Outflow Tract Premature Ventricular Contractions and Ventricular Tachycardia
The Typical and the Challenging

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KEYWORDS

• Outflow tract • Premature ventricular contraction • Ventricular arrhythmia • Catheter ablation

KEY POINTS

- The ventricular outflow tracts are the most common sites of origin of idiopathic ventricular arrhythmias (VAs).
- Structural heart disease should be excluded because the outflow tract can be a source of VAs in early cardiomyopathies.
- Electrocardiogram of the VA is useful in predicting potential ablation sites but careful and sequential mapping of the various structures in the outflow tract is often essential to define sites for successful ablation.
- Ablation for VAs from the right ventricular outflow tract has the highest success, followed by sites in the aortic root, left ventricular (LV) endocardium, and LV epicardium.
- The LV summit is a difficult area to access and, if catheter ablation from surrounding areas proves unsuccessful, surgical ablation is an option.

INTRODUCTION

The ventricular outflow tract is a common site of origin for premature ventricular contractions (PVCs) and repetitive ventricular tachycardia (VT) in patients with structurally normal hearts.[1] However, these sites also generate PVCs in patients with structural heart disease that tend to worsen left ventricular (LV) dysfunction. Rarely, arrhythmias from the outflow tract location can be the early manifestation of a cardiomyopathy, such as sarcoidosis, arrhythmogenic right ventricular cardiomyopathy, or acute myocarditis. Exclusion of significant disease may require the use of sophisticated imaging techniques such as cardiac MRI or PET to exclude areas of scar or inflammation that may not be evident by echocardiography.

β-Blockers and calcium channel blockers have only a modest effect in suppressing idiopathic ventricular arrhythmias (VAs), but are commonly used because of their safety. More potent antiarrhythmic drugs, such as flecainide, mexiletine, and amiodarone, are more effective but long-term use is limited by side effects. Flecainide is avoided in the presence of heart disease or depressed ventricular function. Hence, catheter ablation is an attractive option for many patients. A recent randomized study of patients with frequent PVCs from the right ventricular outflow tract (RVOT) found a greater decrease in burden of PVCs following ablation compared with drug therapy, although LV function improved in both groups.[2] However, catheter ablation for outflow tract arrhythmias is not always successful, largely

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because of anatomic obstacles related to the three-dimensional relationship of the great vessels and their connections to the ventricular muscle. Success rates for catheter ablation largely depend on the sites of origin of these arrhythmias and their accessibility. This article reviews the relevant anatomy of the ventricular outflow regions and proximal great vessels, electrocardiographic clues to the sites of origin, and techniques commonly used to target these arrhythmias for ablation.

ANATOMY OF THE OUTFLOW TRACT

The right ventricle is a conical structure with an inlet, apical trabecular portion, and the outlet tract. The RVOT can be anatomically divided into the rightward (free wall), and leftward (septal and posterior) portions based on its relationship to the aortic root and valve, which are situated posterior and inferior to the pulmonary valve (Fig. 1).[3] Because the pulmonary valve is superior to and leftward of the aortic valve, the posterior-septal RVOT is closely related to the right coronary cusp (RCC) and left coronary cusp (LCC) of the aortic valve. The left main coronary artery arises from the LCC in close relationship to the posterior RVOT below the pulmonary valve. In one study, the left main coursed within 2 mm of the left pulmonary cusp in 43% of cases.[4] Although there is a theoretic risk of damage to coronary arteries from ablation in the region, none have been recorded to date, possibly because of the high flow in the coronary vessels acting as a convective coolant.

The inferior and rightward portion of the RVOT is continuous with the interventricular septum and the tricuspid annulus where the His bundle is located. In the LV outflow tract (LVOT), the RCC and LCC lie superior to the muscular LVOT, whereas the noncoronary cusp (NCC) abuts the membranous septum and the interatrial septum (see Fig. 1). The NCC and the posterior aspect of the LCC are continuous with the fibrotic aortomitral continuity in the posterior-lateral aspect of the LVOT. Ventricular myocardium extends between the scallops of the semilunar valves into the both the aortic and pulmonary valves (Fig. 2).[5] An autopsy study showed that extensions in the LVOT are more common in the region of the RCC (55%) compared with the LCC (24%). Ventricular myocardial extension to the NCC is rare (<1%); in this region, extension of the atrial muscle is more common. In contrast, myocardial extensions above the pulmonic valves are more common and evenly distributed, occurring in 60% to 90% of patients.[6,7]

The Epicardial Outflow Tract

Idiopathic VTs are known to originate from the epicardium, usually in close relation to the venous structures.[8,9] The great cardiac vein (GCV) and its distal anterior interventricular branch can be sites for mapping and ablation of idiopathic VT.[9,10] Because the vein in this location lacks significant muscular layers (unlike the proximal course of the coronary sinus from its ostium to the valve of Vieussens), the likely origin of the VT successfully ablated from within these veins is the adjacent epicardium.

An area of interest for epicardial VTs is the LV summit, an epicardial region overlying the LV base that is anatomically defined by the region between the bifurcation of the left main coronary artery between the left anterior descending artery and left circumflex artery (Fig. 3).[11,12] The first septal branch defines the inferior boundary of the

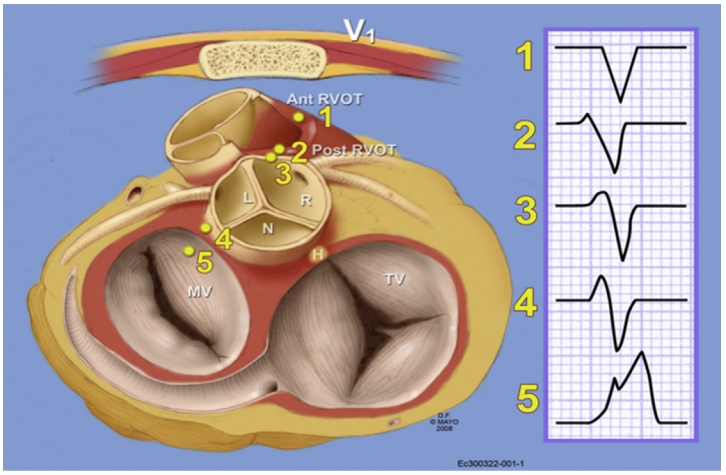

Fig. 1. The base of the left ventricle and RVOT showing leftward location of the right ventricular outflow anterior to the aortic root. QRS configuration lead V is shown for the anterior RVOT (1), posterior RVOT (2), right coronary cusp (3), left coronary cusp (4), and the region of the aortomitral continuity (5). L, left coronary cusp; MV, mitral valve; N, noncoronary cusp; R, right coronary cusp; TV, tricuspid valve. (*Adapted from* Asirvatham SJ. Correlative anatomy for the invasive electrophysiologist: outflow tract supravalvar arrhythmia. J Cardiovasc Electrophysiol 2009;20:955–68; with permission.)