Anatomy for Ventricular Tachycardia Ablation in Structural Heart Disease

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KEYWORDS

• Ventricular tachycardia • Ablation • Structural heart disease • Anatomy • Cardiomyopathy
• Septum • Papillary muscle • Epicardium

KEY POINTS

- Current ablation technology may have limits in the setting of diffuse or midmyocardial scar.
- The term septal is often inappropriately invoked in the outflow region.
- Aspects of the septal right ventricular outflow tract are not truly septal and perforation at that site enters the pericardial space.
- Successful epicardial mapping and ablation requires not just anatomic understanding of the epicardial surfaces of the heart, coronary venous and arterial system, and the pericardial reflections but also requires an understanding of gastrointestinal, diaphragmatic, and pleural anatomy in order to avoid complications.
- Intracavitary structural anatomy must be understood to avoid inadvertent damage (mitral valve apparatus) and to understand the best ablation techniques when these structures are involved in VT (papillary muscles, perivalvular fibrosis).

INTRODUCTION

Ventricular tachycardia (VT) radiofrequency ablation has become standard of care for VT either resistant to antiarrhythmic medication or if the patient prefers not to take antiarrhythmics.[1,2] Further, it seems that early referral may improve patient outcomes[3] and there may be a survival benefit,[4] which may lead physicians to more aggressively refer their patients for ablation and increase the volume of VT ablations performed. VT in the setting of structural heart disease, previously reserved for highly experienced specialized centers, is being performed at an increasing number of centers internationally as cardiac electrophysiologists gain advanced training.

Given the poor tolerance of induced VT in most patients, a substrate-based approach is often required.[5] This technique requires more extensive ablation than an activation mapping/entrainment approach that focuses on a single VT circuit. A substrate-based approach potentially targets current clinical VTs but also regions of slow conduction that may predispose to future VTs. Ablation of potential circuits often requires ablation in multiple segments/regions of the ventricles.

Given the likely increase in VT ablations performed and the use of substrate-based ablation, a comprehensive and detailed understanding of cardiac anatomy is essential for interventional cardiac electrophysiologists.[6–11] The importance of understanding anatomy is further escalated when dealing with patients with structural heart disease, in which understanding the normal anatomy along with anatomic variations that can occur in dilated, rotated, scarred, thinned,

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hypertrophied, and/or aneurysmal hearts can be the difference between successful ablation and major complication. Whether patients have VT from ischemic cardiomyopathy (ICM) or non-ICM (NICM) (eg, idiopathic, arrhythmogenic right ventricular cardiomyopathy [ARVC], sarcoidosis, myocarditis, Chagas disease), the importance of understanding cardiac anatomy remains the same. The understanding of anatomy for any cardiac procedure, and specifically ablation, is best understood attitudinally[10,12] and relative to fluoroscopic views.[13]

PREPROCEDURE AND INTRAPROCEDURE IMAGING

Preprocedure imaging with contrast-enhanced computed tomography or cardiac MRI[14–18] has become a mainstay of VT ablation. Imaging can alert physicians to anatomic variation, but more commonly is used to better define potential arrhythmia substrates (scar/fibrosis). Nuclear imaging can add essential understanding of inflammatory substrates.[19] During mapping and ablation of VT, these imaging modalities can be fused with three-dimensional electroanatomic maps to aid anatomic understanding. The addition of intracardiac ultrasonography imaging can allow direct visualization of ablation substrates.[20,21] Techniques still in development, such as real-time MRI,[22] have the potential to further improve direct anatomic visualization during ablation. However, real-time imaging is still limited, and a clear understanding of anatomy and anatomic variation is essential to interpret imaging findings.

LIMITATIONS OF CURRENT ABLATION TECHNOLOGY

Although techniques have been described to affect distant substrates with local ablation,[23] in some anatomic regions, unipolar radiofrequency ablation lesions may not produce adequately deep lesions[24] to interrupt reentrant circuits or focal arrhythmias originating deep within the myocardium. Regions such as the interventricular septum and left ventricle (LV) summit can provide such a challenge. Ablation technology continues to develop, with externally irrigated ablation being the mainstay of current technology.

SEPTAL SUBSTRATES

Isolated septal scar[25] has been shown in patients with NICM, but septal scars can occur with ICM as well. In patients with NICM with VT, anteroseptal scars have been found to have higher recurrence rates then inferolateral scars, possibly because of a higher prevalence of mid-myocardial substrates.[26] Pace maps should be interpreted with caution in this region, because different outputs and exits sites, and whether or not the conduction system is captured, can vastly change QRS morphology and lead physicians astray. Septal substrates must often be approached with mapping and ablation of both the right and left sides of the septum in order to reach deep midmyocardial circuits or foci. Additional modalities such as alcohol septal ablation[27] and wire mapping/coil embolization[28] have been described to target these arrhythmias (Fig. 1).

Understanding the cardiac conduction system anatomy is essential to understanding septal substrates but also to avoid collateral damage whenever possible[29] (Fig. 2). In patients with previous anteroseptal infarcts, those with right bundle branch block (RBBB) tend to have larger scars then patients with left bundle branch block.[30] The first septal perforator provides blood flow to the right bundle and left anterior fascicle. Therefore, more challenging septal scars may be seen in patients with RBBB. This coronary anatomy is essential to understand in the setting of baseline conduction disease when considering alcohol sepal ablation or coil embolization. In certain situations, the conduction system might be a target for ablation, such as in bundle branch reentry tachycardia or fascicular tachycardia. In other situations, the conduction system may need to be sacrificed in order to successfully ablate intraseptal substrates.

Obtaining good catheter contact on the septum from a transseptal approach often requires a deflectable sheath such as the St. Jude Agilis (St. Jude, Austin, TX). Although nondeflectable sheaths can be used, transseptal access often directs the sheath preferentially to the lateral wall of the LV. Aggressive counterclockwise torque on the sheath can overcome this, but in a dilated ventricle adequate contact may not be possible without a deflectable sheath, particularly when the transseptal puncture is too posterior.

Once common misunderstanding about septal structures is that, when mapping substrates in the lower aspect of the right ventricular outflow tract (RVOT) and the catheter is pointed leftward or septally, the operator is without risk of perforation. However, this region is not truly septal. Overaggressive manipulation can result in the catheter perforating into the pericardial space (Fig. 3). Septal in this instance is used as a way of describing catheter position with the tip pointing toward the LV, but no true septum exists at this level.