INNOVATIVE COLLECTIONS

COMPLEX CASE STUDY

Radiofrequency Ablation of Incessant Orthodromic Atrioventrioventricular Reciprocating Tachycardia on Extracorporeal Membrane Oxygenation Support

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ABSTRACT. Supraventricular tachycardia is typically well tolerated but can occasionally lead to cardiomyopathy and heart failure if incessant. It very rarely causes cardiogenic shock requiring mechanical support for treatment. We present an unusual case of a patient with distant history of repeat prior ablation for Wolf–Parkinson–White syndrome who presented with incessant atrioventricular reciprocating tachycardia that led to cardiogenic shock. He was stabilized with extracorporeal membrane oxygenation (ECMO) to allow for successful radiofrequency ablation. The patient made a full recovery. Limited data predominantly from the pediatric population with use of ECMO support for supraventricular tachycardia ablation is reviewed.

KEYWORDS. catheter ablation, extracorporeal membrane oxygenation support, supraventricular tachycardia, Wolff–Parkinson–White syndrome.

Introduction

Radiofrequency ablation (RFA) is the treatment of choice for medically refractory supraventricular tachycardia. In the adult population, orthodromic atrioventricular reciprocating tachycardia is typically well tolerated but, if incessant and prolonged, can cause acute cardiomyopathy and heart failure. In most cases, patients can be stabilized medically and then taken to the electrophysiology laboratory for ablation, but this may not be possible in the setting of cardiogenic shock. Extracorporeal membrane oxygenation (ECMO) has been used for arrhythmia management primarily in the pediatric population for cardiogenic shock secondary to medically intractable supraventricular arrhythmias and in adults with ventricular tachycardia. There is limited experience with RFA on ECMO, particularly in the adult population. We present a patient with incessant orthodromic atrioventricular reciprocating tachycardia who presented with cardiogenic shock requiring ECMO and urgent RFA.

Case report

A 54-year-old male presented to an outside emergency department with incessant supraventricular tachycardia (SVT). He had history of Wolff–Parkinson–White syndrome and had undergone open surgical cryoablation in 1991 followed by a repeat endocardial ablation in 1992 using a retrograde arterial approach. He presented to the emergency room with a 3-day history of persistent palpitations and dyspnea. An electrocardiogram (ECG) (Figure 1) showed an SVT with a ventricular rate of 170 bpm. The tachycardia was recurrent and incessant despite the administration of escalating doses of adenosine, intravenous metoprolol tartrate, and cardioversion. Pressor support was required for hypotension. An ECG obtained during transient sinus rhythm demonstrated no
evidence of ventricular pre-excitation. Given the recurrent and poorly tolerated nature of the tachycardia, he was transferred to our facility for urgent RFA.

Shortly after arrival to our facility, the patient transiently spontaneously converted to sinus rhythm. A transthoracic echocardiogram in sinus rhythm demonstrated a left ventricular ejection fraction (LVEF) of 10%. While awaiting transport to the electrophysiology laboratory, the patient became increasingly agitated and developed increasing dyspnea and hypoxia. Shortly thereafter, he suffered a cardiopulmonary arrest with severe hypoxia and pulseless electrical activity. The patient was intubated and norepinephrine was initiated for acute hemodynamic support. This triggered incessant SVT that could not be controlled despite intravenous amiodarone and repeated cardioversions. His condition deteriorated rapidly with development of cardiogenic shock with a lactate level of 8 and an arterial pH of 7.1. It was felt that pharmacologic support alone would not be sufficient to support him through the ablation procedure. Veno-arterial ECMO (Cardiohelp, Maquet, Rastatt, Germany) with a 24F Femtrack venous (Edwards Lifesciences, Irvine, CA) sheath and a 22F arterial sheath was initiated with percutaneous cannulation of the left femoral artery and vein and placement of a distal perfusion catheter in an effort to stabilize the patient prior to electrophysiology study. During percutaneous cannulation for ECMO, a transesophageal echocardiogram in SVT demonstrated an LVEF of <10%. An intra-aortic balloon pump (IABP) was placed in the right femoral artery for further unloading. Continuous renal replacement therapy was initiated.

Metabolic abnormalities improved over the first 12 h of ECMO support and the patient was taken to the electrophysiology laboratory in the SVT for an electrophysiology study. Three femoral venous sheaths were placed in the right femoral vein using a modified Seldinger technique. A decapolar coronary sinus catheter (Biosense Webster, Diamond Bar, CA) was positioned, and then a quadripolar catheter (St. Jude Medical, St. Paul, MN) was placed in the right ventricle. The tachycardia briefly terminated during placement of the catheter distally in the coronary sinus. However, it was easily reinduced using burst pacing in the ventricle and atrium and by delivering single extrastimuli from the proximal coronary sinus at pacing cycle length 600 ms and coupling interval of 370 ms. The tachycardia cycle length was 390 ms, with orthodromic activation antegrade through the atrioventricular node. Retrograde atrial activation was eccentric, with bipolar electrodes 5, 6 of the coronary sinus catheter showing earliest activation; the septal ventriculoatrial time was 140 ms, most consistent with left-sided accessory pathway. The tachycardia could not be entrained from the ventricle as it consistently terminated as soon as right ventricular pacing commenced. A transseptal approach was preferred over a retroaortic approach because arterial access for ECMO required a 24F cannula in the left femoral artery and the IABP was placed in the right femoral artery. Transseptal puncture was carried out in standard fashion utilizing a large curve Baylis needle and SL-1 sheath flushed with heparinized saline then a continuous fast flush line. Transesophageal echocardiography was used to guide transseptal puncture instead of intracardiac echo in order to minimize catheters in the venous system, as a 24F cannula was already inserted into the right common femoral vein. Additional boluses and drip adjustments were made after transseptal puncture to maintain ACT between 250 and 300 during the ablation. A Biosense Webster Thermocool 3.5 mm D/F curve SmartTouch catheter (Biosense Webster) was advanced through the sheath and placed on the atrial side of the mitral annulus, and an activation

Figure 1: Twelve-lead electrocardiogram of supraventricular tachycardia.
map was created during tachycardia, mapping the earliest retrograde atrial activation signal. Three-dimensional activation mapping was also performed using CARTO (Biosense Webster). Mapping the endocardial side corresponding to coronary sinus bipolar electrodes 5, 6, there was a small sharp signal preceding the atrial signal that seemed to indicate an accessory pathway potential. However, no typical ventriculoatrial electrogram fusion was seen at successful ablation sites (Figure 2). This most likely reflected damage to the accessory pathway from prior ablations and delayed conduction through the bypass tract. Activation mapping was performed proximally and distally on the mitral annulus and showed later activation signals in both directions. Ablation was carried out during tachycardia at the site with a sharp signal preceding the atrial signal with titrating power to 30–35 watts on the mitral annulus. During the first ablation, the tachycardia terminated within 2 s (Figure 2). Surrounding lesions were applied both proximal and distal to the initial lesion as well as on the atrial and ventricular sides of the annulus. Contact force achieved was between 7 and 12 g, and we obtained greater than 6 ohm impedance drop at each site. Following these lesions, attempts to reinude the tachycardia were unsuccessful. After a waiting period of 30 min, there was still no evidence for accessory pathway conduction. Repeat programmed stimulation did not provoke any further tachyarrhythmias. At a pacing cycle length of 400 ms, there was no evidence of retrograde ventriculoatrial conduction. ECMO and IABP support were maintained awaiting myocardial recovery. The IABP was removed on day 5. By day 6, LVEF had improved to 20%. A weaning trial was conducted by decreasing pump flow initially to 2 lpm. Hemodynamic stability was maintained and increased pulsatility of the ventricle was observed. After heparin bolus increasing ACT to 400, pump flow was decreased to 1 lpm without hemodynamic deterioration. Accordingly, he was taken to the operating room where the ECMO system was removed. Following complete decannulation, a transesophageal echocardiogram showed an LVEF of 25%. By day 8 he had complete recovery of left ventricular function with an LVEF of 50–55% (Figure 3). His hospital course was complicated by hospital-acquired pneumonia and prolonged ventilation secondary to significant underlying lung disease. He made a full recovery.

Discussion

Recurrence rates after Wolff–Parkinson–White ablation can be as high as 9%. Our patient had undergone two prior ablations, presumably for the same SVT and
accessory pathway. This conclusion was supported by the ECG characteristics at the site of successful ablation with local ECG characteristics of an accessory pathway potential and lack of typical ventriculoatrial fusion suggestive of prior ablation. Post-ablation change in ventricular atrial activation timing with inability to conduct at 400 ms argues against an atrial tachycardia despite the inability to perform ventricular pacing maneuvers during tachycardia. Interestingly, the tachycardia became incessant in a much delayed manner and nearly fatal with evidence of delayed conduction through the accessory pathway. The culmination of decompensated heart failure, cardiogenic shock, and cardiopulmonary arrest necessitated temporary mechanical circulatory support to stabilize the patient and allow for definitive treatment. Electrophysiology study and ablation were performed using a fairly standard approach despite the patient being on ECMO, except to minimize the number of catheters used and to employ transesophageal echocardiography rather than intracardiac echocardiography to guide transseptal puncture. Successful treatment of the arrhythmia allowed for relatively rapid recovery of systolic function and ability to wean from ECMO with full recovery of the patient. There are limited data in the literature describing RFA of tachyarrhythmias with ECMO support. ECMO had been employed in the pediatric population with only limited reports of use in the adult population. Mechanical circulatory assist devices such as ECMO allow for stabilization of patients too sick to undergo procedures in their current hemodynamic state. As the early use of mechanical circulatory assist devices in the treatment of cardiogenic shock increases, it is likely there will be a rise in electrophysiology cases that are performed on ECMO support. ECMO support has been successfully used in the pediatric population. Booth et al.2 described pediatric catheterization procedures in 54 patients who required ECMO support for predominantly low cardiac output or sudden cardiac arrest. This patient cohort included two newborns who required ECMO for refractory arrhythmias and underwent successful SVT ablation. Silva et al.3 reported 39 pediatric cases with an average age of 5.5 months who required mechanical support for treatment; 90% of patients were treated with ECMO (43% emergently while undergoing cardiopulmonary resuscitation). Sixty-nine percent required support for SVT. The vast majority (95%) were treated with antiarrhythmic therapy, but 13 patients (33%) required electrophysiology study and ablation. All ablations were acutely successful but with a 15% procedural complication rate. Fewer studies are available in the adult population. Scherrer et al.4 reported a case of ECMO in a 24-year-old female with post-partum cardiogenic shock from persistent left inferior pulmonary vein atrial tachycardia who exhibited recovery in systolic function similar to that we experienced.4 Cheruva et al.5 and Rizkallah et al.6 reported cases of successful ablations for accessory pathway ablation and idiopathic left ventricular tachycardia, respectively. Mechanical support is more commonly used with ventricular tachycardia ablation in adults though more typically partial support with a percutaneous left ventricular assist device is utilized. Lu et al.7 described use of hemodynamic support for unstable ventricular tachycardia in 16 patients. Five patients had percutaneous LVAD (Impella 2.5, Abiomed, Inc, Danvers, MA), six patients had implantable LVAD (HeartMate II, Thoratec, Pleasanton, CA), and peripheral cardiopulmonary bypass (Performer, Medtronic Inc., Minneapolis, MN) was used in five patients. They noted no complications in patients undergoing ablation with full hemodynamic support with a cardiopulmonary bypass; the Impella provided insufficient hemodynamic support alone in one patient who required premature termination of sustained ventricular tachycardia. In our case, full hemodynamic support was required given the profound cardiogenic shock and inability to stop the arrhythmia. We felt that the ECMO support was lifesaving and allowed for safe, successful ablation of an incessant tachycardia associated with a residual concealed left-sided accessory pathway.

References