Role of intracardiac echocardiography for guiding ablation of tricuspid valve arrhythmias

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Introduction

Ventricular tachycardia and premature ventricular contractions (PVCs) arising from around the tricuspid valve (TV) annulus represent 8%–9% of idiopathic ventricular arrhythmias (VAs).[1,2] Additionally, in some patients with nonischemic cardiomyopathy, the perivalvular region is a common source of VAs.[3] Tada and colleagues showed that the outcomes of catheter ablation for TV arrhythmias are relatively modest.[1] In our experience, the 3 main obstacles for ablation of these VAs are a prominent Eustachian ridge that sometimes interferes with advancing the catheter into the right ventricle (RV), the exaggerated annular mobility during the cardiac cycle that limits catheter stability, and the presence of the valve leaflets and chordae, which are often interposed between the tip of the catheter and the myocardial tissue. The same considerations apply for ablation of right-sided accessory pathways (APs) and explain why primary failure and recurrence rates are higher compared to ablation of left free-wall APs.

In this report, we describe 5 cases that illustrate the utility of intracardiac echocardiography (ICE) to guide mapping and ablation of tricuspid annular arrhythmias. In all these cases an initial attempt of ablation had failed using the standard femoral approach.

Anatomy of the tricuspid valve apparatus

The TV is the largest of the heart valves, with a diameter of 27–29 mm and an area of 4–6 cm.[2,4,5] It lies inferiorly and anteriorly to the mitral valve, and is composed of 3 leaflets: anterior (the largest), posterior, and septal (Figure 1A, 1B).

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The anterior papillary muscle (PM) is the most prominent; it originates in part from the moderator band and provides chordae to the anterior and posterior leaflets. The posterior PM is often bifurcated or trifurcated and provides chordae to the posterior and septal leaflets. Finally, the septal PM, also referred to as the conus papillary muscle of Lancisi, is the smallest one, often rudimentary and even absent in 20% of cases; it arises from the outflow tract and provides chordae to the septal and posterior leaflets. In addition, there may be accessory chordal attachments to the RV free wall and to the moderator band.[6]

The membranous portion of the interventricular septum is crossed by the attachment of the septal leaflet of the TV, with the location of the valvular hinge determining the extent of the atrioventricular and interventricular components of the septum.[7] The wall of the right atrium (RA) containing the atrioventricular node is known as the triangle of Koch, delineated anteriorly by the septal leaflet of the TV; posteriorly by the tendon of Todaro, a fibrous extension of the Eustachian valve; and inferiorly by the orifice of the coronary sinus. The compact atrioventricular node is located at the apex of this triangle and is continued distally by the penetrating bundle of His, which crosses the membranous septum and branches on the crest of the muscular septum into right and left cords prior to ramifying apically within the ventricular myocardium.

Case report

In the cases reported here, the electrophysiology study (EPS) was conducted under conscious sedation. A quadripolar catheter was positioned in the RV apex for stimulation and an 8F phased-array ICE catheter (Siemens, Mountain View, CA) was advanced into the RA.

CARTO mapping system (Biosense Webster, Diamond Bar, CA) was utilized in conjunction with the CARTO-SOUND module to allow integration of the electroanatomic map with an ICE-derived anatomic shell. Thus, before mapping, a detailed anatomic reconstruction of both

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KEY TEACHING POINTS

- Ablation of tricuspid valve arrhythmias from a femoral approach can be challenging. The valve leaflets often limit contact between the ablation catheter and the myocardial tissue.
- In some patients with failed ablation attempts, successful arrhythmia elimination may be achieved by positioning the ablation catheter from below the tricuspid annulus, as opposed to the standard approach above the annulus. Intracardiac echocardiography (ICE) is essential in these cases to monitor for real-time catheter position.
- For arrhythmias originating from the anterior tricuspid annulus we describe a novel ICE-guided technique involving the aid of a long sheath and a "double S" configuration on the ablation catheter.

ventricles was created. Valve points were acquired for both the TV and pulmonic valve and incorporated into the geometry. Activation mapping and ablation was performed with a 3.5-mm-tip irrigated ablation catheter (Navistar ThermoCool DF or SmartTouch DF, Biosense Webster, Diamond Bar, CA) and a steerable sheath with a large curve (Agilis, St. Jude Medical, St. Paul, MN) was used to improve catheter maneuverability and stability.

Case 1

A 17-year-old male subject presented with palpitations and was found to have frequent monomorphic PVCs (burden 21%) with a left bundle branch block (LBBB) pattern, V_3 transition, positive lead I, and inferior axis. At the EPS, an activation map of the PVC showed earliest activation (-30 ms pre-QRS) at 11 o'clock on the TV, with a 97% pace map match at that site. However, several radiofrequency (RF) applications failed to suppress the PVCs (Figure 2). An ICE catheter was advanced into the RA, showing impingement of the anterior TV leaflet between the catheter and the annulus. The Agilis sheath was then deflected into the RV and a second curve was applied to the ablation catheter under ICE guidance, which positioned the catheter tip under the valve, where activation timing was -39 ms pre-QRS and a more perpendicular orientation of the catheter was achieved. A single RF application (30 W, 60 seconds) resulted in PVC elimination, without arrhythmia recurrence after a 30-minute waiting period, despite isoproterenol infusion.

Case 2

A 34-year-old healthy female subject was assessed because of a 5-year history of symptomatic PVCs (burden 27%), manifesting as palpitations and dyspnea. The PVCs exhibited an LBBB morphology with late transition (V_6) and right inferior axis. During the EPS, very early bipolar activation (-89 ms) was detected at the anterolateral region of the tricuspid annulus (Supplemental Figure 1). Contact and catheter stability proved challenging at this location despite a steerable sheath. Under ICE guidance, a "reversed S-curve" was applied to the ablation catheter, which achieved adequate reach into the subtricuspid tissue and proper tissue contact, with 98% pace map match. RF application resulted in permanent PVC suppression and no complications occurred.

Case 3

A 39-year-old male patient with symptomatic PVCs (burden 30%) was referred after a prior failed ablation attempt. The PVCs had an LBBB pattern with late precordial transition (V_5), inferior axis, and positive lead I. Activation mapping demonstrated earliest activation at the anterolateral region of the tricuspid annulus (Supplemental Figure 2) and pace mapping at this site showed a 12/12 match. Several RF applications (30 W) resulted in only transient PVC suppression despite a very early signal (-70 ms). A repeat approach, this time using the reversed S-curve technique and ICE guidance, successfully eliminated the PVCs. Supplemental Figure 2 clearly shows how this approach resulted in a more favorable vector at the ablation site.

Case 4

A 65-year-old female patient with Wolff-Parkinson-White syndrome and supraventricular tachycardia was referred after 3 prior failed ablations. The electrocardiogram showed preexcited sinus rhythm with V_4 transition, positive delta wave in I, and relatively isoelectric delta wave in inferior leads (Figure 3). An Agilis sheath was used for improved stability and detailed activation mapping was performed during atrial pacing. Earliest ventricular activation was recorded at 9 o'clock in the tricuspid annulus and ICE imaging from the RA identified a small pouch at this location below the TV. Applying a tight curve on the ablation catheter caused the tip to be positioned at this pouch, and good contact force was achieved (18–20 grams). RF was applied, with early elimination of AP conduction. After 1 hour of waiting time, preexcitation did not recur and VA dissociation was observed with ventricular pacing.

Case 5

A 31-year-old male patient with Wolff-Parkinson-White syndrome and 4 previous ablation attempts of a right free-wall AP was referred for evaluation. His electrocardiogram showed a delta wave that was positive in leads I and aVL, with precordial transition at V_5 (Supplemental Figure 3). Activation mapping during ventricular pacing showed earliest atrial activation at the lateral aspect of the tricuspid annulus (9 o'clock). Using ICE guidance and an Agilis sheath, we positioned the ablation catheter just below the