Ventricular arrhythmias (VA) can develop in patients with structural heart disease (SHD) including prior myocardial infarction and non-ischemic cardiomyopathy. When VAs manifest in structurally normal hearts, they are usually a result of intra-cellular calcium overload (triggered activity) or an abnormal response to adrenergic stimulation (automaticity). Re-entry within the Purkinje fibers and specialized conduction system causes ~ 5% of all VAs in patients undergoing catheter ablation. This may occur in patients with severe dilated cardiomyopathy due to idiopathic or valvular heart disease etiologies, or in ischemic heart disease in which damaged His-Purkinje fibers can facilitate macro-reentrant bundle-branch reentry VT. In patients without structural heart disease, intra-fascicular reentry involving a portion of the LV Purkinje fibers can lead to VT. This most commonly is associated with the left posterior fascicle giving rise to a characteristic narrow complex right bundle branch block (RBBB) superior axis QRS configuration (Belhassen’s VT).

Although implantable cardioverter-defibrillators (ICDS) are the mainstay of therapy to prevent sudden death, they do not prevent VAs, and can lead to painful shocks. Medical therapy has limited efficacy and may introduce adverse side effects. Catheter ablation of VAs is a rapidly evolving field and an important alternative in the management of patients with this disease. VT ablation is often a preferred front line therapy in patients with structurally normal hearts. In this series of clinical vignettes, we highlight the range of substrate-specific strategies used in our electrophysiology laboratory for catheter ablation of VAs.

**Case 1: Premature Ventricular Contractions**

Ms. AF is a 34 year-old woman with frequent palpitations, shortness of breath, and fatigue, with a known history of ventricular premature depolarizations (VPDs). She had previously been on metoprolol without improvement of symptoms. An electrocardiogram (Figure 1) revealed frequent premature ventricular contractions in a bigeminal pattern. An echocardiogram revealed a reduced ejection fraction of 45%. A 24-hour Holter monitor was performed which revealed ~ 30% burden of VPDs.

An EP study was performed with activation mapping of the right and left ventricular outflow tracts. Intra-cardiac echocardiography (Continued on page 12)
was used to create an anatomic shell of the outflow tracts and aortic sinuses, and mark the ostial locations of the left main and right coronary arteries. The earliest site of activation was mapped to the left ventricular outflow tract in the commissure between the right and left coronary cusps. Ablation was performed with immediate termination of the VPDs (Figure 2).

At the 3-month follow-up, the patient had improvement in her symptoms of palpitations and exertional intolerance. A repeat Holter monitor was performed which revealed rare VPDs (< 1%) with an echocardiogram showing normalization of her left ventricular size and function.

In the absence of structural heart disease, VPDs most commonly arise from the right or left ventricular outflow tracts, or the epicardial tissue immediately adjacent to the sinuses of Valsalva. The earliest site of activation was mapped to the left ventricular outflow tract in the commissure between the right and left coronary cusps. Ablation was performed with immediate termination of the VPDs (Figure 2).

Management of VT Storm

| Beta blockade |
| Anti-arrhythmic drug therapy |
| Intubation, general anesthesia |
| Neuraxial modulation (thoracic epidural) |
| Mechanical hemodynamic support |
| Catheter ablation |

Table 1
region resulted in prompt termination of the VT (Figure 3) and inability to induce further VAs with aggressive stimulation. The patient has done well during a 12-month follow-up period without recurrent VA or ICD therapies.

Scars that support VT circuits are comprised of both dense fibrosis and viable myocytes which create a substrate for slow conduction required to sustain re-entrant circuits.8,9 There are multiple strategies for mapping VT with the optimal strategy often using a combination of techniques. In hemodynamically unstable VT, pace mapping with substrate mapping can localize a critical region, and in selected cases percutaneous left ventricular assist device placement can support end-organ perfusion while effectively mapping the VT. The use of such devices may add potential risk and as such requires center expertise.10

**Case 3: Successful Epicardial Cryoablation of Ventricular Tachycardia Not Amenable to Radiofrequency Ablation**

Ms. BB, a 70 year-old woman with a history of atrial fibrillation, was found to have wide complex tachycardia. She underwent evaluation that included echocardiogram, cardiac MRI, and cardiac catheterization, which revealed normal cardiac structure and function and no evidence of coronary artery disease.

The tachycardia morphology was consistent with an exit site in the basal infero-septum. The slurred QRS onset with maximal deflection index (MDI) greater than 0.55 was consistent with an epicardial location (Figure 4). Percutaneous epicardial access was obtained and VT mapping was performed. The earliest site of activation was found on the right ventricular epicardium near the origin of the posterior descending artery (Figure 5).

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Radiofrequency (RF) ablation was then performed at this site with slowing and termination of the tachycardia. Spontaneous re-initiation was observed despite high power lesions (Figure 6). Cryoablation was performed using a 6mm cryoablation catheter to deliver three 4-minute lesions to -75°C. VT terminated without re-initiation or ectopy from that region (Figure 7). The patient has done well during a 16-month follow-up period without recurrent VT.

RF energy remains the primary ablative modality in the epicardium. However, there are several challenges to effective RF delivery in this space including the absence of convective cooling from blood flow (which is required for adequate energy delivery), poor catheter stability, and potential damage to collateral structures (coronary arteries, phrenic nerve, esophagus, great vessels). Cryothermal energy may have several potential benefits including better stability (due to “cryoadherence” to tissue) and improved cooling in the absence of blood flow.

**Case 4: Hybrid Ventricular Tachycardia Ablation using a Novel Catheter**

Mr. GV is a 66 year-old man with coronary artery disease with prior inferior myocardial infarction (4-vessel CABG in 1993), who was transferred in the setting of VT storm. He had undergone a previous endocardial study with...
identification of an epicardial VT originating from the inferior wall of the left ventricle (LV). The decision was made to perform repeat endocardial and epicardial mapping with surgical access.

Surgical access was obtained via a subxiphoid approach. Blunt dissection of adhesions was performed to fully expose the inferior LV wall to the mitral annulus. High-density endocardial and epicardial voltage maps (Figure 8) were created which revealed evidence of low voltage, fractionation, and double potentials on the epicardial surface of the inferior LV. The EpiSense surgical ablation catheter (nContact, Morrisville, NC) contains a 3cm RF ablation coil exposed on one side only with 4 embedded electrodes, with open irrigation and suction (-400mmHg) to maintain tissue contact. Energy was delivered to a broad region in the inferior wall substrate with repeat mapping revealing signal attenuation and homogenization of scar in this region (Figure 9). The patient has done well during the 12-month follow-up period.

In patients with prior cardiac surgery or pericardial adhesions, percutaneous epicardial access may not be feasible. Hybrid surgical access in the EP lab can be achieved via either a subxiphoid approach or limited anterior thoracotomy. This technique facilitates direct visualization and the ability to use a surgical ablation tool. This particular ablation technology has several potential advantages including improved tissue contact, effective cooling, and uni-directional energy delivery, which aid in effective epicardial ventricular lesion formation.

Summary
In patients who have structural heart disease, catheter ablation can be utilized to minimize the incidence of ICD therapies. There are several strategies and techniques that can be used to identify the potential substrate of diseased tissue and eliminate the critical component vital to sustain tachycardia. In the absence of structural heart disease, VAs are typically not life threatening and catheter ablation can often be curative.

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References:


To refer a patient to the Vanderbilt Heart & Vascular Institute, call (615) 343-9188.