Three-dimensional electroanatomical mapping to guide transseptal catheterization

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Introduction

Transseptal catheterization is generally a routine and common technique utilized as part of various cardiac electrophysiology procedures. But at times this can be met with specific challenges, often times owing to anatomic variations in certain patients, particularly those with cardiac anomalies. In this regard, the use of visual aids such as intracardiac echocardiography has significantly improved the safety and efficacy of the transseptal puncture.[1] This manuscript illustrates a case in which the use of three-dimensional (3-D) electroanatomical mapping in turn used as an adjunct imaging tool further facilitated transseptal catheterization to guide mapping and ablation of a left atrial tachycardia in a young patient with structural heart disease.

KEY TEACHING POINTS

- Anatomic variations can dramatically displace the location of the fossa ovalis.
- A 3-D electroanatomical map of the right atrium can be used to help guide a transseptal puncture in addition to intracardiac echocardiography and fluoroscopy.
- Localization of the transseptal needle/guide wire on a 3-D mapping system can be useful to help confirm their position prior to performing transseptal catheterization.

Case report

A 35-year-old woman with a history of advanced nonischemic cardiomyopathy and severe left ventricular dysfunction with an ejection fraction of 20%, marked biatrial enlargement, heart failure, and mitral valve repair was referred to undergo catheter ablation of an incessant atrial flutter mechanism (Figure 1). At electrophysiology study, the tachycardia was determined to be a mitral isthmus–dependent left atrial flutter. As such, transseptal catheterization was attempted. Briefly, a BRK-1 needle was utilized via an SL-0 sheath and the procedure was attempted under the guidance of intracardiac echocardiography and fluoroscopy. However, the fossa ovalis could not be clearly visualized. Furthermore, despite multiple attempts, a typical 2-step transseptal "drop" over the aortic root and the roof of the fossa ovalis could not be appreciated. A number of additional attempts were made by rotating the transseptal apparatus in both an anterior and a posterior orientation. But despite all this, a transseptal puncture could not be successfully performed. Consequently, it was decided to create a 3-D electroanatomical map (CARTO, Biosense Webster, Inc, Diamond Bar, CA). Briefly, a 3-D map of the right atrium and the coronary sinus was created. Subsequently, based on the 3-D map the general locations of the fossa ovalis and the left atrial cavity were extrapolated. Next, direct visualization of the transseptal needle within the 3-D map was made possible by

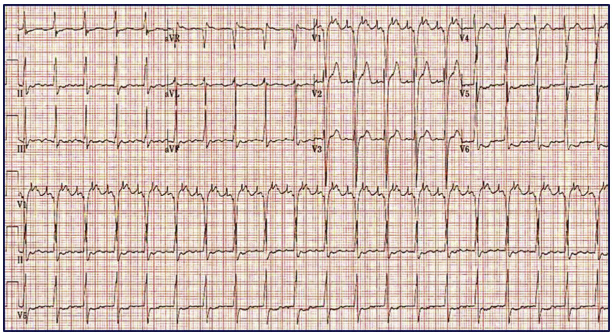

Figure 1 The 12-lead electrocardiogram of the clinical tachycardia illustrating an atypical left atrial flutter with positive P waves in leads V_1 with 2:1 AV conduction.

KEYWORDS 3-D mapping; Catheter ablation; Imaging; Transseptal catheterization; Transseptal puncture
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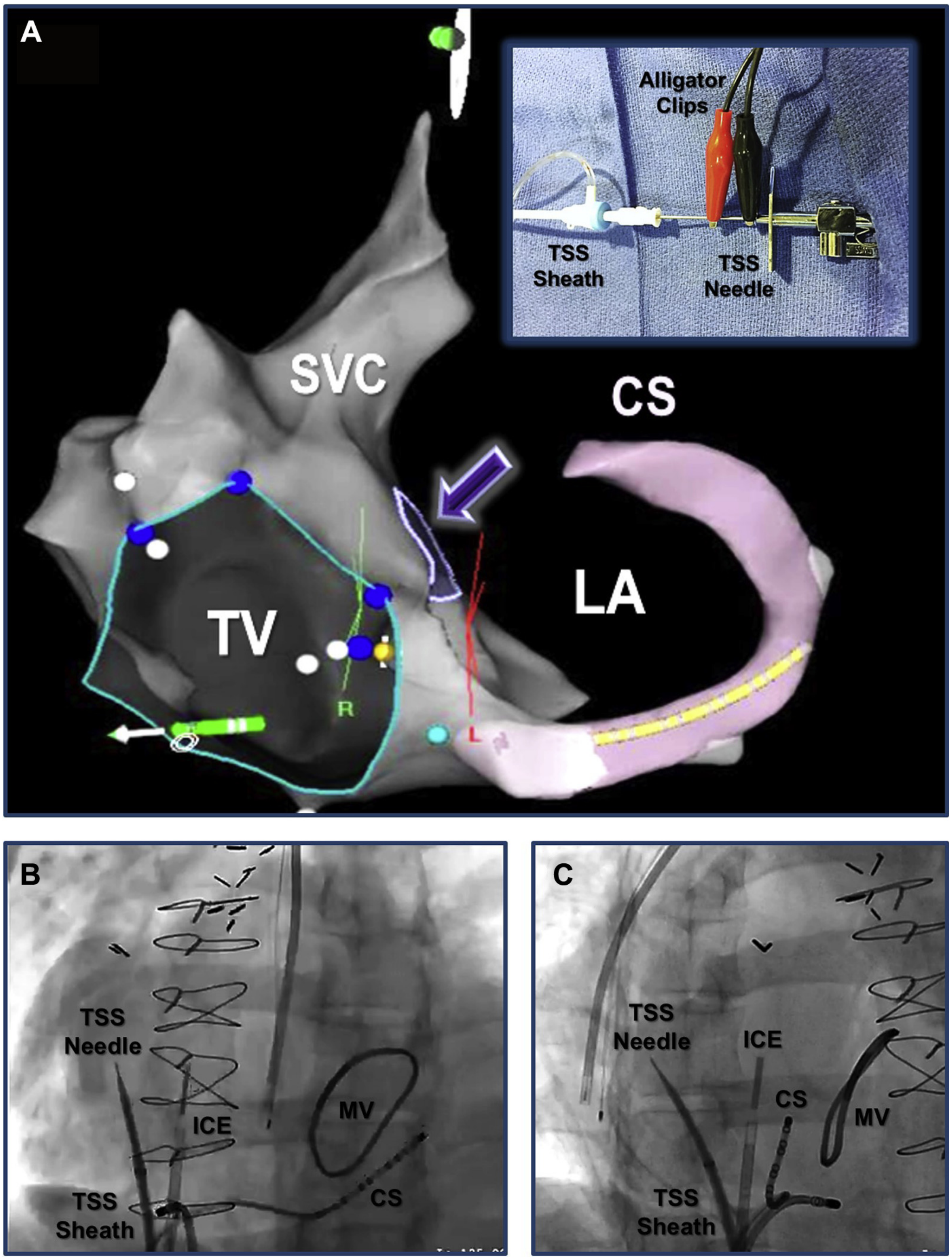

Figure 2 Visualizaton and correlation of the transseptal apparatus on three-dimensional (3-D) mapping and fluorsocopy. **A:** A 3-D electroanatomcial map of the right atrium, the superior vena cava (SVC), and the coronary sinus (CS) in the left anterior oblique projection delineating the left atrial cavity (LA) through extrapolation of geometry using the CS as its lateral boundary and the estimated general location of the fossa ovalis (*purple arrow*). The inset illustrates standard alligator clips conneted to a BRK-1 needle in turn connected to the 3-D mapping system to allow direct visualization of the needle tip/position to guide the transseptal puncture. Left (**B**) and right (**C**) anterior oblique fluoroscopic projections of the transseptal needle and site, illustrating the extreme eccentric posterior deviation of the transseptal apparatus with its tip and angle seemingly "pointing away" from the atrial septum. Additionally, an esophageal temperature probe can be seen on fluoroscopy. ICE = intracardiac echocardiography catheter; MV = mitral valve ring; TSS = transseptal; TV = tricuspid valve.

connecting a standard set of alligator clips (Boston Scientific Corp, Minneapolis, MN) commonly used during pacemaker implantation to the transseptal needle (Figure 2). Based on this approach, the location of the fossa ovalis was determined to be extremely eccentric on fluoroscopy and deviated quite posteriorly (Figure 2). This strategy was ultimately employed to guide transseptal catheterization in this patient. Subsequently, a transseptal guide wire access system (SafeSept, Pressure Products, Charleston, WV) was used to safely puncture the fossa ovalis as the guide wire was visualized entering directly into the left atrium (Figure 3). The SL-0 sheath was then carefully advanced into the left atrium.

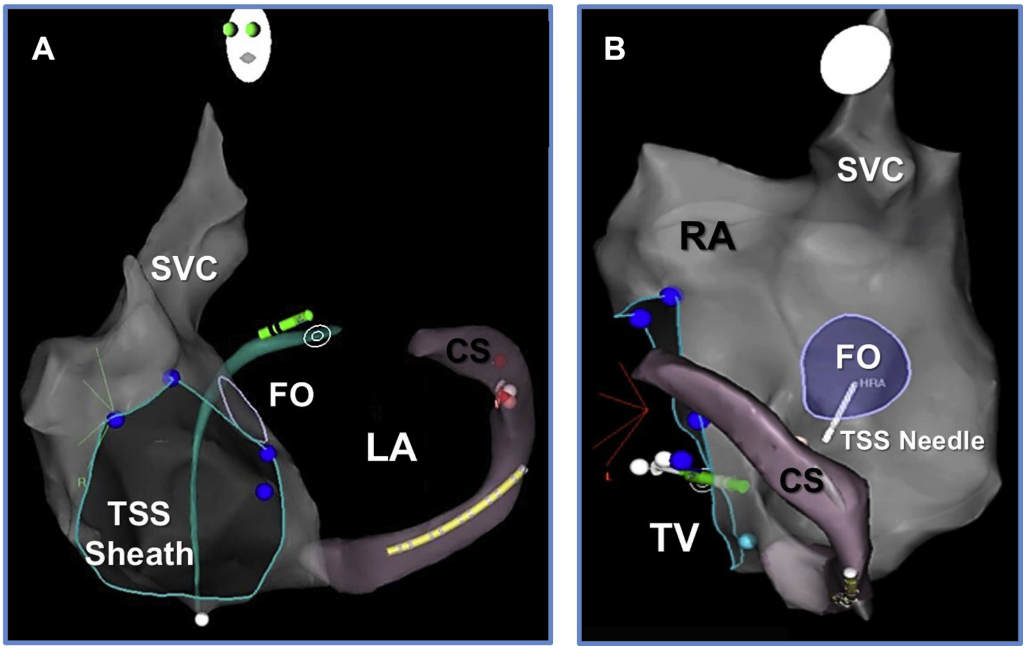

Figure 3 Visualizaton and correlation of the transseptal puncture on three-dimensional (3-D) mapping and fluorsocopy. Shown are 3-D electroanatomcial maps of the right atrium (RA), the superior vena cava (SVC), and the coronary sinus (CS) in the left anterior oblique (**A**) and posterior (**B**) projections delineating the left atrial cavity (LA) and the estimated general location of the fossa ovalis (FO). The final location of the FO was later confirmed by intracardiac echocardiography to be slightly more posterior to this location. **A:** A radiofrequency ablation catheter (ThermoCool SmartTouch, Biosense Webster, Inc, Diamond Bar, CA) crossing the atrial septum with geometry outlining the location of the transseptal sheath. **B:** A transseptal needle (SafeSept, Pressure Products, Charleston, WV) advanced into the LA crossing the FO, visualized directly inside the 3-D map. Additionally, an esophageal temperature probe can also be seen on fluoroscopy. ICE = intracardiac echocardiography catheter; MV = mitral valve ring; TSS = transseptal; TV = tricuspid valve.

The tachycardia was mapped to the mitral isthmus and a single endocardial radiofrequency application along the mitral isthmus resulted in prompt termination of the tachycardia and simultaneous bidirectional block across the mitral isthmus. Meanwhile, the patient tolerated the procedure well, without complications or any sequelae, and she has not had any further recurrences of the clinical tachycardia.

Discussion

Transseptal catheterization was first described by Ross in 1959 with the intention to aid the diagnostic data derived from the right heart catheterization.[2] Since that time transseptal access has been used for various purposes, but most commonly for left atrial catheter ablation. Although during most day-to-day cases a transseptal puncture can be performed safely through the use of fluoroscopy with or without the use of intracardiac echocardiography, this case illustrates that extreme variations in patient anatomy can rarely result in marked displacement of the fossa ovalis, rendering this generally simple and routine procedure at times challenging. Though transseptal catheterization is often the least discussed part of the ablation procedure, it continues to remain the very step most commonly prone to complications.[3–5] This case demonstrates the importance of utilizing multiple imaging modalities to enhance the safety of transseptal catheterization. It also represents the first description of utilizing a 3-D electroanatomical mapping approach to create right atrial geometry used for localization of the transseptal site and direct visualization of the transseptal needle/apparatus. In this case, guidance of transseptal puncture strictly by fluoroscopy would have likely resulted in inadvertent puncture of the aorta or perhaps even the right ventricle. In fact, prior to creating the 3-D map, we were unable to accurately localize the transseptal needle, the fossa ovalis, or tenting using intracardiac echocardiography, as it was displaced very posteriorly. Furthermore, it should also be emphasized that puncture using the transseptal guide wire access system likely aided in the safety of our approach. In conclusion, this case illustrates that when confronted with challenging or unusual cardiac anatomy, utilization of 3-D electroanatomical mapping as another form of visualization aid may prove tremendously helpful in guiding transseptal access and catheterization.

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