

# Successful ventricular tachycardia ablation in a patient with a biventricular ventricular assist device and heparin-induced thrombocytopenia using bivalirudin



Gordon Ho, MD,\* Hao A. Tran, MD,\* Marcus A. Urey, MD,\* Eric D. Adler, MD,\* Victor G. Pretorius, MBChB,<sup>†</sup> Jonathan C. Hsu, MD, MAS, FHRS\*

From the \*Division of Cardiology, Department of Medicine, University of California San Diego, La Jolla, California, and <sup>†</sup>Department of Cardiothoracic Surgery, University of California San Diego, La Jolla, California.

## Introduction

Ventricular arrhythmias are common in patients with ventricular assist devices.<sup>1</sup> Ablation of ventricular tachycardia (VT) in patients with left ventricular assist devices (LVADs) appears to be safe and effective.<sup>2–4</sup> However, in patients with durable biventricular assist devices (BIVAD), the safety and feasibility of VT ablation has not been well characterized in the literature. Only 1 case of VT ablation has been reported in a patient with a BIVAD, in which the right-sided inflow cannula was located in the right ventricle.<sup>5</sup> Electroanatomic (EA) and pace mapping was performed in the right ventricle only to guide ablation of a VT site located near the right ventricular (RV) inflow cannula. However, more recent implantation techniques favor implantation of the RV assist device inflow cannula in the right atrial anterior wall to prevent suction events frequently encountered by RV cannulation.<sup>6,7</sup> With this BIVAD configuration, it is unknown whether transseptal puncture, intracardiac echocardiography (ICE), and EA mapping can be safely performed without encountering significant interference, given the close proximity of electrophysiology catheters and EA mapping patches to the inflow cannula in the right atrium. Secondly, the safety of using bivalirudin for anticoagulation in patients with oliguric renal failure during

VT ablation is unknown, given that it is renally excreted. We report safe and successful VT ablation utilizing transseptal access and bivalirudin in a patient with a BIVAD configured with a right atrial inflow cannula.

## Case report

A 69-year-old man with a history of severe ischemic cardiomyopathy presented with cardiogenic shock and underwent BIVAD implantation with inflow cannulas (HeartWare, Framingham, MA) located in the anterior right atrial wall (Figure 1A, red arrow) and the left ventricular (LV) apex. His bicuspid aortic valve was partially stitched to prevent worsening of his moderate aortic regurgitation after VAD implantation. He had anuric renal failure and received continuous renal replacement therapy. He developed heparin-induced thrombocytopenia confirmed by serotonin release assay and was maintained on a bivalirudin intravenous drip at 0.09 mg/kg/h. Postoperatively, he developed unstable sustained VT refractory to intravenous amiodarone, lidocaine, and stellate ganglion pulsed radiofrequency ablation and was referred for VT ablation.

In the electrophysiology laboratory, continuous renal replacement therapy was temporarily stopped for the ablation procedure. He was given multiple bivalirudin boluses of 0.3 mg/kg and his intravenous drip was eventually increased to 0.3 mg/kg/h to achieve activated clotting time (ACT) 300–350 s, with ACT checks every 30 minutes (Figure 2). Transseptal access was performed successfully per standard fashion using a radiofrequency transseptal needle (Baylis, Montreal, Canada), steerable long sheath (Agilis, Abbott, St. Paul, MN), fluoroscopy, and ICE, as shown in Figure 1A. No interference was experienced on ICE despite close proximity of the ICE catheter (Figure 1A, white arrow) to the right atrial inflow cannula (Figure 1A and C, red arrows).

Programmed electrical stimulation induced at least 7 VT morphologies. However, VT morphologies would switch or be electrically unstable, so substrate mapping was mainly

**KEYWORDS** Anticoagulation; Biventricular assist device; Catheter ablation; Electroanatomic mapping; Ventricular tachycardia (Heart Rhythm Case Reports 2018;4:367–370)

Dr Ho has received fellowship support from Boston Scientific, Medtronic, and Biotronik, and has equity in Vektor Medical Inc (<\$10,000) for work unrelated to this manuscript. Dr Adler has been a consultant for Medtronic. Dr Pretorius is a consultant for Medtronic and Abbott. Dr Hsu has received honoraria from Medtronic, St. Jude Medical, Boston Scientific, and Biotronik and research grants from Biosense Webster and Biotronik. Drs Urey and Tran have no disclosures. **Address reprint requests and correspondence:** Dr Jonathan C. Hsu, University of California San Diego, 9444 Medical Center Dr #7411, La Jolla, CA 92037. E-mail address: [Jonathan.Hsu@ucsd.edu](mailto:Jonathan.Hsu@ucsd.edu).

## KEY TEACHING POINTS

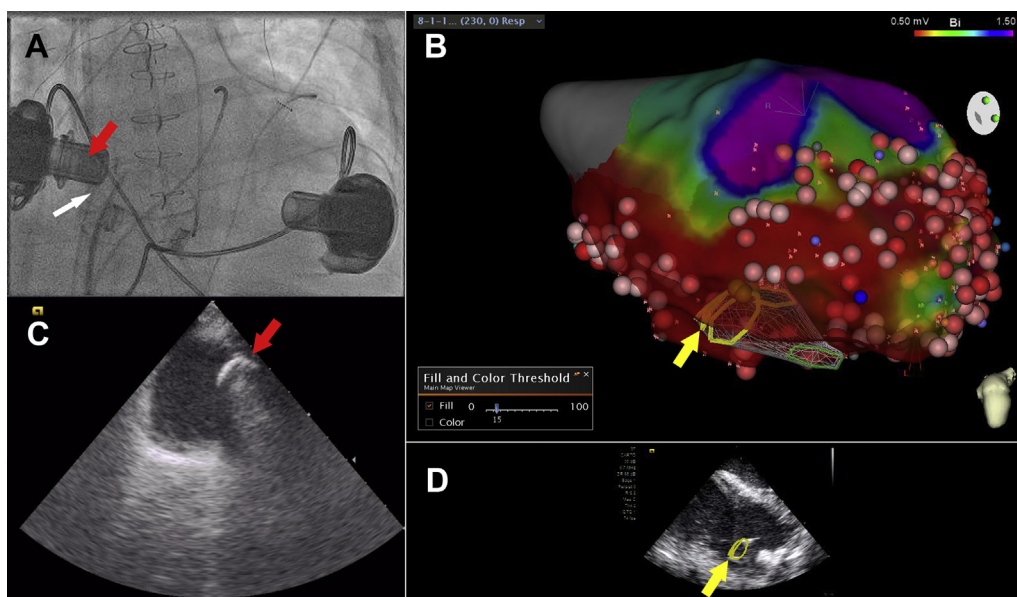
- In patients with a biventricular assist device configured with a right atrial inflow cannula in addition to the left ventricular inflow cannula, ventricular tachycardia (VT) ablation may be safely and effectively performed using standard techniques for transseptal access, intracardiac echocardiography (ICE), and electroanatomic (EA) mapping.
- ICE and its integration with EA mapping is feasible without interference from the right atrial inflow cannula, despite close proximity of the ICE catheter to the inflow cannula. EA mapping reference patches should be placed as far away from underlying inflow cannulas as possible to minimize interference with the mapping system.
- An anticoagulation strategy utilizing bivalirudin may be considered for patients with heparin-induced thrombocytopenia, anuric renal failure, and ventricular assist device hardware, but may require titration of standard renal dosing to maintain adequate anticoagulation for transseptal access to the left ventricle.

was obtained using a 3.5 mm contact force open-irrigated ablation catheter (SmartTouch SF, Biosense Webster). The mapping reference patches were positioned on the chest wall in a manner to avoid overlaying the 2 inflow cannulas. Interference was experienced with EA mapping when the ablator was within 1 cm of the LV apical inflow cannula, manifesting as loss of catheter visualization. No interference was experienced with ICE integration, and the LV inflow cannula was well visualized on ICE (Figure 1B and D). Extensive substrate modification was performed to homogenize the entire scar located circumferentially around the entire mid-LV and sites of late potentials and fractionation. A total of 119 lesions were delivered (Figure 1B, balls). At the end of the procedure, VT was no longer inducible down to ventricular effective refractory period with double extrastimuli. Despite uninterrupted anticoagulation with bivalirudin, complete hemostasis was achieved using percutaneous sutures for all venous access sites (Perclose, Abbott, St. Paul, MN). No complications related to the procedure occurred. Unfortunately, although the burden of VT was significantly reduced, the patient had 3 episodes of polymorphic VT 1 week later when he developed bleeding from a gastric arteriovenous malformation that was clipped. He ultimately died of sepsis and candidemia 1 month later.

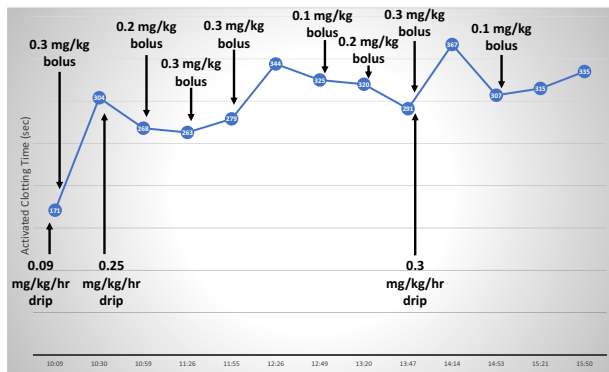
## Discussion

Durable BIVADs utilizing 2 centrifugal VADs are increasingly being used to support LVAD patients with RV failure. More recently, a novel technique of implanting the right-sided VAD in the right atrial anterior wall instead of the right ventricle wall offers several advantages, such as preventing

performed (Figure 3). Electroanatomic mapping was integrated with ICE (Carto 3/CartoSound, Biosense Webster, Diamond Bar, CA), and LV geometry and a substrate map



**Figure 1** Ventricular tachycardia ablation for a patient with a biventricular assist device. **A:** An anteroposterior fluoroscopy image shows ventricular assist devices implanted at the right atrial wall (red arrow) and the left ventricular apex. An intracardiac echocardiography (ICE) catheter (white arrow) and transseptal steerable sheath are in close proximity to the right atrial inflow cannula (red arrow). The right atrial inflow cannula is visualized using ICE (**C**, red arrow). **B:** Electroanatomic mapping demonstrates extensive substrate ablation (round balls) with the left ventricular assist device inflow cannula denoted by the yellow circle and mesh (yellow arrow), visualized by ICE and CartoSound (**D**, yellow arrow).



**Figure 2** Trend of activated clotting time with bivalirudin dose during ventricular tachycardia ablation. A graph of the activated clotting time (ACT) is plotted against time during the procedure with timing and dosing of boluses (top) and infusion (bottom). The baseline ACT was 171 seconds at the beginning of the case on the patient's maintenance bivalirudin. The patient was off continuous renal replacement therapy during the case.

suction events or obstruction of flow by the tricuspid valve.<sup>6,7</sup> There have been no reports of VT ablation in patients with this BIVAD configuration, and it is unknown whether the right atrial cannula may impede transseptal catheterization or cause electromagnetic interference with catheters typically positioned in the right atrium.

Interference in the LV has been reported with magnetic-based mapping systems such as Carto 3 in patients with an axial LVAD (HeartMate II, Abbott, Chicago, IL), centrifugal LVAD (HeartWare, Medtronic), or percutaneous LV micro-axial assist device (Impella 2.5, Abiomed, Danvers, MA).<sup>8–10</sup> The interference is typically limited to the areas where the ablation catheter is in close proximity to the rotational assist device, and manifests as loss of catheter visualization, electromagnetic interference, and/or altered force readings. However, the interference usually has not been significant enough to prevent successful completion of VT ablation. Interference with the percutaneous Impella 2.5 has been noted at higher performance (P8, 50,000 rpm)

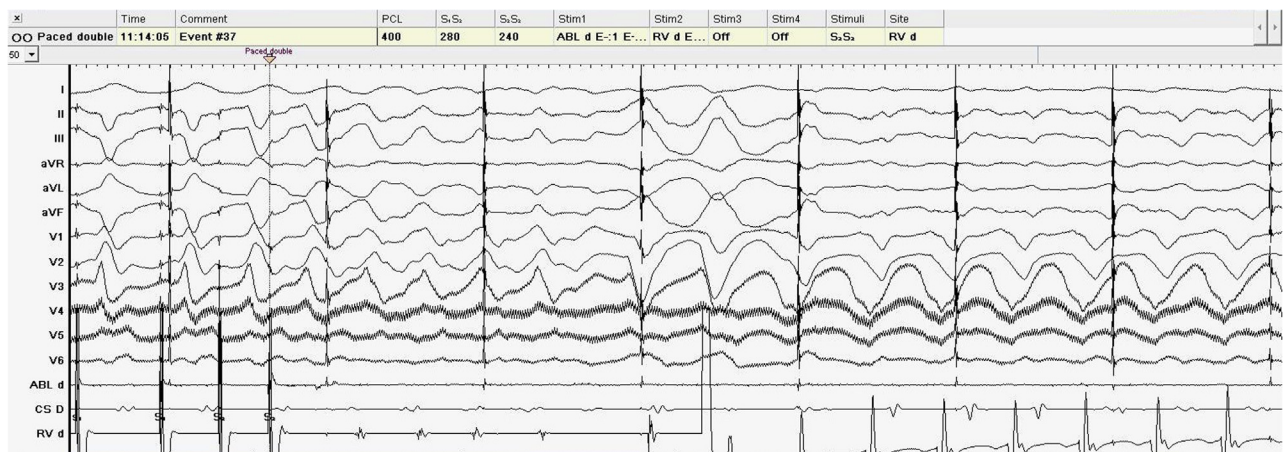
and can be reduced by temporarily turning down the performance specifically to P6 (45,000 rpm).<sup>10</sup> Interestingly, interference has not been reported with purely impedance-based mapping systems such as Velocity (Abbott, St. Paul, MN)<sup>4</sup> or with externally placed pumps such as VA ECMO and TandemHeart (CardiacAssist, Pittsburgh, PA),<sup>11</sup> although the experience with these systems has not been as widely published.

In this case, the right atrial inflow cannula did not cause interference with EA mapping or impede ICE or transseptal puncture. Although loss of catheter visualization occurred in the area immediately surrounding the LV cannula, as reported previously,<sup>4</sup> no interference was experienced anywhere else in the LV, and the areas around both the LV and right atrial inflow cannulas were well visualized with ICE and easily integrated into the EA mapping system. This is the first report of safe and successful manipulation of electrophysiology catheters around a right atrial inflow cannula, and supports further studies into the feasibility of right atrial ablation in these patients. The use of ICE near the right atrial inflow cannula appears safe and may help improve visualization of the areas obscured by interference from EA mapping.

Secondly, the use of bivalirudin during catheter ablation has only been reported in patients with normal renal function using percutaneous coronary intervention dosing.<sup>12–14</sup> Although this case demonstrates that bivalirudin may be safe and effective in patients with anuric renal failure and a BIVAD, the standard hemodialysis-adjusted dosing may not be enough to maintain therapeutic ACT. This suggests that in longer left-sided procedures in the setting of renal failure, it may be necessary to titrate standard renal bivalirudin dosing to maintain adequate anticoagulation levels.

## Conclusion

EA mapping, ICE, and transseptal puncture are feasible and appear safe in patients with a BIVAD with a right atrial



**Figure 3** Induced ventricular tachycardia. This surface and intracardiac electrogram shows programmed electrical stimulation using double extrastimuli (400–200–240) inducing a ventricular tachycardia that spontaneously changes morphology from a right bundle branch block inferior axis to a left bundle branch block superior axis apical morphology.

inflow cannula. Anticoagulation with bivalirudin appears to be safe in patients with oliguric renal failure undergoing LV endocardial ablation via transseptal access, but may require titration with standard laboratory monitoring in order to assure proper anticoagulation status.

## Acknowledgments

The authors thank Byron Klassen, BS, CEPS, and Lynn Ho, BS, for technical assistance to help create the figures.

## References

- Al-Khatib SM, Stevenson WG, Ackerman MJ, et al. 2017 AHA/ACC/HRS Guideline for Management of Patients With Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines and the Heart Rhythm Society [published online ahead of print October 30, 2017]. *Heart Rhythm*. <https://doi.org/10.1016/j.hrthm.2017.10.035>.
- Garan AR, Iyer V, Whang W, Mody KP, Yuzefpolskaya M, Colombo PC, Te-Frey R, Takayama H, Naka Y, Garan H. Catheter ablation for ventricular tachyarrhythmias in patients supported by continuous-flow left ventricular assist devices. *ASAIO J* 2014;60:311–316.
- Moss JD, Flatley EE, Beaser AD, Shin JH, Nayak HM, Upadhyay GA, Burke MC, Jeevanandam V, Uriel N, Tung R. Characterization of ventricular tachycardia after left ventricular assist device implantation as destination therapy: a single-center ablation experience. *JACC Clin Electrophysiol* 2017; 3:1412–1424.
- Sacher F, Reichlin T, Zado ES, Field ME, Viles-Gonzalez JF, Peichl P, Ellenbogen KA, Maury P, Dukkipati SR, Picard F. Characteristics of ventricular tachycardia ablation in patients with continuous flow left ventricular assist devices. *Circ Arrhythm Electrophysiol* 2015;8:592–597.
- Mulukutla V, Lam W, Simpson L, Mathuria N. Successful catheter ablation of hemodynamically significant ventricular tachycardia in a patient with biventricular assist device support. *HeartRhythm Case Rep* 2015;1:209.
- Cork DP, Tran HA, Silva J, Barnard D, Greenberg B, Adler ED, Pretorius V. A case series of biventricular circulatory support using two ventricular assist devices: a novel operative approach. *Ann Thorac Surg* 2015;100:e75–e77.
- Tran HA, Pollema TL, Silva JE, Greenberg BH, Barnard DD, Adler ED, Pretorius VG. Durable biventricular support using right atrial placement of the HeartWare HVAD. *ASAIO J* 2018;64:323–327.
- Miller MA, Dukkipati SR, Chinitz JS, Koruth JS, Mittnacht AJ, Napolitano C, d'Avila A, Reddy VY. Percutaneous hemodynamic support with Impella 2.5 during scar-related ventricular tachycardia ablation (PERMIT 1). *Circ Arrhythm Electrophysiol* 2013;6(1):151–159.
- Miller MA, Dukkipati SR, Koruth JS, d'Avila A, Reddy VY. How to perform ventricular tachycardia ablation with a percutaneous left ventricular assist device. *Heart Rhythm* 2012;9:1168–1176.
- Vaidya VR, Desimone CV, Madhavan M, Noheria A, Shahid M, Walters J, Ladewig DJ, Mikell SB, Johnson SB, Suddendorf SH, Asirvatham SJ. Compatibility of electroanatomical mapping systems with a concurrent percutaneous axial flow ventricular assist device. *J Cardiovasc Electrophysiol* 2014;25:781–786.
- Miller AC, Evans AC, Revenaugh J, Weiss JP, Reid BB, Kfoury AG. Combined use of TandemHeart percutaneous ventricular assist device and Stereotaxis magnetic navigation during cardiac ablation procedure. *HeartRhythm Case Rep* 2016;2:14.
- Baetz BE, Gerstenfeld EP, Kolansky DM, Spinler SA. Bivalirudin use during radiofrequency catheter ablation procedures in two patients with a history of heparin-induced thrombocytopenia. *Pharmacotherapy* 2010;30:952.
- Bellmann B, Nagel P, Muntean BG. Successful intraprocedural anticoagulation with bivalirudin during pulmonary vein isolation in a patient with known heparin-induced thrombocytopenia type II. *J Arrhythm* 2016;32:154–155.
- Ellis ER. Successful use of bivalirudin in place of heparin infusion for pulmonary vein isolation using a cryoballoon catheter in a patient with heparin allergy. *Heart-Rhythm Case Rep* 2017;3:10–12.