Intracardiac Myocardial Elastography for Assessment of Right and Left Atrial Radiofrequency Ablation Lesions in Humans

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***Abstract*— Radiofrequency (RF) ablation is an effective method for treatment of cardiac arrhythmias; however, current assessment of RF lesion formation by measuring impedance changes, electrogram dimunition, power and catheter temperature are indirect and may be inaccurate. We present a novel, imaging modality, myocardial elastography (ME), which when used in adjunct with intracardiac echocardiography (ICE) may provide real-time assessment of RF lesion formation, and changes in tissue mechanics after lesion delivery [1-4].**

I. Materials and Methods

In an institutional approved IACUC protocol, 3 sedated canines underwent cardiac imaging using an ICE catheter inserted into internal jugular vein (images shown on the right).

In an institutional IRB approved protocol, 8 patients (61.1±15.1 years old) undergoing ablation for AF had imaging of their left atrium (LA) with a 5.8-MHz ICE probe before and after RF ablation with an irrigated catheter at high frame rates (1200 Hz). The channel data was acquired on a clinical ultrasound system. Image reconstruction and motion tracking were performed, and cumulative axial strains were obtained from displacement estimations. The location of the ablation lesion was confirmed using ICE imaging, electro-anatomic mapping and fluoroscopy. ICE images were acquired before and after RF ablations with an irrigated catheter (mean power of 31±3 W, mean of 38±14 secs, mean impedance of 112±5 Ω, catheter temperature of 31±3 degrees Celsius). As a control, an ICE image was obtained prior to RF delivery

II. Results

When RF was not used, ME showed a mean absolute strain of 15.1±5.1 % before vs, 16.7±7.5 % (p=NS) after catheter positioning, thus demonstrating no difference in strain due to catheter contact. ME showed a mean absolute strain of 17.1 ± 9.7 % before and 6.7±3.1% % after ablation ($p<0.05$) in the left atrium. In the cavotricuspid isthmus (CTI) region, mean absolute strain magnitude at end RA systole was found to be higher during ablation 43.0 ± 18.1%, compared to after ablation 33.7±15.8%.

This demonstrates that ME can detect changes in mechanical deformation due to RF, and that ablated regions have lower strains. After RF delivery, changes in strain were apparent when reviewed by three blinded independent operators.

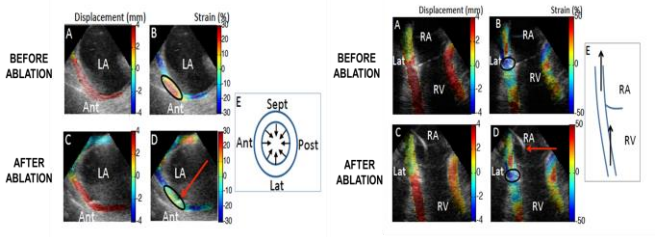

Figure 1: Displacements and strains were estimated in the LA before, during and after RF ablation. During LA systole, LA contracted inwards and the corresponding strains are shown at LA end systole (above image on the left). The black ellipse indicates the region of ablation and the red arrow points to the ablation catheter. The absolute strain magnitude is decreased in the region where ablation occurred, whereas regions where no ablation was performed there was no significant change in strain. Cumulative axial displacements and strains at right atrial (RA) and right ventricular (RV) end-systole were also evaluated in the CTI region prior to and after CTI flutter ablation. The RA and RV lateral walls moved in the superior direction. The RA longitudinal shortening and RV longitudinal lengthening are shown above on the right..

III. Conclusion

Myocardial strains can be imaged with ICE at high temporal and spatial resolution in canines and humans in vivo. Ablated regions in the human myocardium have lower strains after ablation compared to before ablation. Myocardial strains can be used to assess deformation and myocardial changes in the LA during AF ablation, as well as, in the CTI during atrial flutter ablation.

References

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