Cardiac registration: going further than atrial fibrillation ablation

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This editorial refers to ‘Accuracy and usefulness of fusion imaging between three-dimensional coronary sinus and coronary veins computed tomographic images with projection images obtained using fluoroscopy’ by A. Auricchio et al., on page 1483

Precise delineation of anatomy and function are essential for accurately delivering interventional tools during electrophysiologic procedures. Fluoroscopy is the traditional imaging modality used because it provides instantaneous information. However, it lacks precise anatomic visualization due to poor soft-tissue contrast between the area of interest and surrounding structures in a moving organ like the heart, resulting in a lack of proper intraprocedure guidance during interventional procedures, especially complex procedures such as atrial fibrillation (AF) ablation and biventricular pacing.

Three-dimensional imaging modalities such as computed tomography (CT) and magnetic resonance imaging offer high-quality anatomic visualization, given their excellent tissue contrast characteristics and high spatial and temporal resolutions. Cardiac image registration, which involves integration of two images in the context of cardiac structures such as the left atrium, is intermodal, with the acquired image and the real-time reference image residing in different image spaces, and involves optimization, where one image space is transformed into the other.1,2 Cardiac image registration is currently being investigated and is clinically used for AF ablation.3–9

In another complex cardiac intervention, biventricular pacing, for many patients, cannulating the coronary sinus (CS) is the one-step procedure of choice for left ventricular lead placement. However, in many of these patients, lead placement in the CS may be unsuccessful or involve a very lengthy procedure due to complex CS and right atrial anatomy. Other difficulties with this lead placement procedure may also include unavailability of a suitable CS branch, significant rotation of the CS due to left atrium and left ventricle dilation, and the presence of the Thesbian valve therein. In most instances, these problems are identified only at the time of the interventional procedure, and thus the procedure is typically either completely abandoned or the patient is brought back into the operating theatre where, through a surgical incision, the left ventricle lead is placed epicardially.

Auricchio et al.10 take us a step further than the currently available registration techniques in AF, imaging and registering the CS in patients undergoing CS lead placement for biventricular pacing. These findings have significant clinical implications in patients with complex cardiac anatomy undergoing biventricular pacing where identification of this anatomy pre- and intra-procedure and real-time navigation of the left ventricular lead on the registered image could help simplify this procedure significantly.

A significant advantage of CT to X-ray registration over 3D-to-3D registration is its comparative ease of implementability, given the widespread availability in any electrophysiology laboratory of X-ray imaging systems. Another advantage is the smaller data sets involved with 2D X-ray images. A disadvantage of 2D–3D like other registrations is the complex and variable nature of structures and functions. An objective validation would evaluate the accuracy of a registration application independent of its chosen cost function and optimization routine. Parallel projection of 3D structures during fluoroscopy can cause image distortions. In-plane and out-of-plane rotational errors due to interscan patient positions, spatial errors due to systole and diastole, and dynamic motion due to phasic changes in respiration can cause changes in cardiac chamber size and position.

Despite these inherent limitations which will need to be addressed in future studies, Auricchio et al. have taken us a step further where structures other than left atrium can be registered using fluoroscopy, routinely available in all laboratories. This is a logical extension of currently available imaging and registration techniques for the left atrium and an exciting new tool of possible enormous value and potential. The process, if simplified and reproduced in larger studies, could open another chapter in treatment of complex electrophysiologic problems where the physician not only has advanced knowledge of the cardiac structure that is being targeted, but also uses the knowledge for real-time navigation.
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References