Minimizing Magnetic Interaction Between an Electroanatomic Navigation System and a Left Ventricular Assist Device

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ABSTRACT. Ventricular tachycardia catheter ablation in the presence of a left ventricular assist device (LVAD) is increasing in frequency due to the independent growth of both procedures. We present a case report illustrating two procedural challenges with resolution: 1) inability to pass a catheter retrograde through the aortic valve due to low flow; and 2) interference between the magnetic electroanatomic mapping system and the magnetic LVAD pump. We demonstrate the advantages of newer ablation tools including automated pace-mapping, fluoro integration, and variable ablation lesion formation in this setting.

KEYWORDS. catheter ablation, image integration, left ventricular assist device, mapping, ventricular tachycardia.

Introduction
Commonly used electroanatomic mapping systems record images based on weak magnetic fields of the heart. We present a case report where this imaging was compromised by the magnetic field generated from a left ventricular assist device. Opportunities to minimize this interference as well as other aspects of the challenging scenario are discussed.

Case presentation
A 67-year-old man was admitted with ventricular tachycardia storm. He had a longstanding history of an ischemic cardiomyopathy with prior coronary artery bypass surgery in 2003 and prior biventricular implantable cardioverter-defibrillator (ICD) (CRT-D Unify, Model 3231-40, St. Jude Medical, Sylmar, CA) in September 2011. He developed severely symptomatic systolic heart failure. In June 2012, the patient underwent insertion of a left ventricular assist device (LVAD) (HeartMate II, Thoratec Corporation, Pleasanton, CA). Over 12 h, the patient received 60 antitachycardia pacing terminations and five shocks from his ICD. Device interrogation and clinical rhythm strips documented a monomorphic ventricular tachycardia (VT) at a cycle length of 393 ms (Figure 2). Medication therapy with amiodarone and lidocaine were ineffective. Although the patient was pressor-dependent and listed on the transplant waiting list, it was anticipated that he was unlikely to receive a cardiac transplant for several weeks because of lack of donor availability, related to body size and blood type.

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The patient was emergently taken to the electrophysiology (EP) laboratory for VT mapping and ablation. He presented 100% biventricular paced with LVAD speed at 8800 rpm. Arterial and venous access was obtained and an ultrasound catheter (SoundStar, Biosense Webster, Diamond Bar, CA) was used to create an initial map of the right ventricle. An irrigated tip catheter (Thermacool SF, Biosense Webster) was placed in the right ventricle (RV) and used to perform a fast anatomical map (FAM). Catheter manipulation induced a sustained monomorphic VT, different from VT #1 with a left bundle...
branch (LBB) morphology, superior access, and precordial transition in V5 at a cycle length of 458 ms (VT #1, Figure 1). While creating the anatomical map, the irrigated magnetic based catheter encountered severe magnetic interference whenever in close proximity (approximately 8 cm) to the LVAD motor. While electrogram images were undisturbed, the three-dimensional electroanatomic activation and voltage maps could not be created. Owing to the patient’s dependence and the risk of thrombosis, it was not possible to temporarily stop the LVAD. A 12-lead electrocardiogram (ECG) of the VT analyzed using the Segal algorithm suggested an inferior LV origin (Figure 1). With ECG and RV pace mapping suggesting the VT origin was in the LV, a retrograde aortic approach was performed with the mapping/ablation catheter.

Difficulty was encountered passing the irrigated tip ablation catheter retrograde across the aortic valve. An echocardiogram documented that the LV function was so poor (ejection fraction 5%) that the valve would not open in systole. With the assistance of an interventional cardiologist (KH), the valve was crossed with an angled 180-cm, 0.035-inch Glidewire (Terumo, Somerset, NJ), and then an 8F 100-cm sheath was advanced into the body of the left ventricle (Arrow, Reading, PA), and the ablation catheter then maneuvered for intracardiac mapping. Care was taken to avoid inadvertent insertion of the catheter or sheath into the inflow of the LVAD at
Figure 3: Integration of fluoroscopic image into electroanatomic map (CARTO UniVu).
Figure 4: Electroanatomic map with left ventricular assist device (LVAD) pump at 8800 rpm setting. Substrate (voltage or activation) mapping at catheter locations close to the LVAD were not possible.
Figure 5: Electroanatomic map with left ventricular assist device pump at 6000 rpm setting resulted in less magnetic interference and an improved anatomic map.
the LV apex. A second VT (VT #2, Figure 2) was induced: LBB morphology, inferior axis, precordial transition in V5, cycle length 393 ms. It correlated with the predominant clinical VT. Again, the anatomic map was compromised by magnetic interference. However, pace mapping could be performed with superimposed fluoroscopic images (UniVu, Biosense Webster) (Figure 4). A software-assisted pace map (PaSo, Biosense Webster) concordance of 91% was obtained for VT #2 at a septal superior LV location. However, the magnetic interference prohibited substrate mapping to document ablation lesion locations (Figure 4). With the assistance of the LVAD team, the pump speed was diminished gradually from 8800 rpm to 6000 rpm, associated with acceptable hypotension (MAP diminished from 75 to 61 mmHg), performed in 3-min increments. This slower LVAD pump speed was associated with less magnetic interference allowing visualization of ventricular anatomy up to 4 cm from the LVAD. A better electroanatomic map was achieved (Figures 5). This permitted radiofrequency (RF) ablation of two separate VT sites, one from the LV lateral wall (VT #2) and one from the RV septum (VT #1) (Figure 6). Intracardiac echocardiography (ICE) and voltage mapping were also performed, identifying scar borders which were also connected with RF energy, all at 40 W through the irrigated catheter. Subsequently, pacing maneuvers with and without isoproterenol, at doses up to 5 μg/min, could no longer induce VT. Ventricular fibrillation was induced on one occasion and promptly terminated. Interestingly, when in ventricular fibrillation, the mean arterial pressure was unchanged, confirming LVAD dependence with minimal contribution from intrinsic cardiac function.

Figure 6: Final post-ablation map showing right and left ventricular tachycardia ablation sites, circled.
Subsequently, the patient’s clinical VT dramatically diminished with only two documented episodes in the next week, both successfully pace terminated with the ICDs antitachycardia pacing feature. Fifteen days later, the patient underwent successful cardiac transplantation with removal of the LVAD and ICD. He continues to improve clinically.

Commentary

Prior reports have documented the feasibility of VT ablation in patients with continuous flow LVADs. We highlight some uncommon clinical challenges when performing ablation in the setting of an LVAD. While apical LV foci can be mapped utilizing a transseptal approach, septal and basal VTs are often best reached using the retrograde aortic approach. In a patient with a closed but functioning aortic valve, interventional cardiology techniques were useful in crossing the valve for LV access. Care must be taken to avoid damage to the aortic valve leaflets as well as inadvertent catheter transgression into the LVAD inflow tract.

Secondly, the case demonstrates the challenge of interference between a magnetic LVAD and a magnetic electroanatomic map used for catheter ablation of ventricular tachycardia. Both of these procedures are increasing in frequency. When performing ablation with electroanatomic mapping, a non-magnetic system should be considered. If a magnetic based map is performed, this case demonstrates the need for temporarily slowing the LVAD pump rate to minimize interference. This allowed for utilization of the additional tools available in this magnetic mapping system, such as automated pace-mapping, fluoro integration, and variable ablation lesion formation. As a result, a successful ablation ensued. This is the first case report highlighting opportunities to utilize these new complex mapping technologies in the setting of an implanted LVAD.

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References