Incorporating Image Processing and Visualization in the Treatment of Atrial Fibrillation

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**Cardiac MRI**

Intracardiac catheter ablation has rapidly emerged as a potentially curative therapy for treating atrial fibrillation (AF), the most common clinically relevant arrhythmia. Abolition of AF both reduces the risk of stroke and other adverse cardiovascular events, and significantly restores quality of life to patients. However, the AF ablation procedure still suffers from low and variable rates of success (40-80%). The shortcomings of this procedure are largely attributed to the complex anatomy of the left atrium, and lack of a clear metric by which operators may assess successful targeting of pathological tissue. Recently, cardiac magnetic resonance imaging (cMRI) has been implemented to evaluate atrial tissue before and after catheter ablation. Our group and others have shown the feasibility of using contrast enhanced cMRI to evaluate scar formation following ablation of AF. The software solutions created by the CIBC including (Seg3D, ImageVis3D and SCIRun) provide the tools that allow the extraction and display of relevant cMRI data to facilitate analysis of procedural outcome. Furthermore, the flexibility of these tools allows integration of data acquired from other clinical systems, e.g., electroanatomical mapping (EAM), with the MRI data to create a comprehensive picture of factors influencing clinical outcome.

**Segmentation**

Figure 3 - Segmentation of left atrium. Using Seg3D the endocardial surface, or lumen, of the left atrium is delineated. The geometry generated from this step is then used to create surface models and volume renderings of the atrial tissue.

**Model Creation**

Figure 4 - Generation of left atrial surface models. Models representing the endocardial surface of the left atrium are generated using SCIRun. These models are useful for visualization and analysis of the left atrial tissue properties and shape.

**Registration**

Figure 5 - Registration of MRI and EAM data. Alignment of these data allows quantitative comparisons of electrical properties with structural properties, both of which serve as indicators of AF ablation (Red dots signify locations of electrical recordings).

**Volume Rendering**

Figure 6 - Rendering of left atrial tissue. The isolated cardiac tissue volume rendered using ImageVis3D, showing regions of contrast enhanced tissue.

**Conclusions and Future Work**

Evaluation of post-ablation scar formation has shown that the extent and location of scarring directly influences the success of catheter ablation. Surface models (Figure 6) and volume renderings (Figure 7) of left atrial scarring provide intuitive post-procedural feedback to operating physicians. In parallel research, we have used the same cMRI and image processing approaches to evaluate structural changes in the left atrium that accompany AF as a form of tissue remodeling. This interplay between structural changes and cardiac electrophysiology provides an opportunity to noninvasively evaluate AF progression and even to guide therapy in a patient specific manner. The software packages developed and maintained by the CIBC provide the necessary platform for development of this pioneering analysis.

**Surface Model**

Figure 7 - Surface model of left atrial scar formation. Using SCIRun, the local MRI voxel intensities are projected onto the atrial surface model. The volume rendered torso in the background provides context.