CATHETER ABLATION

INNOVATIVE & EMERGING TECHNIQUES

Zero-fluoroscopy Intracardiac Echocardiography-guided Ablation of Atrial Fibrillation Using a Single-catheter Technique

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ABSTRACT. *Advanced electroanatomic mapping and contact force-sensing catheters have improved outcomes, increased efficiency, and significantly reduced the need for fluoroscopy during radiofrequency ablation of atrial fibrillation (AF). However, fluoroscopic guidance is still routinely used for the procedure, posing a long-term risk to the patient, the operator, and laboratory staff. Furthermore, rapid high-density mapping has diminished the need for a second multipolar or circular left atrial catheter to demonstrate electrical isolation of pulmonary veins. We describe a novel approach to AF ablation using only intracardiac echo guidance, a decapolar coronary sinus catheter, and a single ablation catheter in the left atrium. Mapping is performed using the CARTO-3 system with Confidense module (Biosense Webster, Diamond Bar, CA) to achieve and verify pulmonary vein isolation.*

KEYWORDS. *atrial fibrillation, catheter ablation, fluoroscopy, radiation safety.*

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Introduction

Significant progress has been made in the ablation of atrial fibrillation (AF) over the last 17 years, with significant reductions in complications and improvements in efficacy.^{1,2} However, significant fluoroscopy used during most AF ablation procedures exposes patients, operators, and laboratory staff to potentially dangerous doses of ionizing radiation.^{3–10} Total fluoroscopy times, even in clinical trials of paroxysmal AF ablation, often exceed 20 min on average. Efforts to reduce radiation exposure have become common in recent years as a quality metric, with the goal of keeping

fluoroscopy time “as low as reasonably achievable” (ALARA).

Radiofrequency (RF) AF ablation is routinely performed with two transseptal punctures, or with catheter exchange through a single transseptal sheath, using a multi-electrode catheter to verify pulmonary vein isolation and locate sites of electrical reconnection. In fact, prior studies have shown the safety and feasibility of ablation of AF without the use of fluoroscopy using a standard set-up with a contact force-sensing catheter and a multi-electrode catheter.^{11,12} A study published by Tamborero et al.¹³ in 2010 found that omitting a circular mapping catheter was associated with an increase in AF recurrence but was also associated with shorter procedure times and a trend toward decreased major complications. However, rapid acquisition of high-density electroanatomic maps (EAMs) now provides a mechanism for assessing isolation and locating persistent connection without the use of a second multipolar left atrial catheter. Using only a single transseptal sheath with a single force-sensing ablation catheter has the potential to simultaneously reduce procedural cost and to reduce silent (and likely manifest) cerebral infarcts.¹⁴ We describe a zero-fluoroscopy approach to RF ablation for AF using only intracardiac echo (ICE), a decapolar

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coronary sinus (CS) catheter, and a single transseptal sheath with a force-sensing ablation catheter (Smart-Touch, Biosense-Webster, Diamond Bar, CA, USA) in the left atrium (LA). Mapping is performed using the CARTO 3 system with Confidense module to achieve and verify pulmonary vein isolation.

Pre-procedural set-up

In order to perform the procedure we describe, a fully equipped electrophysiology (EP) laboratory with the CARTO 3 electroanatomic mapping system with Confidense module for high-density mapping (Biosense-Webster, Diamond Bar, CA, USA) is suggested. A pre-procedural cardiac computed tomography (CT) scan or magnetic resonance imaging (MRI) scan is used for registration of left atrial geometry and pulmonary vein anatomy.

Procedure

Step 1: Access. Access is obtained in the right femoral vein using a modified Seldinger technique with placement of two short J guidewires and a single long J guidewire into the right femoral vein. The long wire is advanced into the inferior vena cava to a length based on the rough measurement from the inferior costal margin to the femoral access site. Next, two short sheaths (7F and 9F) are placed over the short guidewires. All sheaths are aspirated and flushed after placement and again before any catheter placement or exchange. An 8F Accunav Soundstar ICE catheter (Biosense-Webster, Diamond Bar, CA, USA) is placed through the 9F sheath and advanced to the right atrium (RA) using continuous ultrasound visualization. If the ICE catheter engages a side vessel, it can be retracted slightly and rotated to visualize the main vessel lumen and then deflected in that direction, following the long J wire. A Thermocool Smart Touch 3.5-mm D-F or F-J irrigated tip ablation catheter (Biosense-Webster,

Diamond Bar, CA) is flushed and attached to the EP recording system (but not placed in the body) to allow visualization of the ICE catheter and CS decapolar catheter. ICE can be used to quickly locate the interatrial septum and CS os. A soundmap can be created with location of the fossa, pulmonary veins, and esophagus and computed tomography angiography or MRI of the LA can be registered to align anatomically. An esophageal temperature probe can be seen clearly as an echodense object. The tip of the esophageal probe is most obvious when visualized on ICE while the probe is being advanced or retracted (**Figure 1**).

Next, a decapolar CS catheter (Biosense Webster, Diamond Bar, CA) is attached to the EP recording system and advanced to the RA. The location of the CS catheter can be determined using the appearance of atrial electrograms to denote entry of the catheter into the RA. Visualization of the CS and the catheter with ICE and on the CARTO EAM can be used, if needed, to aid placement of the catheter into the CS (**Figure 2**). The ICE catheter is positioned near the interatrial septum, and posterior tilt will allow visualization of the superior vena cava (SVC)–RA junction superior to the aortic valve. Next, the long J guidewire is advanced to the RA and visualized as it passes into the SVC (**Figure 3**). An SL-0 sheath (St. Jude Medical, St. Paul, MN, USA) is then advanced over the long J guidewire carefully to a position in the RA with the sheath angled to the 3–4 o'clock position. At this point the Smart Touch is inserted into the SL-0 and used to complete fast anatomic mapping (FAM) of the RA, SVC, and CS os, with a point tag taken at the ideal transseptal access site on the fossa (**Figure 4**).

Step 2: Transseptal puncture. The ICE catheter is rotated and deflected as needed to visualize the interatrial septum with the left pulmonary veins seen in the distal field of view. The Smart Touch is advanced to the SVC. The SL-0 is then advanced to near the tip of the Smart Touch as noted by black electrode coloration on the Carto

Figure 1: Soundmap of the left atrium as visualized on intracardiac echocardiogram. The esophageal temperature probe is seen as an echodense structure (green circle) that can be visualized more easily when being actively advanced or retracted.

Figure 2: Intracardiac echocardiography can be used to visualize the coronary sinus (CS) ostium and the CS catheter, aiding catheter placement.

screen when the SL-0 covers the Smart Touch electrodes (**Figure 5**). A 71-cm NRG RF Transseptal Needle (Baylis Medical, Montreal, Canada) is advanced through the SL-0 sheath until the RF needle is near the tip of the SL-0 dilator. Full heparinization is performed with an activated clotting time (ACT) goal of 300–350 s for the remainder of the case.

The SL-0 is guided to the interatrial septum using ICE, either by pulling the SL-0 down from the SVC or by alignment within the RA, depending on where the SL-0 was initially placed. Adjustment is made to optimize tenting of the thin portion of the interatrial septum within a field of view that is angled toward the left-sided pulmonary veins to ensure posterior orientation. The RF

needle is extended and may be visualized on CARTO-3 as two small yellow point tags. Optimal location is again verified on ICE with saline injection through the RF needle to better visualize the needle tip. RF application is then delivered at 10 W for 2 s (maximum) with continuous saline injection and under ICE visualization. Saline can be visualized in the LA on ICE once the needle has successfully crossed. At this point, the dilator is advanced slightly over the RF needle, and the needle is replaced with an Amplatz long J guidewire, which is advanced under ICE into a left-sided pulmonary vein (**Figure 6**). The dilator and sheath are advanced until the sheath is felt to pop across the atrial septum, at which point the dilator is held in place and the sheath advanced

Figure 3: Posterior tilt and rotation of the intracardiac echo probe can be used to visualize the J wire as it enters the superior vena cava.

Figure 4: A location point tag can be used to aid transseptal access by placing the ablation catheter at the site of planned transseptal puncture as visualized on intracardiac echo.

over the dilator to the mid LA. The dilator and sheath are then removed, and the sheath is aspirated and flushed and connected to continuous irrigation with heparinized saline.

Step 3: Left atrial mapping and registration. The Smart Touch ablation catheter is then advanced through the SL-0 sheath into the LA and zeroed. The catheter is then advanced into the left pulmonary veins, and fast anatomic mapping (FAM) is used to register the locations of both pulmonary veins. The process is repeated for the right pulmonary veins and the ostium

of the left atrial appendage, confirmed by CTA or MRI image. Next, the ablation catheter is used to take a point-by-point map of the LA with continuous CS pacing from the CS proximal electrode with points for bipolar voltage and activation (**Figure 7**). AF ablation is performed using a wide-area circumferential ablation technique at 20–25 W on the posterior wall and 30–40 W of power on the anterior and septal walls, targeting a contact force of $>10\text{ gm}$ for 30 s minimum at each site guided by VisiTag module. The position of the sheath in relation to the ablation catheter can be deduced on the CARTO EAM. When more proximal

Figure 5: Prior to transseptal puncture, the ablation catheter is advanced into the superior vena cava. The SL-0 sheath can then be advanced slowly over the ablation catheter. When the sheath is near the tip of the Smart Touch, the proximal electrodes will change from gray to black appearance on the CARTO EAM screen.

Figure 6: After the RF needle crosses the septum, the dilator is advanced over the RF needle slightly. The needle is then exchanged for an Amplatz wire, which can be visualized entering the left pulmonary veins on intracardiac echo.

sensors along the catheter shaft are out of the sheath, the ablation catheter appears long with full curve visualization. When the curve sensors are covered by the sheath, the ablation catheter appears shorter on the screen. When the proximal bipole of the catheter tip is covered by the sheath, the bipole appears black and “SH” appears in the contact force-sensing box.

Step 4: Checking for pulmonary vein isolation and antral conduction block. After ablation lesions have been placed encircling the veins, the ablation catheter is used to test for pulmonary vein isolation in standard fashion during CS proximal pacing or sinus rhythm, by moving the catheter within the vein ostia to test for

conducted electrograms into the veins at 0.3 mV gain. A comprehensive sweep of all antral tissue and pulmonary vein (PV) sleeves is performed with force sensing ensuring good tissue contact. Testing for exit block is performed with 20 mA at 2 ms pacing through multiple sites just inside the antral ablation line, guided by contact force $>20\text{ gm}$ at each pacing site. If conduction into the veins is seen, then high-density Confidense mapping during CS pacing at a fixed cycle length (i.e. 700 ms) can be used to localize the earliest sites of breakthrough. This can also be performed without the Confidense module, but will take significantly longer using a point-by-point technique (**Figure 8**).

Figure 7: The ablation catheter is used to take a point-by-point map of the left atrium with continuous coronary sinus (CS) pacing from the CS proximal electrode with points for bipolar voltage and activation.

Figure 8: After ablation lesions have been placed encircling the veins, the ablation catheter is used to test for pulmonary vein isolation in standard fashion during coronary sinus (CS) proximal pacing or sinus rhythm, by moving the catheter within the vein ostia to test for conducted electrograms into the veins at 0.3 mV gain. If conduction into the veins is seen, then high-density Confidense mapping during CS pacing at a fixed cycle length (i.e. 700 ms) can be used to localize the earliest sites of breakthrough.

Results

To date, 14 procedures have been completed using this technique in our laboratory. No procedural complications have been noted. The operators have not worn lead for these cases, and the fluoroscopy C-arm has been left in a parked position, away from the procedural table. In one case, fluoroscopy was needed to advance the ICE catheter to the RA. At this point, lead aprons were removed, and the C-arm was once again placed into a parked position. In the first four patients, a multipolar Lasso or Pentaray catheter (Biosense Webster, Diamond Bar, CA, USA) was used to validate that antral block was present after the veins were deemed isolated using the above-described technique. Isolation was confirmed in all four cases. Our technique is associated with a reduced procedural cost, given the reduction of one long sheath (SL-0 sheath at \$225) and a multi-electrode catheter (Pentaray \$1625, or Lasso \$1403) from a typical set-up for AF ablation.

Conclusions

We present a zero-fluoroscopy, completely ICE-guided approach to RF ablation of AF using a single transeptal access, a single force-sensing RF ablation catheter, and a CS decapolar catheter. There are several advantages to this approach. First, the complete elimination of fluoroscopy from what is commonly a 2.5–4-h procedure for many electrophysiologists eliminates radiation exposure to the patient, the operator, and laboratory staff. A report by Ector et al.¹⁰ suggest an increase of one cancer-related patient death for every 671 (obese patients) to 1667 (normal BMI) AF ablation procedures. Roguin et al.¹⁵ catalogued 31 brain tumors among interventional cardiologists (n = 23), electrophysiologists (n = 2), and interventional radiologists (n = 6),

with the most striking finding being that 85% of the tumors were left-sided, the side most exposed to occupational radiation. It is hoped that strategies to reduce or eliminate radiation exposure to patients and staff may lead to a reduction in radiation-related malignancy. In addition to the direct health benefits of radiation reduction, there is an increasing appreciation for the long-term orthopedic effects of chronic use of heavy lead aprons by cardiac interventionalists.¹⁶ Eliminating the need for lead reduces the risk of orthopedic injury as well as physical fatigue after multiple cases.

Our technique has not been associated with any procedural complications, though only 14 patients have undergone ablation using this technique. In the future, we plan to perform a 1-year outcome comparison versus a matched control group in our institutional atrial fibrillation ablation registry to more fully assess efficacy and safety.

Our single catheter technique has other benefits as well, including a reduction of procedural cost and increased access to the patient's airway with no X-ray equipment in place.

Limitations

This technique requires familiarity with ICE and is safest when combined with the use of a contact force-sensing catheter. There are certain situations that may make fluoroscopic guidance necessary. Pre-operatively, a patient with intracardiac pacing or defibrillator leads may not be deemed a good candidate for this technique as lead dislodgement could be more likely. Intra-operatively, conversion to a fluoroscopy-guided procedure may be necessary if ICE guidance to the RA is difficult, if ICE windows are poor, or if there is inability of the transeptal sheath to engage the septum. ICE navigation through the venous system can

sometimes be clarified by injecting agitated saline in the femoral sheath and observing bubbles on ICE as they inevitably course toward the RA. A further limitation to using this technique is the availability of the ICE console (Vivid *i*, GE Healthcare, Little Chalfont, Buckinghamshire, UK), which is sometimes being used concurrently for ablation of ventricular tachycardia or other cardiac procedures in a separate procedure room.

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