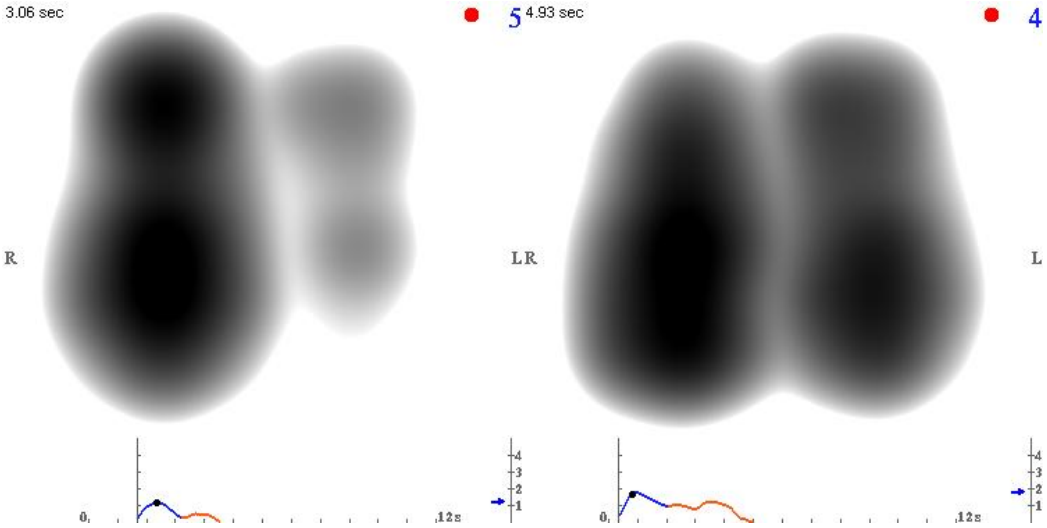

Figure 5: VRI-MEF images of a patient (male, 11 years) positive for foreign body obstruction **a.** Image before removal of foreign object. **b**. Image after removal of foreign object.

Conclusion: The VRI provides an immediate dynamic image that can simultaneously identify and locate both structural and functional abnormalities throughout the lungs. Furthermore, the VRI doesn't require strict patient cooperation, and is hence an ideal tool for managing respiratory conditions of pediatric patients.

References

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