INNOVATIVE TECHNIQUES

EMERGING TECHNIQUES

Three-Dimensional Mapping-Guided Implantation of an Atrial Pacing Lead in a Dilated Scarred Quiescent Right Atrium Following CHD Repair

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ABSTRACT. A 41-year-old male born with complex congenital heart defects after multiple cardiac surgeries presented with symptomatic sinus node dysfunction and atrial flutter. Prior to pacemaker implantation, he was detected to have elevated central venous pressures and dilated scarred quiescent right atrium (RA). Three-dimensional mapping of the RA was carried out during the electrophysiology study and was used to target the site of atrial lead implantation for pacing the RA as there was only a small area of electrically active atrial tissue with adequate sensing and pacing. This simple, innovative technique for lead implantation can be used to target specific sites in certain cases.

KEYWORDS. congenital heart defect, lead implantation, three-dimensional mapping.

Case report

A 41-year-old male patient born with tetralogy of Fallot with a right aortic arch and absent right pulmonary artery underwent implantation of a dual-chamber pacemaker/implantable cardioverter-defibrillator (ICD) for sinus node dysfunction and inducible ventricular tachycardia. He had undergone bilateral classic Blalock–Taussig (BT) shunt placement in his infancy. At 10 years of age he underwent complete repair with a transannular patch, ventricular septal defect patch closure, and unfocalization of collaterals to the right lung. However, he developed severe pulmonary insufficiency, requiring him at 19 years of age to undergo placement of a 16-mm prosthetic valve (St. Jude Medical, St Paul, MN) in the pulmonary position. His follow-up was complicated with history of intermittent recurrent atrial flutter requiring electrical cardioversions. Magnetic resonance imaging (MRI) of his heart performed 2 years previously had revealed dilated right atrium (RA), tricuspid regurgitation (TR), and right lung perfused by collateral flow only. Recently, he had started to experience symptoms of easy fatigability, tiredness, and occasional dizziness. A Holter monitor revealed multiple episodes of sinus pauses and multiple isolated premature ventricular contractions. An echocardiogram revealed severely dilated RA, mildly dilated right ventricle (RV), moderate tricuspid regurgitation, and adequately functioning prosthetic pulmonary valve (PV). His left ventricular function appeared normal. He was unable to perform an exercise stress test secondary to congenital left-sided malformation. He underwent a diagnostic cardiac catheterization with an electrophysiology study. He was detected to have elevated central venous pressure, severely dilated RA with moderate TR, mildly dilated RV, normally functioning prosthetic PV with no significant stenosis or regurgitation and no prograde flow to the right lung. An electrophysiology study revealed evidence of sinus node dysfunction with maximum corrected sinus node recovery time of 648 ms and AV node dysfunction with Wenckebach cycle length of 550 ms. The St Jude...
Medical’s Ensite mapping system was used to map the RA. However, interestingly, the RA appeared scarred and quiescent with no adequate sensing of atrial activity on voltage mapping of the RA (less than 0.3 mV amplitude signals was defined as scar) or ability to pace (using 10 V amplitude and 0.5 ms pulse width) except for a small location in the high RA and posteriorly in the low septum. The pacing thresholds were not measured during the electrophysiologic study with the standard mapping and ablating catheters. The sites of the RA where sensing and pacing were feasible were tagged (Figure 1). The patient had an inducible polymorphic ventricular tachycardia. It was decided to upgrade the initial plan of transvenous pacemaker implantation to dual-chamber ICD implantation. Under aseptic precautions, the left axillary vein was accessed by the Seldinger technique. A 7-Fr St Jude’s Durata dual-coil ICD lead was implanted in the RV low septum. A 4-Fr Medtronic 3830 lumenless lead (Medtronic Inc, St. Paul, MN) was then advanced through the Select Site Secure sheath to the RA. The pacing lead was advanced just beyond the tip of the sheath. The other end was then connected to the three-dimensional (3D) mapping unit using St Jude’s threshold cable with alligator clips attached to the pacing lead and pins connected to the Ensite pin box. The target region of the RA was accessed under 3D guidance. The lead was screwed to the tagged atrial wall (Figure 2). The pacing threshold was less than 1 volt at 0.5 m, with pacing impedance of 550 ohms and sensed P waves of 2.5 mV. The implantation of the atrial lead was performed in a short time with no need for attempts to reposition the lead for adequate sensing and pacing thresholds. The leads

Figure 1: Three-dimensional mapping image with the sites tagged # and bordered with red where pacing and sensing of atrial activity was feasible.

Figure 2: Three-dimensional mapping image showing the lead being implanted at the previously tagged site.
were then secured and a Medtronic Virtuoso ICD generator was implanted (Figure 3). Defibrillation threshold testing was performed and the incision was closed in multiple layers and staples. At 6-month follow-up, the atrial lead sensing and pacing thresholds had remained stable and he has not experienced any episodes of tachyarrhythmia.

**Discussion**

With the rapidly growing population of adults with congenital heart defects and a substantial proportion of them encountering conduction abnormalities, pacing is one of the therapeutic options to manage conduction defects, arrhythmias, and poor cardiac function. The increased risk of sinus node dysfunction after congenital heart disease surgery is possibly due to scarring in the RA, interruption of the sinus node artery during surgery, right atrial hypertension, and manipulation of the right atrial-superior vena cava junction during atrial cannulation.1 Implanting pacing leads in patients having previously undergone multiple cardiac surgeries and with significant hemodynamic abnormalities can sometimes be challenging from various aspects. Obtaining sites with adequate sensing and pacing thresholds is not always simple in the scarred and dilated chambers and is one of the challenges for which adequate options are not available. Multiple sites sometimes need to be accessed before achieving an ideal lead placement with adequate sensing and pacing thresholds.

Our patient was born with a significant congenital heart defect requiring multiple surgeries. In addition, he had a dilated RA with moderate tricuspid regurgitation and elevated central venous pressures. During the electrophysiology study, it was evident that the RA was severely dilated, had extensive scarring, and was electrically quiescent with widespread areas of extremely low amplitude-sensed atrial activity as well as with a high threshold for pacing the atrium. We had mapped out the area of the RA where there was adequate sensing and capture during the initial electrophysiology study. We were able to implant the atrial lead in the selected site very conveniently using the 3D mapping system without any difficulty. The site had adequate sensed atrial activity and pacing threshold.

Voltage-based scar tissue delineation is routinely performed while mapping for atrial tachyarrhythmias and is useful for ablation of these arrhythmias.2 We used the same technique in our patient for mapping and as a guide for atrial lead implantation. This technique may be beneficial in implanting pacing leads in the subgroup of patients that have extensively scarred chambers secondary to previous surgeries or hemodynamic abnormalities.

Kloosterman et al3 have previously described this innovative technique when they utilized the Biosense CARTO System (Biosense Webster, Diamond Bar, CA) anatomic electromagnetic voltage mapping as a guide to implanting the atrial lead after multiple unsuccessful attempts using the standard trial and error method to obtain an adequate site, in an adult patient with repaired Ebstein’s anomaly. The Ensite system gives us the advantage of using any electrophysiology catheter, define anatomy as well as view the real time image of multiple catheters, compared with the CARTO mapping system. With CARTO mapping the geometry is based on acquisition of one point per cardiac cycle, and patient movement can disrupt the location technology requiring reacquisition of the geometry. Ruiz-Granell et al4 used the same technology to implant single chamber lead implantation in normal hearts in place of fluoroscopy. 3D mapping used for mapping during an electrophysiology study can be used as an aid to target optimal sites for sensing and pacing. It can help to reduce the time required for finding the optimum site and act as a target to place the lead. This technology can be useful in patients with scarred chambers where finding the optimal site of lead placement with the standard trial and error method can be time consuming, especially in adult congenital heart defect patients.

**References**

