

Wavelet-Based Evaluation for the Thoracic Aorta Stiffness from CINE-MR Images

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Introduction: MR imaging is an attractive modality that allows direct and non-invasive evaluation of the aortic stiffness. This is commonly done using Cine-MR sequences in which the evolution of the aortic contour is tracked during the cardiac cycle, commonly in an axial plane at the level of the pulmonary trunk. The maximum and minimum of the area are then used to calculate the aortic compliance. Although this parameter can serve as an early hallmark in specific diseases, it remains inadequate to distinguish various other disorders such as Marfan syndrome (inherited disorder of connective tissue) or Ehlers-Danlos disease. In this study we propose an approach in which the whole curve representing the evolution of the aortic area during the cardiac cycle is taken into consideration and analyzed. The analysis of the aortic area variation is done using the wavelet transform [1] which gives an insight about the spectral components of this variation and their localization in time. The proposed approach was used in this study to distinguish two classes of patients (subjects with Marfan syndrome [2, 3], and subject with MYH11 mutation [4]) from normal healthy subjects. In addition, some of the commonly used aortic stiffness measurements such as compliance, and pulse wave velocity (PWV) were obtained for the studied population for comparison.

Material and Methods: The population recruited for this study consisted of 29 subjects (10 patients with Marfan syndrome; 11 patients with MYH11 mutation and 8 normal control subjects). Cine-MR Images were acquired using ECG-gated sequences at the level of the pulmonary trunk with a plane orientated perpendicular to the ascending and descending aortas. Aortic compliance was calculated for each patient using an automatic segmentation algorithm developed to track aortic contour over the cardiac cycle [5]. In addition, the absolute and relative variation of the aortic area over the cardiac cycle was analyzed using the wavelet decomposition. Moreover, the PWV was determined for each patient with velocity encoded sequence acquired at the ascending and descending aorta at level of the pulmonary trunk. To calculate the transit time for the pulse wave between the two sites we used cross correlation [6, 7].

Discussion and Results: The results show that, the classical measurements, namely compliance, were effective in distinguishing the MYH11 mutation carriers from the normal control subjects with no overlap. However, the results also shows that the compliance and PWV fail to separate between the Marfan and the healthy subjects; and a wide overlap was observed in the range of these measurements between the two groups. This confirms that, it is difficult to differentiate cases with some pathologies like Marfan from healthy subjects by merely considering the conventional stiffness parameters obtain from MR images.

The result also shows that - in the wavelet representation of the relative aortic area variation - the Marfan class is separated very well from the rest of the population. This finding suggests that, the magnitude of some frequency components in the wavelet domain can be used as a hallmark for the Marfan syndrome. Similar results were obtained for the MYH11 mutation carriers.

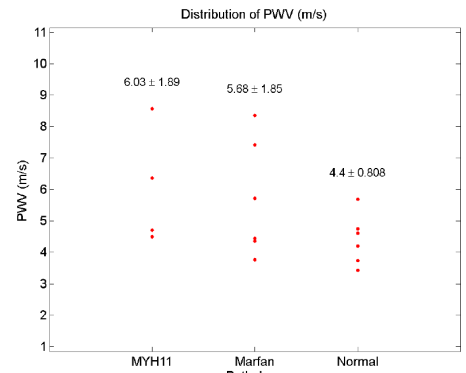


Fig 1: PWV for the study population

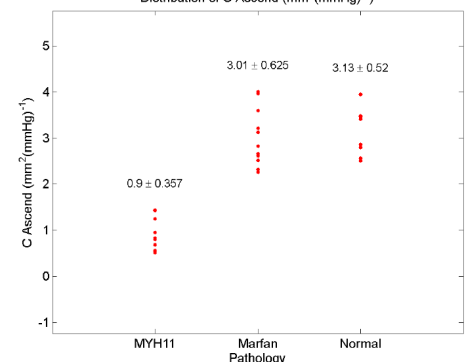


Fig 2: compliance of the ascending aorta for the population

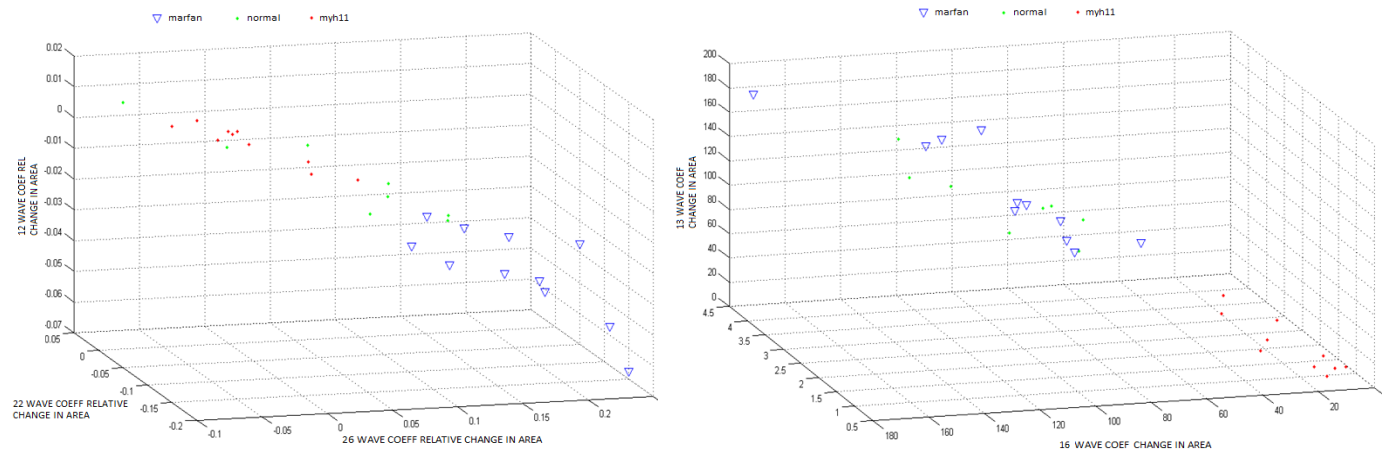


Fig 3: Scatter plot of some wavelet coefficients

Conclusion and Future Work: A novel diagnosing approach to evaluate the condition of the aorta and its abnormality was proposed and promising results were obtained. These findings will be validated in a population with larger size. In addition the approach will be tested on other aortic pathologies.

References: [1] Abibullaev, et al. ICIS 2009; 09:702-707. [2] Hirata, et al. Am Coll Cardiol 1991; 18:57-63. [3] Nollen, et al. I J Cardiol 2004; 97:103-108. [4] Khau Van Kien, et al. Circulation Aha 2005; 112:200-206. [5] Rose, et al. Magn Reson Imag 2010; 28(2) : 255-263. [6] Xavier, et al. Comput Cardiol. 2007; 34 :375-378. [7] Delfino, et al. Magn Reson Imag 2008; 28:1086-1091.