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Percutaneous Inter-Ventricular Septal Access in a Patient with Aortic and Mitral Mechanical Valves: A Novel Technique for Catheter Ablation of Ventricular Tachycardia

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Keywords

catheter ablation; ventricular septal puncture; mechanical valves; VT

Introduction

Catheter ablation of ventricular tachycardia (VT) is typically performed using either the atrial transseptal approach or a retrograde aortic approach in order to gain access to the left ventricle (LV). However, neither approach is feasible in the setting of mechanical aortic and mitral valve replacements, given the risk of catheter entrapment and death.^{1, 2} Therefore, approaches that avoid traversing these valves, such as a percutaneous trans-apical approach, have been developed.³⁻⁶ However, the trans-apical approach is associated with a significant rate of access related complications, particularly bleeding at the puncture site, and necessitates the placement of closure devices in the LV.^{7, 8} We describe a novel percutaneous inter-ventricular transseptal puncture technique and placement of a sheath across the inter-ventricular septum for catheter ablation of VT. This method allowed for stable LV access and spontaneous closure of the septal access site.

Case Report

Clinical History

A 35-year-old male was referred to our center for catheter ablation of recurrent VT requiring multiple implantable cardiac defibrillator (ICD) therapies. He had undergone mechanical aortic and mitral valve replacements after developing endocarditis due to a dental abscess. Five years later, he suffered from sudden cardiac arrest and a single-lead ICD was placed. His ejection fraction was estimated at 35% and Q waves were noted on the ECG in the inferior leads. He subsequently suffered from VT storm with increasing number of ICD shocks and anti-tachycardia pace terminated (ATP) episodes despite therapy with sotalol and

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Disclosure: The Regents of the University of California, Los Angeles has intellectual property developed by the author (KS) that relate to data reported in this paper.

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amiodarone, and also developed trans-aminitis secondary to amiodarone. In the past year, he had suffered from 110 episodes of VT requiring either ATP or ICD shocks and was highly symptomatic, even during the ATP episodes. Given the presence of mechanical prostheses in the mitral and aortic valve positions, a novel method of LV access across the inter-ventricular septum was discussed with the patient, and he agreed to proceed. The patient was asked to continue oral anticoagulation prior to the procedure to avoid mechanical valve thrombosis.

Description of Procedure

Pre-procedure, a cardiac CT angiography was performed to evaluate LV and right ventricular (RV) septal anatomy. Trans-esophageal echocardiography prior to the procedure showed no intracardiac shunts, adequate prosthetic valve function, inferior wall motion abnormality, and LVEF of 40%. Non-invasive programmed stimulation prior to start of the procedure reproducibly induced the same monomorphic VT with right bundle branch block morphology, superior axis, and V4 transition with double extra-stimuli.

At the beginning of the procedure, under general anesthesia, venous access was obtained from right internal jugular vein in addition to the right femoral artery and vein and the left femoral vein. Intravenous heparin was started to maintain an ACT above 250 seconds. A right ventriculogram with levophase imaging for left ventriculography was performed to evaluate septal anatomy, positions of prosthetic valves, and LV function. The levophase confirmed a dyskinetic segment of the LV inferior wall, which correlated with inferior Q waves on his baseline ECG. Subsequently, coronary angiography was performed to assess presence of large septal coronary artery perforators at the region of the mid inter-ventricular septum, where safe access could be attempted. Coronary angiography showed no significant coronary artery stenosis and also defined the location of the septal perforator coronary arteries.

Through a 10 F sheath in the right internal jugular vein, an 8.5 French Mullins transseptal sheath was advanced into the RV over a J tipped guide wire. The wire was removed and a Brockenbrough needle (BRK-1) was advanced through the dilator and positioned just inside the distal end of the transseptal sheath. Prior to its insertion, the BRK-1 was manually bent approximately 5 cm from the tip to allow for better reach and contact with the inter-ventricular septum. After insertion of the BRK-1 through the dilator, the dilator tip was pulled back slightly, a counter-clockwise torque was applied, and the sheath was positioned in the mid inter-ventricular septum, above the ICD coil, under fluoroscopic guidance (figure 1). This area did not demonstrate any large septal perforator coronary arteries, as confirmed by coronary angiography. Intracardiac echocardiography (ICE) was also used to guide dilator tip position at the inter-ventricular septum. Contrast injection through the BRK-1 needle was used to stain the septum (figure 1). It was then easily advanced (without resistance) across the muscular inter-ventricular septum into the LV. Contrast injection and pressure monitoring confirmed position in the LV, figure 1. The dilator and sheath were then advanced over the needle and positioned in the LV. The needle and dilator were then removed, the sheath was flushed and a 3.5 mm ThermoCool ablation catheter (Biosense-Webster, Diamond Bar, CA) was advanced via the Mullins sheath into the LV. Additional heparin was given during the procedure to maintain ACT over 300 seconds, and electroanatomic and activation mapping of the LV performed. The procedure from the insertion of the 10F sheath into the internal jugular vein to the insertion of the transseptal sheath into the LV took approximately 22 minutes. Of note, two other positions, one slightly higher and one slightly lower below the ICD coil were assessed before the final position noted in figure 1 was chosen. The position that was finally selected was better seated at the mid-portion of the inter-ventricular septum, which is safer, and allows for easier maneuverability of the sheath within the LV.

The clinical monomorphic VT (figure 2), was repeatedly induced and activation mapping of the VT performed. The VT successfully terminated with ablation at an exit site (-56 ms) in the mid inferior wall of the LV, and the acute endpoint of non-inducibility was achieved. Voltage mapping of the inferior wall scar was then performed and all the late potentials that were mapped were targeted with ablation (figure 2). At the end of the procedure, the ablation catheter and Mullins sheath were removed from the LV. ICE confirmed lack of pericardial effusion. TEE post procedure showed no evidence of left to right shunt or septal intramural hematoma.

Cardiac magnetic resonance imaging (MRI) was also obtained the morning after the procedure to assess location and closure of the transseptal sheath site. The MRI demonstrated a thin linear streak of delayed myocardial enhancement extending across the inter-ventricular septum (figure 3), likely representing the path of the transseptal sheath. No evidence of left to right shunt was again noted. Aneurysmal inferior wall dilatation and thinning, noted during ventriculography were also confirmed (figure 3).

The patient remained hemodynamically stable throughout the procedure and was discharged home 48 hours later. Repeat transthoracic echocardiography also showed no evidence of a ventricular septal defect and confirmed lack of intracardiac shunt.

Discussion

We describe the first reported human experience of a percutaneous inter--ventricular septal puncture to gain access to the LV endocardium. Traditionally, LV diagnostic hemodynamic monitoring and electrophysiological procedures in patients with combined mechanical aortic and mitral valve replacements have presented a challenge. In one patient, crossing of a mechanical mitral valve was reported for VT ablation in the setting of a LV assist device.⁹ The risks of catheter entrapment, hypotension, life-threatening valvular insufficiency, and death have shown that crossing these valves is undesirable.^{1, 2, 10, 11} Coronary pressure sensing wires have been used for invasive hemodynamic evaluation and measurement of bileaflet mechanical valve gradients.¹² However, these techniques are not suitable when larger catheters are needed to be introduced into the LV. Therefore, a percutaneous trans-apical approach has been undertaken for electrophysiology and interventional procedures in the LV. This method has been used for over 50 years for measuring gradients across aortic valve prostheses.^{13, 14} Hsieh *et al.* described catheter ablation of VT using this technique.¹⁵ However, trans-apical approaches carry a high risk of bleeding and other major and minor complications, ranging from 8 to 40%. These risks include pericardial bleeding, pneumothorax, hypotension, and injury to intercostal vessels or coronary arteries.^{4, 7, 8, 16-19} Further, the trans-apical approach requires the closure of the apical access site given the high risk of bleeding.²⁰

In this patient, an endocardial approach was initially chosen, despite the fact that he had normal coronary arteries. We chose an endocardial approach because he had clear evidence of an inferior wall myocardial infarction with Q waves noted on the inferior leads of his ECG and evidence of focal inferior wall motion abnormality on echocardiography and the levo phase (LV angiogram) of his RV angiography. It was suspected that he suffered from an inferior wall myocardial infarction due to an embolic mechanism that likely occurred during his aortic valve replacement. Therefore, endocardial predominant substrate was suspected and an initial endocardial approach pursued.

We chose to approach the inter-ventricular septum from the right internal jugular, instead of the femoral veins. This is because a superior approach would avoid the additional turn required to cross the tricuspid valve, and therefore, would provide an easier route to the

inter-ventricular septum. Subsequently, with a simple torque of transseptal sheath and needle, adequate contact on the inter-ventricular septum could be achieved.

Trans-ventricular delivery of large devices into the LV from the RV free wall using a subxiphoid approach across the inter-ventricular septum has been described in porcine hearts, where this procedure was performed successfully under magnetic resonance or echocardiographic guidance.^{21, 22} However, crossing the RV and inter-ventricular septum can increase the complication rate of either procedure alone and would still require the need for epicardial access and closure of the RV free wall. In this report, we describe obtaining LV access utilizing a superior approach (from the internal jugular vein) by crossing the inter-ventricular septum at its mid portion under ICE and fluoroscopic guidance with a therapeutic ACT of 300-350. Performing coronary angiography and RV angiography with levophase for LV angiography are key aspects of this procedure, required to delineate the muscular septal anatomy in relationship to the prosthetic valves, and to identify areas without interference from a septal perforator coronary artery. Further, this procedure would be expected to have a much lower risk of bleeding and tamponade, given that an epicardial approach to the apex is not required. Damage to major epicardial coronary arteries are also unlikely to occur with this approach. Finally, adhesions of the pericardium in post thoracotomy patients do not pose a challenge.

An additional benefit of the inter-ventricular transseptal approach is the orientation of myocardial fibers at the inter-ventricular septum compared to the apex. The fibers of the LV apex are oriented in a single direction, so that upon removal of large sheaths, spontaneous closure is difficult, resulting in bleeding, and requiring the use of closure devices. On the other hand, given the zig-zag geometry of the fibers of the RV versus the LV at the muscular inter-ventricular septum, crossing at this level would be expected to carry a minimal risk of shunting.²³⁻²⁷ Immediate recoil of the septum occurs and lower trans-myocardial pressure gradients across the RV vs. LV compared to the LV vs. pericardium would decrease the likelihood of bleeding. In this patient, no evidence of ventricular septal defect, intramural hematoma, or left to right shunt was found immediately post procedure on ICE, trans-esophageal or trans-thoracic echocardiography, and by MRI*. The septal puncture track was faintly seen on contrast enhanced MRI (Figure 3).

The inter-ventricular transseptal approach described in this report can also be considered for other interventions requiring LV access, where crossing the aortic or mitral valves is undesirable. Currently, in patients with severe aortic stenosis and comorbidities precluding open heart surgery, percutaneous aortic valve replacement using a trans-apical approach has been reported.^{28, 29} The inter-ventricular septal approach may present an alternate route for performing these procedures.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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*In the author's (KS) experience two additional cases (one patient needing LV access across a post-infarct septal defect resulted in a puncture above the defect and another case where this was done intentionally to access the LV for a para-valvular leak closure) where this approach was used the septal puncture site closed spontaneously. These cases provided the rationale for designing this novel procedure for clinical use.

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Figure 1. Inter-Ventricular Septal Puncture Technique

Upper right panel shows the transseptal needle that has been advanced through a Mullins transseptal sheath via the right internal jugular vein and positioned above the ICD coil, at the muscular interventricular septum. Staining of the inter-ventricular septum, best seen in the LAO view, is performed to confirm position. The needle is advanced across the septum and the sheath and dilator are advanced over the needle. The needle and dilator are removed and angiography of the LV is performed to assess position of the sheath in the LV (lower panels). RAO = right anterior oblique view, LAO = left anterior oblique view, RV = right ventricular catheter, His = Bundle of His catheter, LV = left ventricle, Mech MV = mechanical mitral valve, Mech AV = mechanical aortic valve.

Figure 2. Targeted VT, Fluoroscopy Images and Electroanatomic Map

The clinical RBBB morphology monomorphic VT with superior axis likely coming from the inferior scar of the LV is shown in the left panel. The successful ablation in the scar is shown in the middle panel and marked on the electroanatomic voltage map (right panel, arrow). Late potentials are further targeted within the inferior scar, as shown by red circles on the electroanatomic map. RAO = right anterior oblique view, LAO = left anterior oblique view, Abl = ablation catheter, Mech MV = mechanical mitral valve. Mech AV = mechanical aortic valve.

Figure 3. Magnetic Resonance Imaging

Magnetic resonance imaging with delayed enhancement (left panel) post procedure shows mild enhancement of the muscular inter-ventricular septum where access to the LV was obtained at a slightly oblique angle (arrows). The right panel shows short-axis bright blood MR imaging, demonstrating lack of a left to right shunt and thinning of the inferior LV wall (arrows). LV = left ventricle, RV = right ventricle, LA = left atrium, RA = right atrium, MV = mitral valve.