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EDITORIAL COMMENT

# Imaging and Cardiac Ablation

## Improving on Success*

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Ask a group of invasive electrophysiologists to name a complex ablation, and you would hear chronic atrial fibrillation, ischemic ventricular tachycardia, ventricular fibrillation, and others. Ask the same group what ablation they would name as the simplest, best understood, and most likely to achieve universal success, and you would hear cavotricuspid isthmus (CVTI) ablation for typical atrial flutter (1).

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How, then, can we improve on what already is a highly successful procedure? In this issue of *iJACC*, Regoli et al. (2) provide a case for using real-time 3-dimensional transesophageal echocardiography (3DTEE) to significantly minimize patient fluoroscopic exposure and possibly decrease procedural time. To appreciate the significance of this well-constructed pilot study and the thoughtful analysis provided by the investigators, we need to understand what imaging options the electrophysiologist has and how far away from an ideal visualization tool we are.

## Visualizing What We Ablate

There are several options available for pre-procedural imaging. These include computed tomography, cardiac magnetic resonance, and echocardiography (3). The clarity with which the detailed regional anatomy needed for ablation procedures being offered depends on the imaging modality but is generally excellent. These procedures do not add to the procedural time but also cannot help us with real-time troubleshooting of difficult catheter manipulation and contact issues or allow immediate recognition of complications when they arise.

**Real-time visualization.** Much of what is required to help improve efficacy and safety of complex ablation procedures is imaging what we ablate at the time of energy delivery and catheter manipulation. Typically, the ablationist synthesizes multiple pieces of "imaging" information during the procedure.

**Fluoroscopy.** In most laboratories performing complex ablations, biplane fluoroscopy with anatomic fluoroscopic views is the primary modality used to guide catheter manipulation. Once fluoroscopic anatomic correlation is mastered, the proceduralist can quickly and easily identify which chamber of origin a catheter is in and when catheter movement or positioning suggests an anatomic variant.

Fluoroscopy, however, has significant limitations, the biohazards pointed out by Regoli et al. (2), difficulty with assessing catheter contact, and major anatomic variation that precludes routine fluoroscopic assessment. As a result of these limitations, various imaging modalities that provide high resolution in real time have been explored clinically (4).

**Intracardiac ultrasound.** Intracardiac ultrasound using either linear phased array (5) or circular array catheters is increasingly used with ablation procedures (4–6). Because intracardiac ultrasound does not require general anesthesia and is performed and interpreted by cardiac electrophysiologists, it typically obviates the need for additional personnel. However, vascular access is required, and there is some additional risk of periprocedural complication, including cardiac perforation, associated with its use. Although 3-dimensional intracardiac ultrasound integration has been explored (7), it is not routinely clinically available, and image interpretation and acquisition are not straightforward.

**3DTEE.** Regoli et al. (2) report the first systematic assessment of real-time 3DTEE to guide CVTI

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ablation. In their study comparing 3DTEE use to standard fluoroscopy, fluoroscopy time was significantly and impressively reduced to one-third of that seen with controls. The compelling images included in their manuscript are a clear advance in our ability to visualize detailed right atrial anatomy.

Although they also report on shorter procedural time, they did not include the additional time required for induction of general anesthesia (not typically done with atrial flutter ablation), as well as time for extubation, recovery, and so forth.

The impressive reduction in fluoroscopy exposure necessitates consideration of adjunctive 3DTEE with atrial flutter ablation despite the already anticipated success with minimal risk.

However, in addition to the need for general anesthesia, there are tradeoffs in terms of resource utilization and expectation of similar benefit with more complex ablation procedures. For example, esophageal placement of the imaging probe may increase risk of esophageal trauma when ablating on the posterior wall of the left atrium. In older, sicker patients, the additional risk with esophageal intubation and general anesthesia may outweigh the potential future and long-term benefit of reducing fluoroscopic exposure (8).

**Electrical visualization and navigation.** Not all imaging in the electrophysiology laboratory is "visual." The extraordinarily low fluoroscopy times that have been reported and are commonly observed with experienced operators (9) result in part with the use of the sensed electrograms during invasive procedures. For example, it is relatively straightforward to know when a catheter is on the tricuspid annulus, as well as at the end of CVTI ablation where the inferior vena cava has been reached.

## Seeing Is Believing. . .

Regardless of the imaging modality used, reproducibly reliable image quality is essential to allow operators to trust the information they are receiving. In their study involving 15 patients with 3DTEE (2), images could not be obtained in 1 patient and were considered good quality in 73%. Further, the catheter electrodes could be visualized in only 50% of study cases. With increasing experience and future iterations of the probe used, we can perhaps anticipate better results.

Given the lack of catheter tip visualization in half the cases, a question that arises is, why, then, was there this remarkable reduction in fluoroscopy time? If simply knowing the anatomic terrain in a given patient requiring CVTI ablation is sufficient to guide catheter choice and lateral placement of a successful line (10), then perhaps the same information can be obtained pre-procedurally with high-definition imaging (computed tomography, cardiac magnetic resonance, echocardiography, and so forth) without increasing procedural time and risk on the day of ablation.

## What You See Is What You Get?

A surprising finding in the study by Regoli et al. (2) is that 93% of the study patients had findings suggestive of anatomic causes for difficulty with ablation and 43% had 3 or more such findings recognized. These numbers are significantly higher than those reported (11). How do we explain this discrepancy?

One issue has to do with definition of what is seen and what actually causes difficulty with ablation. For example, defining a pouch in the sub-Eustachian isthmus versus simply more inferior tissue compared with the elevated Eustachian ridge posteriorly is not straightforward. At what depth should we call a true pouch? Put another way, what depth of pouch will affect ablation efficacy and safety? Another issue to consider is distinguishing between universal anatomy and true variants that cause difficulty. The Eustachian ridge or valve, for example, by virtue of its simple presence, typically should not result in difficulty or cause the operators to change their usual ablation paradigm. Without resolving these issues, however, we do run the risk that increasingly picturesque visualization may paradoxically complicate otherwise simple procedures.

## What Do We *Need* to See?

There is, without question, a pressing need for improved real-time visualization with both relatively straightforward procedures (to decrease fluoroscopy time) and more complex ablations (to improve efficacy and safety).

**CVTI ablation.** In their study, the length of the sub-Eustachian pouch was measured. For an ablationist, however, the depth of the pouch is more relevant because catheters deep in the pouch may result in poor energy delivery and coagulum formation (10).

**Pectinate encroachment on the CVTI.** Visualizing exactly how far medial the pectinates encroach on the CVTI will allow the operator to choose how septally the ablation line should be created.

**Visualizing sheaths used for ablation.** The Eustachian ridge, per se, does not create difficulty with local ablation but can create catheter manipulation difficulty (10). To overcome this, the tip of the guiding sheath should typically be distal to the ridge but proximal to the tricuspid annulus. We do not know from the present study whether sheath visualization is possible and reproducible.

**Right coronary artery location.** Real-time visualization of the coronary vasculature can be very helpful in avoiding collateral damage in several ablation procedures (epicardial ablation, left-side mitral annular ablation). Specifically when a sub-Eustachian pouch is present, catheter proximity with ablation energy may inadvertently damage the right coronary artery (12).

**Complex ablation procedures.** Visualization of catheter contact and lesion formation, particularly to understand when a transmural lesion has been completed, is a key component of real-time visualization with ablation. Whether this can be accomplished with real-time 3DTEE needs to be determined. The relationship of the esophagus, phrenic nerve, vasculature, and the actual visualization of abnormal substrate (scars, endocavitary structures [13]) are what we need to see with unquestionable benefit with complex procedures.

## What Is the Ideal Imaging Modality for Cardiac Ablation?

Ideal visualization should be real time, should not require general anesthesia, and should be performed by the same operator doing the ablation. Imaging to understand the arrhythmogenic substrate and future high temporal resolution imaging to map the electromechanical wave front during arrhythmia will likely be of significant value. Three-dimensional reconstruction should be intuitive and similar to what electrophysiologists typically use. Although we will have to wait for this ideal modality, Regoli et al. (2), importantly reconstructed their images to mimic the right and left anterior oblique projections used fluoroscopically and immediately enhance intuitive recognition of the structures visualized.

Regoli et al. (2) should be congratulated for providing us from their pilot study a clear appreciation of the potential use of 3DTEE to reduce fluoroscopy time and allow us to see what we are doing. In selected patients, this technology, along with training and experience using existing imaging technology and electrogram interpretation, may truly allow us to improve on our success.

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