

Left Ventricular Strain through Radial Tagging: Efficiency and Validity

A. N. Moghaddam^{1,2}, K. Z. Abd-Elmoniem³, G. Heidari¹, S. Ruehm¹, and J. P. Finn¹

¹David Geffen School of Medicine, UCLA, Los Angeles, CA, United States, ²Biomedical Engineering, Polytechnique University, Tehran, Iran, ³National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health, Bethesda, MD, United States

Introduction: Assessment of local contractility of the left ventricle complements global functional parameters such as cardiac output and ejection fraction. The local contraction of the LV is quantifiable by its circumferential strain, which can be calculated from tagged images. This process, however, mandates tissue tracking and calculation of spatial derivatives. We have shown that radial tagging facilitates the extraction of this parameter directly from the K-Space data if the density of the radial taglines is sufficiently high¹. We have now developed a sequence which lays down a densely packed array of radial tag lines and, in this study, we present our initial findings on the performance of this approach and validity of the results.

Methods:

a) Data acquisition: We acquired data from short axis slices of a healthy volunteer spanning the entire cardiac cycle at 1.5T (Magnetom TIM Avanto, Siemens Medical Solutions). Each image has 15 radial taglines in the half circle of the LV. Other MR parameters are as follows: 250mm FOV, 5mm slice thickness, TE/TR = 4.6/87 ms 250 Hz/pixel bandwidth and 15° flip angle. The same slice positions were imaged again with conventional parallel taglines with parameters similar to that of the radial tagging for comparison purposes. Radial tagging was also exploited to acquire data for 5 healthy volunteers and one patient with congenital single ventricle anatomy. The imaging parameters were slightly different for each case depending on patient specific characteristics.

b) Strain measurement: Global circumferential strain was determined by the shift of the circumferential frequency average, resolved from sequential band pass filtering of the k-space as detailed in reference 1 (CIRCOME). Regional circumferential strain was then calculated using the harmonic phase (HARP) method on the parallel line 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 segment; two in the septal region and four in the free-wall region as shown in Fig. 2 (left). Average circumferential strain in each segment was calculated and the strain time-profiles in three of the segments are plotted in Fig. 2 (right).

Results: Measured global circumferential strains in five healthy volunteers were in the physiological range in contrast to the single ventricle patient, which had a maximum absolute strain of 27%.

The qualitative comparison between strain results from HARP and those from CIRCOME showed general agreement. HARP results for segments in the mid ventricle are shown in Fig. 2.

Discussion and Conclusion: Regional strain measurements from HARP show the inter-segment spatial variations particularly the free wall versus the septum. The overall strain calculated from CIRCOME, however, is similar to the average of the strain for these segments. It shows that the accuracy of the automatic LV circumferential strain measurement through CIRCOME is likely comparable to existing methods. The comparison of the healthy subjects and congenital heart disease patient suggests that this new approach hold promise for clinical strain measurement in congenital as well as acquired heart diseases.

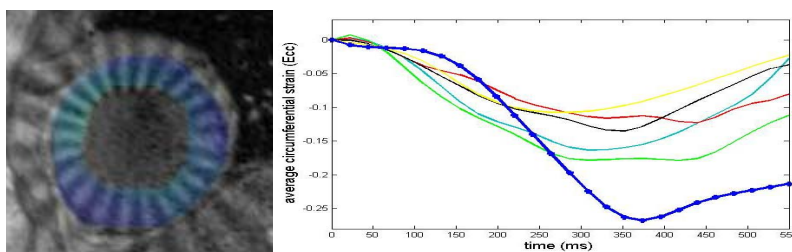


Figure 1. (Left) The radially tagged image of a uni-ventricle patient overlaid by the density weighted image of the taglines. (Right) Strain estimation for normal vs a single ventricle patient data (bold line with dots). The circumferential strain is significantly higher in the single ventricle patient compared to normal people at all levels.

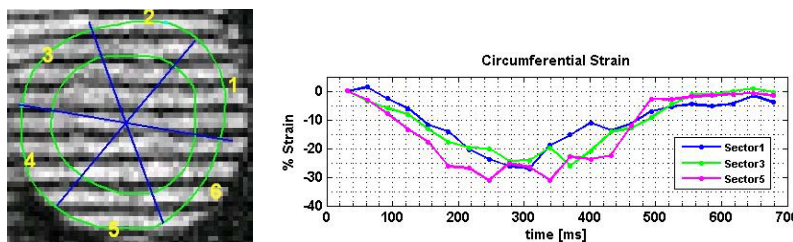


Figure 2. (Left) A mid ventricle short axis view is shown with parallel taglines and standard segments. (Right) Regional circumferential strain for three segments, calculated by HARP. The inter-segment differences are visible in both magnitude and the peak-time of the strain.

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