Measuring the Radial Component of Left Ventricular Strain with Circular Tagging: Feasibility and Initial Results.

Maryam Haftekhanaki[1], Abbas N Moghaddam[1,2], Khaled Abd-Elmoniem[3], and J. Paul Finn[2]

[1]*Biomedical Engineering, Tehran Polytechnic, Tehran, Tehran, Iran,* [2]*Radiology, UCLA, Los Angeles, CA, United States,* [3]*Biomedical and Metabolic Imaging Branch, NIDDK, NIH*

Introduction: Left ventricular (LV) wall thickening is a crucial component of systolic ejection and cardiac output. LV wall thickening is reflected in radial strain. The development of tagging patterns directly in the polar coordinate system has facilitated the calculation of radial strain. In this study we have extended the K-space based compression encoding method[1] to directly measure the local and global radial strain for the LV from the circularly tagged images. We report our initial findings on the feasibility of this approach.

Methods:

a) Data acquisition: We performed short axis, breath-held tagging in four healthy volunteers at 1.5T (Magnetom TIM Avanto, Siemens Medical Solutions) and one volunteer at 3.0T (Magnetom TIM Trio, Siemens Medical Solutions) using both circular tagging and conventional grid tagging. The separation of un-deformed (first frame) circular taglines, which are centered at the center of the LV, was 5 mm. Other MR parameters were: 280 mm FOV, 6 mm slice thickness, TE/TR = 2.4/44.2 ms 250 Hz/pixel bandwidth and 15° flip angle. The same slice positions were imaged with the conventional grid taglines with parameters similar to that of the circular tagging for comparison purposes.

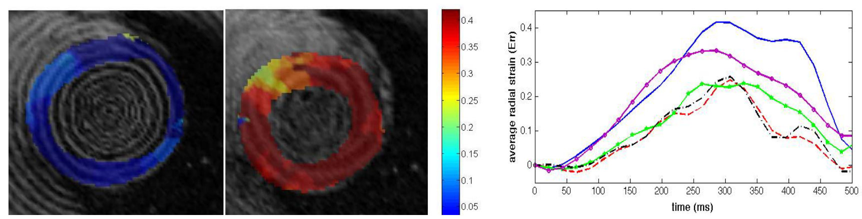

Figure 1. The radial strain map on a per pixel basis overlaid on the circularly tagged image of a healthy volunteer at 40 and 305 ms after QRS (Left). Global radial strain estimation over the cardiac cycle for five normal volunteers in the mid LV, calculated in k-space using compression encoding[1] (Right).

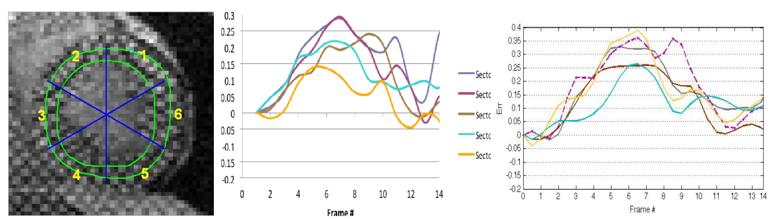

Figure 2. A mid ventricle short axis view is shown with grid taglines and standard segments (Left). Global radial strain estimation over the cardiac cycle for sections of one volunteer in the mid LV, calculated by HARP (Middle) and compression encoding method (Right).

b) Strain measurement: In the circularly tagged images the spatial frequency that represents the taglines is originally constant for all points. The representative spatial frequency of each point in the deformed images was resolved by sequential band pass filtering of the k-space data as detailed in reference 1. The radial strain map was then determined by the relative changes in this representative frequency compared to the original one. Regional radial strain was then also calculated using the harmonic phase (HARP) method on the grid tagging images. The first spectral harmonic peak was cropped and harmonic phases were extracted and used for strain computations. Epicardial and endocardial contours were delineated manually and the myocardium was divided into six segments; two in the septal region and four along the free-wall as shown in Fig. 2 (left).

Results: Maximum measured local radial strain in five healthy volunteers was in the physiological range as previously reported by other investigators[2]. Average radial strain in each segment was calculated and for one of the volunteers the mid ventricle strain time-profiles in five of the segments are plotted in Fig. 2 (right). The qualitative comparison between strain results from HARP and those from proposed method showed general agreement, though the HARP method appeared to slightly underestimate radial strain.

Discussion and Conclusion: Regional strain calculated from circular tagging shows expected results in normal volunteers; slightly lower in the septum and homogeneous elsewhere at maximum systole. Our results suggest that the accuracy of the automatic LV radial strain measurement through our compression encoding method is likely comparable to existing methods, but faster and simpler. Since the proposed method does not need to any tracking or differentiation, it has potential advantages over other methods in practicality, computational cost and accuracy.

---

[1] Moghaddam A.N., "CIRcumferential COMpression Encoding (CIRCOME)," *Proc. ISMRM* 15: 2515 (2007)

[2] Moore C.C,. et al "Three-dimensional Systolic Strain Patterns in the Normal Human Left Ventricle: Characterization with Tagged MR Imaging,". *Radiology* 214: 453-466, 2000