EMERGING TECHNIQUES

Hybrid Surgical Procedures for Epicardial Ventricular Tachycardia Ablation: An Update

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ABSTRACT. The indications for catheter ablation of ventricular tachycardia (VT) continue to expand and are recommended earlier in the course of the disease. In 15–30% of patients undergoing VT ablation, epicardial mapping and/or ablation is necessary. In patients with prior cardiac surgery or failed percutaneous epicardial access, a surgical exposure is required to map and ablate within the epicardium. The purpose of this review is to provide an update regarding the experience of hybrid surgical access for epicardial catheter ablation of VT.

Introduction

The indications for catheter ablation of ventricular tachycardia (VT) continue to expand and are recommended earlier in the course of the disease.1 Recent clinical trials have shown improvement in VT events after ablation.2 In 15–30% of patients undergoing VT ablation, epicardial mapping is required for locating successful ablation sites.1,3 Furthermore, in patients with prior cardiac surgery or failed percutaneous epicardial access, a surgical exposure is required to map and ablate within the epicardium. The purpose of this review is to provide an update regarding the experience of epicardial surgical hybrid catheter ablation for VT.

Consideration of epicardial access

In the last two decades, the use of epicardial access and ablation has expanded the potential approaches in VT ablation. Sosa et al4 initially described a subxiphoid percutaneous epicardial approach, which has been widely adopted worldwide. Patient subsets that may benefit from epicardial mapping include patients with a VT suggestive of an epicardial exit based on electrocardiogram (EKG) criteria5 and/or previously failed endocardial ablation. This primarily includes patients with either non-ischemic cardiomyopathy,6 patients with prior inferior infarction,7 chagasic heart disease,8 arrhythmogenic right ventricular dysplasia,9 and occasionally epicardial premature ventricular contractions.10

Surgical access

Despite the advancements in percutaneous epicardial access, the procedure is frequently hindered in patients with previous cardiac surgery. This is due to the development of pericardial adhesions from the prior surgical instrumentation. Although percutaneous access can be attempted in these patients,11 success rates are lower and may be associated with a greater risk of complications. Even with successful percutaneous access in patients with previous cardiac surgery, limitations may include decreased catheter manipulation due to pericardial adhesions.12

Soejima et al7 in 2004 described the initial experience of six patients who underwent surgical subxiphoid exposure for epicardial mapping of VT. Five of the six patients had prior cardiac surgery (2/5 with epicardial implantable cardioverter-defibrillator [ICD] patches). Surgical exposure to the epicardial space was created, and an 8 Fr sheath was placed for catheter manipulation. In all patients, the inferior aspects of the left ventricle (LV) were mapped, and in four of six patients the anterior and lateral LV was also accessible. All patients in this series had evidence of inferior/inferolateral scar based on epicardial electroanatomic mapping. A subsequent case report by Maury et al13 in 2007 also described a subxiphoid surgical approach with mapping and termination of VT in the inferior LV.

The above series of patients all underwent subxiphoid surgical exposure with inferior/inferolateral scar. Even with a subxiphoid epicardial exposure, patients with anterior and/or anterolateral scar may not benefit from
this procedure because of adhesions, precluding catheter manipulation in this region. Maury et al\textsuperscript{14} in 2009 reported a case of a patient who underwent a left, lateral thoracotomy in the operating room for recurrent monomorphic VT arising from the anterolateral LV. This approach was chosen given the appearance of the 12-lead EKG and due to the presence of aortic and mitral mechanical valves.

Recently, a multicenter study assessing the safety and complication rate of epicardial ablation for VT noted 20 out of 134 patients had to undergo a surgical procedure for exposure to the epicardium.\textsuperscript{3} Fourteen of 20 patients underwent a subxiphoid approach and six patients underwent a lateral thoracotomy. Although the specific indications for surgical access were not defined for each patient, the majority was noted to have prior cardiac surgery. Furthermore, no specific complications were noted with surgical epicardial exposure that was successful in every patient.

Our institution recently published our experience with regard to surgical hybrid epicardial exposure and ablation in the electrophysiology laboratory for VT.\textsuperscript{15} From 2004 to 2010, 14 patients underwent hybrid surgical epicardial ablation. Eleven of 14 patients had a subxiphoid approach, and the remainder had a limited anterior thoracotomy. The observations from these procedures were that the subxiphoid approach consistently provided access to the inferior wall, extending posteriorly to the basal/inferolateral wall. The anterior thoracotomy approach, conversely, exposed the apex, anterior, and mid to apical anterolateral LV. Additionally, all thoracotomy procedures were performed in the electrophysiology laboratory. Obtaining surgical exposure with an anterior thoracotomy in the electrophysiology laboratory had not been described previously in the literature. Complications related to surgical access were limited in our series. In three patients, <$1 L of blood had collected in the pericardial space after the subxiphoid approach and required a temporary drain; one patient developed a wound infection after thoracotomy that resolved with antibiotics.

Fifty-seven percent of the patients in this series achieved acute procedural success as defined by non-inducibility for VT post-ablation and/or no recurrence of VT prior to hospital discharge. At a mean follow-up of 583 days, 50% had survival free of VT. To our knowledge, this was the largest single center experience of surgical hybrid ablation for VT with minimal complications and results similar to the published literature.

**Procedural considerations**

Based on the descriptions in the literature of hybrid surgical catheter ablation of VT, certain important procedural characteristics must be addressed. First, many patients with prior cardiac surgery have had coronary artery bypass graft surgery. Given this, these patients must have a thorough assessment of coronary and graft location. This may be performed with preprocedure computed tomography (CT) imaging (Figure 1) and/or coronary angiography (Figure 2). For patients undergoing anterior thoracotomy, double lung ventilation is recommended as the left lung may need to be deflated to allow for the appropriate exposure.

During the procedure, a greater extent of adhesions may be encountered during the anterior thoracotomy approach, as it is from this region that the heart is exposed during cardiac surgery (Figure 3). Additionally,
the anterior thoracotomy exposure may displace the precordial lead placement, making interpretation of these leads unreliable when comparing with previous EKGs.

During ablation, certain distinct features should be noted. With the anterior thoracotomy approach, impedance rises and steam pops occurred frequently in our case series. Presumably, increased contact force led to steam pops while accumulation of air may have caused transient rises in impedance. During a subxiphoid approach, irrigated radiofrequency ablation may lead to fluid accumulation in the pericardial space, which needs continuous hemodynamic monitoring and drainage. Finally, defibrillation thresholds may rise with accumulation of air within the epicardial space; therefore, patients with ICDs should be enabled to deliver therapy. A comparison of the two surgical approaches is provided in Table 1.

Conclusion

Epicardial access and mapping is an emerging technique for catheter ablation of VT. In patients with previous cardiac surgery or failed percutaneous epicardial access, hybrid surgical catheter ablation may be performed. A small, yet growing body of literature suggests that surgical access to the epicardium is feasible and relatively safe. When considering a hybrid surgical ablation, it is critical to determine beforehand which area of the ventricle should be mapped and/or ablated as this will impact the surgical approach. The subxiphoid approach provides access to the inferior and inferolateral LV whereas an anterior thoracotomy approach exposes the anterior, mid to apical anterolateral wall, and the true apex. Finally, a multidisciplinary approach including cardiac surgeons, perfusionists, and cardiologists is critical in the care of these patients.

Figure 2: Fluoroscopy of a patient undergoing simultaneous endocardial and epicardial mapping via a subxiphoid surgical exposure. The ablation catheter is within the epicardial space, while an endocardial mapping catheter is in the left ventricle via trans-septal puncture. Bypass graft angiography was performed to assess proximity to potential ablation sites. Epi Abl = epicardial ablation catheter; Endo catheter = multipolar catheter within endocardium of left ventricle; BG = bypass graft; CS = coronary sinus.

Figure 3: View of the exposed heart of a patient undergoing limited anterior thoracotomy for ventricular tachycardia ablation.

A pacing catheter was placed for pacing and induction with an internally irrigated ablation catheter for ablation. During the procedure, further exposure was needed and achieved by extending the exposure by one intercostal space. IC = intercostal space. (With permission from.)
Table 1: Comparison of surgical access via subxiphoid window and limited anterior thoracotomy

| Approach                        | Ventilation  | EKG     | Ablation catheter            | Exposure area                      | Adhesions | Mapping area | Possible collateral damage | RF application problems | Defibrillation
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<td>Subxiphoid</td>
<td>Double lung</td>
<td>Standard</td>
<td>Internal or external irrigated catheter*</td>
<td>Inferior to inferolateral LV (more basal)</td>
<td>Mild to severe</td>
<td>Variable</td>
<td>Bypass graft to PDA</td>
<td>None</td>
<td>Should have ICD backup</td>
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<td>Limited anterior thoracotomy</td>
<td>Single lung ventilation</td>
<td>Precordial leads may be displaced</td>
<td>Internal irrigated catheter*</td>
<td>Anterior and lateral walls as well as the true apex. May need to reenter at a different IC space</td>
<td>Usually severe</td>
<td>Limited to exposed area</td>
<td>Bypass graft to LAD diagonals and OM, phrenic nerve</td>
<td>Possible high impedance and steam pop</td>
<td>Should have ICD backup</td>
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*Internally irrigated catheter is easier to manually hold during ablation. LV = left ventricle; RF = radiofrequency; IC = intercostal; PDA = posterior descending artery; LAD = left anterior descending; OM = obtuse marginal; ICD = internal cardioverter-defibrillator. (With permission from15.)

References

1. Aliot EM, Stevenson WG, Almendral-Garrote JM, et al. EHRA/HRS expert consensus on catheter ablation of ventricular arrhythmias: developed in a partnership with the European Heart Rhythm Association (EHRA), a Registered Branch of the European Society of Cardiology (ESC), and the Heart Rhythm Society (HRS); in collaboration with the American College of Cardiology (ACC) and the American Heart Association (AHA). Heart Rhythm 2009; 6:886–933.


