Characterization of the myocardial fiber structure using high-frequency ultrasound

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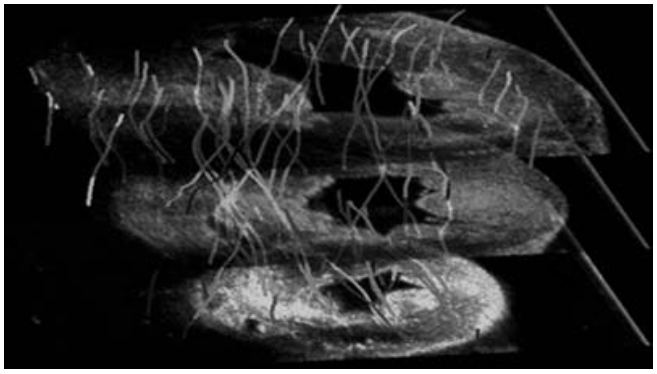
Objectives: The three-dimensional (3D) arrangement of the myocardial fibers (MF) plays an important role in systolic and diastolic function of the left ventricle (LV). We hypothesized that the full spatial distribution of MF can be characterized by tracking ultrasound speckles along image voxels, provided that a 3D ultrasound sequence is acquired at sufficient spatial resolution.

Methods: In three explanted swine hearts two-dimensional short axis view images were acquired. The LV was scanned along its long axis from base to apex using a linear 10 or 12-MHz array transducer. A computer controlled gantry was used to move the transducer and capture one image every 0.5 mm/3 seconds. A custom image correlation algorithm was designed to track the orientation of the fibers at each point of the myocardium.

Results: In all animals a 3D reconstruction of the orientation of the MF was obtained, showing different helical arrangements depending on the position of the speckles within the LV (see Figure). The trajectories of the speckles suggested that MF have predominantly an oblique disposition from base to apex. It was possible to observe different directions and turn angles in the fibers according to their location. Interestingly, these same observations were made in a beating heart by gating the ECG with the image correlation system. This technique enabled to quantify the parameters defining the speckle trajectories



Myocardial fibers within the LV.

Conclusions: For the first time, the 3D arrangement of the myocardial macrostructure was characterized using high-frequency ultrasound images. Our results are consistent with the MF architecture reported in previous works based on histology and magnetic resonance imaging. This technique offers new insight into the characterization of LV function based on the analysis of myocardial structure.