Mapping myocardial elasticity changes after RF-ablation using Supersonic Shear Imaging

Mathieu Pernot, Emilie Macé, Rémi Dubois, Mathieu Couade, Mathias Fink, Mickael Tanter

Institut Langevin, ESPCI ParisTech, CNRS UMR 7587, INSERM

Laboratoire d'Électronique, ESPCI-ParisTech, CNRS UMR 7084

SuperSonic Imagine, Aix-en-Provence

Motivation and Objective

Supersonic Shear Imaging (SSI) is a new ultrasound-based technique for imaging non-invasively and quantitatively the elastic modulus of soft tissues. Monitoring tissue stiffness changes during Radio-Frequency Ablation (RFA) may quantify the size and shape of the ablation necrosis and therefore assesses if the RFA is complete. We propose to apply SSI for monitoring the myocardial elasticity and evaluate the correlation with the RF Ablation necrosis size in both in vitro and in vivo experiments.

Methods

Experiments were performed in vivo on a sheep and in vitro samples of bovine muscle. In in vivo settings, a lateral thoracotomy was performed and the transducer was placed directly on the postero-lateral wall of the left ventricle. A shear wave was generated on the myocardium using the acoustic radiation force induced by a conventional linear ultrasonic probe (8MHz). The shear wave propagation along the muscle was imaged in real-time using an ultrafast scanner (12 000 frames/s). Tissue velocities were obtained from conventional speckle tracking techniques and the shear wave phase velocity was derived at each frequency in the range of 100-800Hz from a single broadband radiation force excitation. Each elasticity measurement was achieved in less than 20 ms and was repeated 20 times every 50 ms during 1 second allowing to measure variation of elasticity within one cardiac cycle. ECG was recorded and synchronized with the acquisitions. RF ablation of the left ventricle was performed on the epicardic surface (total RF time: 2 min 20 s power: 22.5W), and elasticity measurements were estimated every 30 seconds.

Results

The feasibility of imaging the myocardial elasticity was demonstrated before and after RFA. Before ablation, the variation of the shear wave velocity in myocardium (i.e. myocardial stiffness) was measured during the cardiac cycle. The mean shear wave velocity was found to be 4.8 ± 1.1 m/s in the systolic phase and 2 ± 0.3 m/s in the diastolic phase. Immediately after ablation a 20% increase of the shear wave velocity was measured in the ablated region. The feasibility of mapping the ablated region was also shown during in vitro experiments.

Discussion and conclusions

The reproducibility and the accuracy of the measurements are discussed. This novel approach offers a promising technique for monitoring myocardial elasticity changes during RFA.