INNOVATIVE COLLECTIONS

COMPLEX CASE STUDY

Two Distinct Ventricular Tachycardia Morphologies Eliminated with Ablation in the Left Coronary Cusp

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ABSTRACT. Ventricular tachycardias (VTs) in patients without structural heart disease often manifest distinct and characteristic morphologies that suggest their site of origin and the chamber or structure from which they can be successfully ablated. We describe two distinct VT morphologies in a single patient both successfully eliminated with ablation within the left coronary cusp.

KEYWORDS. aortic cusps, catheter ablation, ventricular tachycardia.

Case presentation

A 58-year-old male with hypertension, non-insulin-dependent diabetes mellitus and asthma reported a long history of exercise-induced palpitations that first developed in childhood. In March 2008, he had presented to another hospital in sustained monomorphic ventricular tachycardia (VT), with left bundle branch block (LBBB), left inferior axis morphology. The only available 12-lead electrocardiogram (ECG) revealed sinus rhythm with premature ventricular contractions (PVCs) and ventricular couplets (Figure 1). Cardiac catheterization performed several years earlier, to evaluate mild left ventricular (LV) dysfunction on echocardiography, had revealed normal coronary arteries. With the evidence of sustained monomorphic VT in the setting of an underlying non-ischemic cardiomyopathy, a single-chamber implantable cardioverter-defibrillator (ICD) was implanted for secondary prevention of sudden cardiac death.

Thirteen and 16 months following ICD implantation, the patient received a single appropriate shock from his device for termination of VT. Device interrogation at that time revealed a total of four VT episodes with similar electrogram morphology and cycle length (250–260 ms). Two episodes were terminated with anti-tachycardia pacing; the other two each terminated with a single 35-J ICD shock. Following the first ICD shock, β-blockers were initiated; amiodarone was initiated following the second ICD shock.

On guideline-directed medical therapy, the patient’s LV function normalized. However, because of recurrent ICD shocks, he was referred for catheter ablation in September 2009. At electrophysiology study, the ectopy (left bundle branch, left inferior axis morphology) was mapped to the left coronary cusp using the CARTO 3 electroanatomic mapping system (Biosense Webster, Diamond Bar, CA) in conjunction with a remote magnetic navigation system (Stereotaxis, St. Louis, MO). Activation mapping within the left coronary cusp showed early activation, and pace mapping yielded a 12/12 match (Figure 2). Ablation at this site abolished the patient’s ventricular ectopy. A pre-procedure computed tomography (CT) scan was used in conjunction with the intraprocedure electroanatomic map; the merged images confirmed the ablation site to be within the left coronary cusp (Figure 3).

Programmed ventricular stimulation performed before and following initial ablation, repeatedly induced non-sustained episodes of VT with right bundle branch block (RBBB), left inferior axis morphology at a cycle length of 304 ms. Given its uncertain clinical significance and inability to sustain, this VT was neither mapped nor targeted for ablation. However, overnight telemetry monitoring disclosed occasional ventricular ectopy with RBBB morphology. Nonetheless, amiodarone was discontinued. ICD interrogation performed a month following...
Ablation showed that the burden of ventricular ectopy had decreased from 140 to 5 PVCs/h.

The patient did well until August 2013, when he presented after receiving two more ICD shocks; each was preceded by a sensation of palpitations. Device interrogation disclosed that he also had 22 episodes of monomorphic VT, which were successfully terminated with anti-tachycardia pacing (ATP). An echocardiogram disclosed mild concentric LV hypertrophy with normal LV function. Repeat electrophysiologic testing was performed. Delivery of a single ventricular extra-stimulus reproducibly induced sustained monomorphic VT with RBBB, left inferior axis morphology at a cycle length of 340–350 ms (Figure 4). The VT was again mapped using the CARTO 3 electroanatomic mapping system in conjunction with the Stereotaxis remote magnetic navigation system. The entire mitral valve annulus, aortic root, and the great cardiac–anterior interventricular vein junction were mapped; the last one was mapped via the coronary sinus. Aortography was performed to define the location of the coronary cusps as well as the relationship of the cusps to the origin of the coronary arteries. A site of early activation was identified in the left coronary cusp; at this site a 12/12 pace map was also present (Figure 5). Ablation within the left cusp eliminated all ectopy; post-ablation programmed stimulation in the baseline state and during infusion of isoproterenol failed to induce any further ectopy or tachycardia. The patient underwent 3 weeks of mobile cardiac outpatient telemetry monitoring; neither ectopy nor tachycardia was observed. He has had no further episodes of VT since ablation.

Discussion
LV outflow tachycardias account for approximately 10–30% of idiopathic VTs. These outflow tract tachycardias can manifest as repetitive monomorphic ventricular ectopy, non-sustained VT or sustained VT; irrespective of phenotypic expression, they are all believed to share a common mechanism, namely triggered activity.1,2 This report highlights several important features of VTs that can be successfully eliminated with catheter ablation delivered within the coronary cusps.3 When the LV epicardium and sinuses of Valsalva have been mapped simultaneously in these patients, slightly earlier activation has been recorded from the epicardium. Nonetheless, all were successfully ablated from the left coronary cusp.
which suggests that these arrhythmias arise from the myocardium immediately adjacent to the coronary cusps. Several studies have characterized specific electrocardiographic features capable of distinguishing between right versus left-sided origin of idiopathic VTs. In addition, ECG criteria have been suggested to distinguish between the various left-sided sites of VT origin: the epicardium at the LV summit near the great cardiac vein (GCV); the left, right, and non-coronary cusps; the aorto-mitral continuity; and the crux of the heart by the posterior descending coronary artery. In our patient, the ECG morphology of the original tachycardia targeted for ablation was fairly typical for VTs originating adjacent to the coronary cusps. Fluoroscopy, three-dimensional electroanatomic mapping, and merged CT images (Figure 3) confirmed an anterior and superior catheter position within the aortic root, consistent with the left coronary cusp. The second PVC/VT morphology that was targeted for ablation had an R wave in lead V1 and a morphology (RBBB, left inferior axis) that has been reported in epicardial VTs that originate from the anterior epicardial veins. Typically, earliest activation can be recorded from the GCV and yet ablation is often possible from the left coronary cusp. In our patient, despite the RBBB morphology, both earliest activation and pacemapping was again best from the left coronary cusp as opposed to the GCV.

Conclusion

We believe that our patient had a single epicardial focus to account for the two morphologies of his ventricular arrhythmias. At initial presentation, there was preferential conduction over a posterior and septal route, consistent with the larger and more continuous myocardial fibers overlying the LV septal base. However, immediately following initial ablation, ectopy began to exit more anteriorly to depolarize the LV summit, an area characterized anatomically by myofibers that are
Figure 3: Merged images of a pre-procedure computed tomography scan and intraprocedure electroanatomic map. The anterior-posterior (AP, left) and left anterior oblique (LAO, right) projections confirm that the site of earliest activation (shown in red) was within the left coronary cusp (LCC).

Figure 4: Twelve-lead electrocardiogram (ECG) of the patient's induced ventricular tachycardia (VT) identified at the repeat electrophysiology study. The ECG shows sustained monomorphic VT with right bundle branch block, left inferior axis morphology.
sparser and often separated by fibrous tissue. This explains how pacing from within the left aortic cusp in our patient produced two distinct VT morphologies. This report further highlights the utility of carefully mapping the aortic root, epicardial venous system, right ventricular and LV outflow tracts in patients with idiopathic outflow tract tachycardias.

References


**Figure 5:** Pacemapping of ventricular tachycardia (VT) #2. (a) The electrocardiogram morphology of the patient’s sustained monomorphic VT. (b) A 12/12 pacemap was observed when pacing was instituted at the putative site of origin within the left coronary cusp. (c) Shallow left anterior oblique fluoroscopic image shows the ablation catheter to be in the left coronary cusp. (d) Shallow right anterior oblique fluoroscopic image shows the ablation catheter to be in the left coronary cusp.