Left atrial strain is correlated to atrial fibrosis by late gadolinium enhancement, in an AF population.

Dana C Peters[1], Daniel Cornfeld[1], Albert J Sinusas[2], James S Duncan[1], Xenios Papademetris[1], Karl Grunseich[1], and Sudhakar Chelikani[1]
[1]Radiology, Yale School of Medicine, New Haven, CT, United States, [2]Cardiology, Yale School of Medicine, New Haven, CT, United States

Purpose: Abnormal left atrial (LA) strain has recently been investigated as a potential cause of LA fibrosis (1-2). Furthermore, the presence of fibrosis itself might be reflected in LA strain measurements. LA strain is difficult to assess with conventional MR tagging due to the thin LA wall, but has been assessed with DENSE MRI (3) and speckle tracking (4), where strain was related to fibrosis by late gadolinium enhancement (LGE) MRI. Speckle tracking has also been used to assess LA strain as a predictor of post-operative atrial fibrillation (AF) (5). We present a point-tracking method applied to 2- and 4-chamber cine data, to assess LA strain based on contours of a cine scan (6). This method is a refinement and extension of our previous studies, based on improving the robustness of point-matching algorithm with a local registration, optimizing atrial contouring process and analyzing a larger cohort using both 2-chamber and 4-chamber images. Our hypothesis is that atrial strain is correlated with LGE measures of fibrosis.

Methods: Twenty nine patients were retrospectively included in this IRB approved study, having 2-chamber and 4-chamber cines and high resolution 3D late gadolinium enhancement images of the LA. Sixteen patients had AF (31% female, 58±11 years old) and other cardiovascular disease, while thirteen (46% female, 44± 18 years old) had no AF, and no cardiac diagnosis at imaging. All imaging was performed on a 1.5T Siemens Aera (Siemens Healthcare, Erlangen, Germany). The LGE images were analyzed blinded to other data, using an 18 segment model, resulting in scar scores from 0 to 1 (1 = all segments with scar). To calculate maximal strain, the cine data sets were segmented to include the LA cavity using thresholding, and manual ROIs, excluding the pulmonary veins, at time-points of minimum (begin ventricular systole) and maximum LA volumes (Figure 1A-B). The edges of the segmented LA cavities were extracted using Matlab. The edges were then discretized into finite sets of points. The point sets were matched to each iteratively using closest point matching, followed by a non-rigid point cloud registration (6). Average and regional circumferential strains were were estimated.

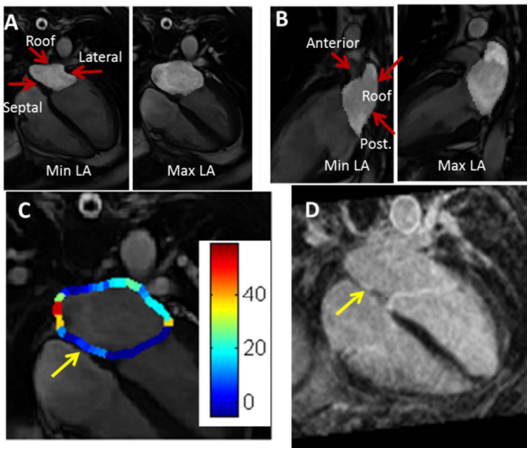

Figure 1: Begin and end-systole 4-ch (A) and 2-ch (B) images are contoured, excluding veins, and regions are identified. C) Color-coded strain map (%) displayed on a cine image. D) Reformatted LGE image shows fibrosis in a corresponding region of low strain. Strains in valvular regions and at ostial locations were excluded.

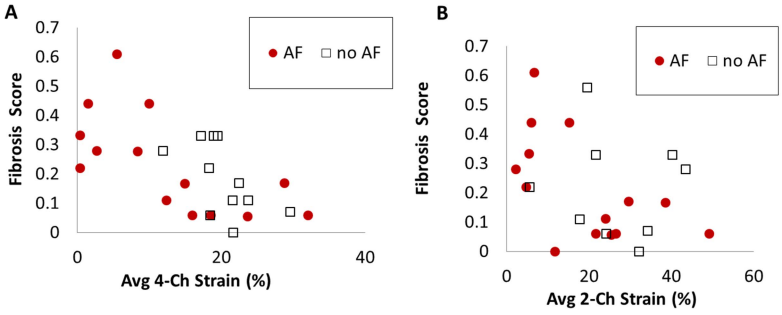

Figure 2: Correlation of fibrosis score with average strains. A) Average 4ch strain For AF (R^2=0.43, p=0.01) and non AF (R^2=0.33, p=0.06) subjects. B) Average 2ch strain for AF (R^2=0.32, p=0.03) and non AF (R^2=0.007,p=NS) subjects.

Results: Figure 1 illustrates the contouring process, and detailed results from one subject, demonstrating a regional agreement between low strain and fibrosis (Fig 1C-D, arrows). Figure 2 shows that a greater LGE score is correlated to lower average strain for AF subjects. Additionally, for AF subjects, the strains measured in the septal (R^2=0.38, p=0.01), lateral (R^2=0.43, p=0.01) and posterior (R^2=0.39, p=0.01) walls of the LA were each significantly correlated to overall LGE (all p<0.05), i.e. all regions except the roof and anterior wall (see Fig. 1). For non-AF subjects, strain was not correlated with fibrosis. Average 4-chamber and 2-chamber strains were well correlated with atrial ejection fraction, R^2=0.63 and 0.57, respectively.

Discussion: For the first time, MRI-derived atrial strain is shown to be highly correlated to LGE in the left atrium. No correlation was observed for the control group of non-AF patients, possibly because the non-AF patients had a narrow range of strain values. Poor correlations in the anterior and roof regions may be due to tethering, e.g. of veins. This study shows the promise of pinpoint correlations between cine-derived atrial strain and LGE maps of fibrosis.

References: 1) Bellini, C et al,. J Biomech Eng, 2012; 134(2). 2)Di Martino et al., J Biomech, 2011; 44(16): 2755-60. 3) Schmidt EJ et al,Europace 2013. 4)Kupphaly SS et al, Circ Cardiovasc Imaging, 2010; 3(3): 231-.9 5) Paschalis A, et al. *Intl J Card* 2014;173:327-328. 6) Rangarajan, A. et al, H. Med Image Anal, 1997; 1(4): 379-98.