Novel use of preprocedure imaging for planning and guidance of right atrium–to–left ventricle access for catheter ablation of ventricular tachycardia

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Introduction

Traditional approaches to access the left ventricle (LV) for endocardial catheter ablation of ventricular tachycardia (VT) are not feasible in patients with simultaneous mitral and aortic mechanical valve replacements. Recent data[1] have shown that access directly from the right atrium (RA) through the inferior septal process of the LV, site of a so-called Gerbode defect, can be safely performed. In this report, preprocedure imaging was used to plan the optimal site of access and registered to the mapping system to help guide the procedure in real time.

Case report

A 78-year-old man with bicuspid aortic valve and subsequent endocarditis resulting in placement of mechanical aortic and mitral valves, closure of a mitral paravalvular leak with an Amplatzer device, and myocardial infarction due to thromboembolism to the left circumflex artery during cardiac surgery subsequently developed heart failure with reduced ejection fraction with episodes of VT and underwent placement of an implantable cardiac defibrillator (ICD) with later development of complete heart block and upgrade to a cardiac resynchronization therapy defibrillator with epicardial LV leads. Over the prior several months he began having frequent episodes of monomorphic VT requiring antitachycardia pacing and defibrillation despite 2 antiarrhythmic drugs, so the decision was made to pursue catheter ablation. Given his dual mechanical valves, a traditional transseptal or retrograde aortic approach would not be possible, so after discussion with the patient, we planned for RA-to-LV puncture through the inferior septal process of the LV (region of a Gerbode defect).

In order to enhance preprocedural planning and maximize safety and success for the procedure, we obtained a noncontrast electrocardiogram-gated cardiac computed tomography (CT) scan (gated at end-diastole) and processed the images with image reconstruction software (inHeart, Bordeaux, France). Though contrast was not used owing to his advanced

KEY TEACHING POINTS

- Trans–right atrial to left ventricular access via the inferior septal process is a safe technique for catheter ablation of ventricular tachycardia in patients with mechanical aortic and mitral valve prostheses.
- Preprocedure cardiac computed tomography (CT) can be used to identify the optimal site of puncture, allowing for the appropriate distance from the His bundle and mechanical valves, as well as choosing the ideal trajectory into the left ventricle (LV) for the ablation procedure.
- The aortic root and mechanical valves can be used for accurate coregistration of a 3-D cardiac CT reconstruction with the electroanatomic mapping system and allow enhanced real-time guidance of LV access and ablation.

KEYWORDS Ablation; Imaging; LV access; Mechanical valves; Ventricular tachycardia
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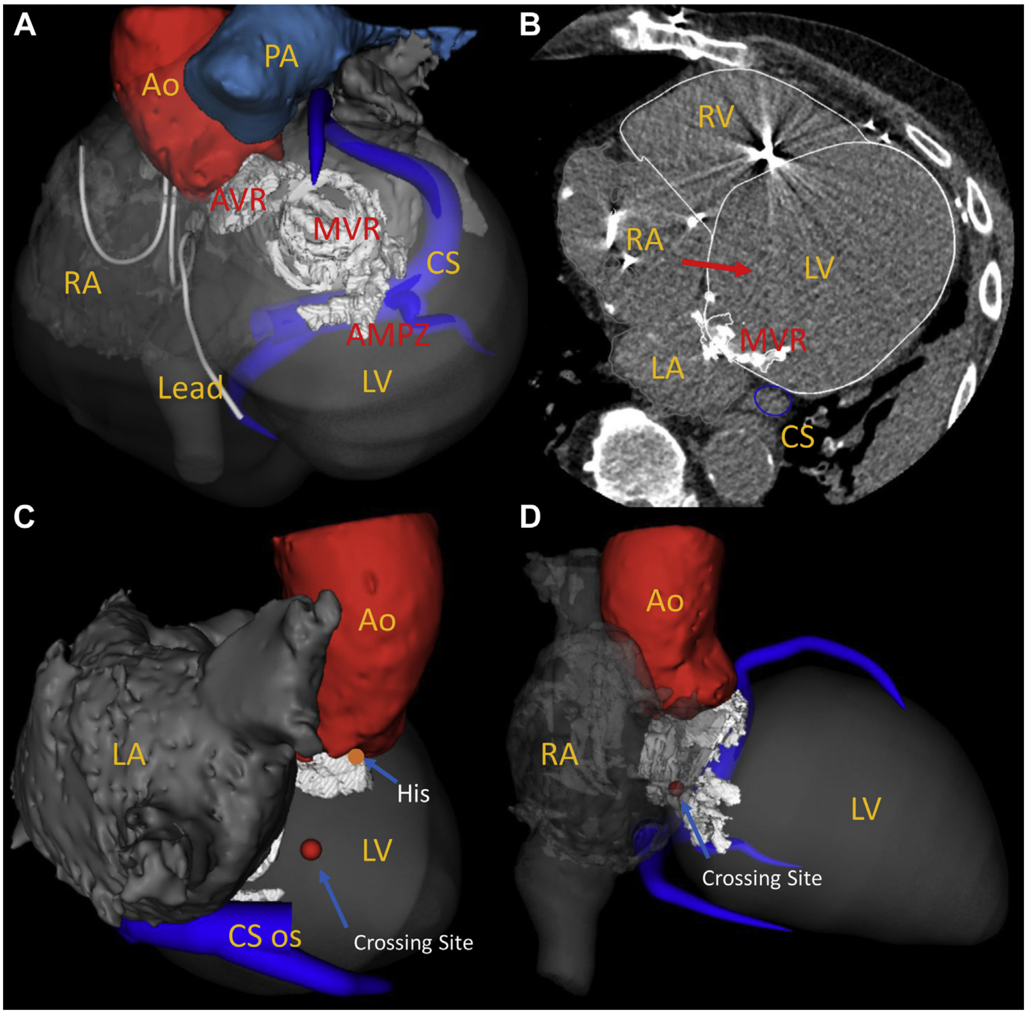

Figure 1 Preprocedure noncontrast segmented electrocardiogram-gated cardiac computed tomography (CT). **A:** Three-dimensional reconstruction of cardiac anatomy in left anterior oblique orientation. **B:** Segmented axial CT slice with red arrow showing planned crossing site from right atrium (RA) to left ventricle (LV) on the inferior septal process. **C:** Surgeon's view showing chosen crossing site as red tag and relationship with His region. **D:** Redemonstration of chosen crossing site in right anterior oblique view. AMPZ = Amplatzer plug; Ao = aorta; AVR = aortic valve replacement; CS = coronary sinus; His = His bundle anatomic region; LA = left atrium; Lead = pacing and implantable cardiac defibrillator leads; LV = left ventricle; MVR = mitral valve replacement; RA = right atrium; RV = right ventricle.

kidney disease, this allowed for chambers of the heart and key structures (such as prosthetic valves) to be individually segmented (Figure 1). Images were reviewed offline and a tag was placed in the intended site of puncture, noting a safe distance from the mechanical valves as well as the anatomic location of the His bundle (Figure 1B–1D). During the procedure, the anatomy of the LV, mitral and aortic valves, and interventricular septum were contoured by intracardiac echo (ICE) images (CARTOSOUND; Biosense Webster, Irvine, CA). A long Vizigo sheath and ThermoCool ST-SF ablation catheter (Biosense Webster) were then used to define the right atrial and coronary sinus anatomy. The CT imaging was then registered to the generated anatomy using the CARTOMerge module, which not only provided real-time overlay of the chambers and structure, but also projected the predetermined puncture site. As the Vizigo sheath can be visualized real-time in CARTO 3 v7 (Biosense Webster), it was possible to position the tip close to our intended site. After confirming the location on ICE (Figure 2A) and fluoroscopy, a PowerWire RF Guidewire (Baylis Medical, St. Laurent, Canada) was inserted through the sheath and used to cross to the LV using 3 sequential 1-second bursts of radiofrequency (RF) energy, which caused only short runs of nonsustained VT. After ensuring proper position without complications, the wire was exchanged for an Amplatz extra-stiff J-wire using a Quick-Cross support catheter (Philips Healthworks, Cambridge, MA) and then a 6 $\times$ 40-mm noncompliant Charger balloon dilation catheter (Boston Scientific) was positioned across the septum. Following a single dilation (Figure 2B), the Vizigo sheath was advanced to the LV. Given the lack of a dilator, this required partial inflation with the balloon extended beyond the sheath tip, known as balloon-assisted tracking,[2] to combat the thick contracting septum. Final position of the puncture was very close to our intended site, anterior and superior to the coronary sinus, and inferior to the aortic valve, which was over 2 cm

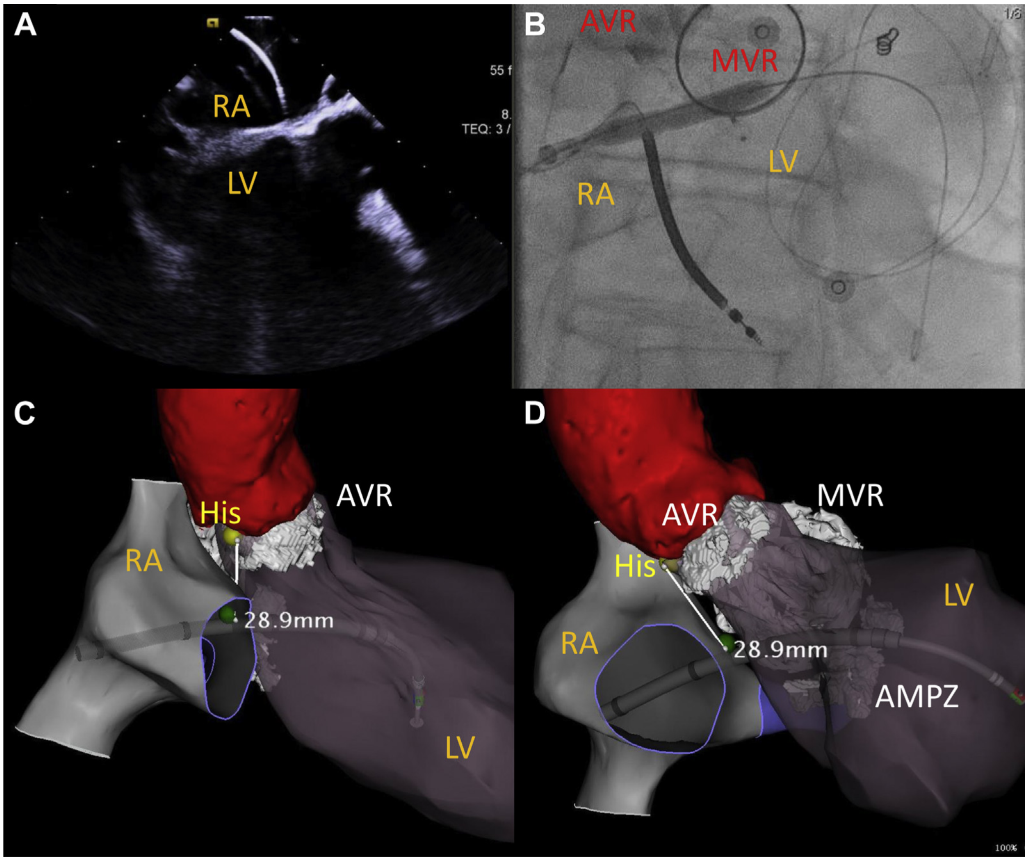

Figure 2 Representative imaging during right atrium (RA)–to–left ventricle (LV) access. **A:** Intracardiac echo image with the catheter in the RA and imaging plane across the interior septal process of the LV, with the sheath shown in contact at the intended crossing site. **B:** Fluoroscopic image with a wire in the LV and balloon catheter inflated across the inferior septal LV process. **C:** Electroanatomic map in right anterior oblique projection showing the sheath and catheter advanced from the RA (*gray*) to the LV (*purple*) with overlay of the aorta (*red*), coronary sinus (*blue*), aortic valve replacement (AVR), mitral valve replacement (MVR), and Amplatzer devices (*white*) and planned crossing site (*green dot*) from registered preprocedure computed tomography imaging. Putative His bundle location (*yellow dot*) is measured to be >2 cm away from the crossing site. **D:** Left anterior oblique projection of the same image. AMPZ = Amplatzer plug; His = His bundle anatomic region.

away from the putative junction of the non-coronary and right coronary cusps, where the His bundle is anatomically located (Figure 2C and 2D). LV endocardial late-activation mapping performed during right ventricle pacing and short VT inductions identified a possible isthmus and exit site (Figure 3A and 3B, Supplemental video). Extensive ablation was performed, targeting all potential channels in the core and borders of the scar, rendering VT no longer inducible with programmed stimulation. The sheath was withdrawn to the RA. No complications were identified and on ICE a small residual left-to-right shunt was seen (Figure 3C) with velocity above 3 m/s. The patient was extubated without incident and subsequently discharged from the hospital. In initial follow-up of 45 days, he has had 1 sustained episode of VT requiring ICD therapy, with cycle length and morphology different from his prior VT, as compared to 105 episodes of VT requiring ICD therapy in the 6 months leading up to the ablation.

Discussion

Patients with dual mitral and aortic mechanical valve replacements who require catheter ablation for VT represent a management challenge. While advancing a catheter or sheath across native or bioprosthetic valves is routine, doing so across mechanical valves raises the risk of acute interference with leaflet function, long-term damage to the leaflets, or catheter entrapment.[3] Alternative approaches include direct transapical access, percutaneous or surgical epicardial access, or stereotactic radioablation; however, these may be limited by degree of surgical risk, number of prior sternotomies, presence of coronary bypass grafts, location of scar, and ability to adequately localize substrate. In our case, the patient had known myocardial infarct with likely subendocardial scar as well as 3 prior sternotomies, which would make an epicardial approach unfavorable. A direct transapical approach[4] was discussed but was felt to be higher risk and would require contrast angiography to delineate the coronary arteries, which would compromise his advanced kidney disease. Similarly, stereotactic radioablation[5] was considered; however, without prior electroanatomic mapping or contrast imaging to guide dose planning, it was felt to have a lower chance of success. Thus, a direct RA-to-LV approach[1] was felt to be the optimal approach. Furthermore, in case of difficulty with sheath contact or

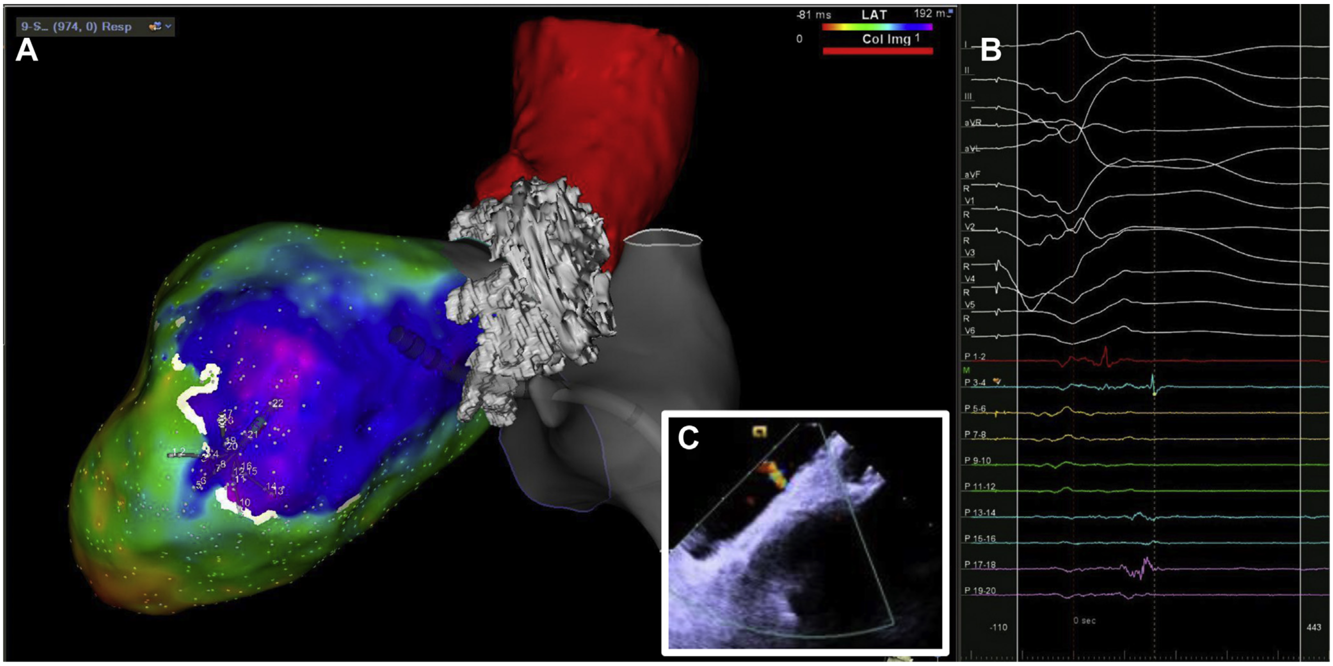

Figure 3 Left ventricle (LV) mapping and ablation following right atrium (RA)-to-LV access. **A:** Final map with annotation of latest activation under right ventricular pacing showing a large lateral substrate with putative lines of block (*white*) and channels of slowed propagation. **B:** Representative electrograms from the depicted position of the mapping catheter in panel A, showing late potentials. **C:** Color Doppler imaging on intracardiac echo after sheath removal showing a small jet of flow from the LV to RA.

stability in this region, we discussed attempting puncture from just inside the ostium of the coronary sinus, as has been anecdotally reported; however, this was ultimately not required.

In order to maximize safety and likelihood of success, we took advantage of preprocedure imaging to aid with access planning. Several approaches have been described for advanced image processing, segmentation, and registration to electroanatomic mapping systems for real-time guidance during VT ablation procedures.[6] While in this case, the inability to use contrast limited our ability to define regions of scar or wall thinning, we found it useful to review the anatomy prior to the procedure, which allowed us to identify an optimal puncture site that was a safe distance from the aorta, mechanical valves, and anatomic location of the His bundle. The inHeart platform proved ideal for this purpose, as its 3-D cardiac reconstructions are optimized for integration into electronic anatomic mapping systems, including the exportation of tagged sites and structures. With the CARTO system, contours taken from ICE imaging can be used to construct the LV, aortic valve, and mitral valve anatomy and used to register the preprocedure imaging and associated site tags. By using a sheath that is visible to the mapping system, guiding the equipment to the intended puncture site was quick and had close concordance with the best site determined by ICE. Though we still relied on fluoroscopy and ICE, this added a third facet to a multimodal imaging approach that can be useful, especially in cases where ICE views are suboptimal. The actual puncture site was measured to be over 2 cm away from the putative location of the His bundle, and though the patient was already pacemaker-dependent owing to chronic complete heart block, we believe this technique will be useful in avoiding conduction system injury in patients who do not have existing AV conduction disease.

Finally, while in the original published series of RA-to-LV access 2 of the 4 patients developed sustained ventricular arrhythmias requiring cardioversion during use of the RF wire,[1] in our case only short runs of nonsustained VT were induced with RF, which we believe was because we chose to use shorter 1-second bursts rather than 4- to 5-second bursts as previously described. Furthermore, after balloon dilation, the sheath was successfully advanced using a technique known as balloon-assisted tracking. We believe the technique, originally developed to overcome radial artery spasm during coronary angiography,[2] is useful for crossing thick muscular septa without the aid of an inner dilator and may prevent the need to upsize to a larger-diameter balloon.

Conclusion

In patients with dual mitral and aortic mechanical valves in need of catheter ablation in the LV, direct access from the RA to the LV is feasible and can be aided by the use of preprocedure imaging with 3-D reconstruction and real-time registration with the electroanatomic mapping system. As this approach continues to evolve, it may represent a safer and more effective avenue for patients with previously inaccessible LV.

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Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2021.07.013.

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