Novel direct approach for placement of permanent transvenous pacing leads after Fontan procedure

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ABSTRACT

The need for transvenous pacing (patients who have exhausted epicardial options) after a Fontan-type operation has been recognized. Many novel strategies have been proposed, but currently, all of them require additional maneuvers or rerouting of the leads to the pacemaker pocket. In this report, we describe a novel direct approach to transvenous pacing after a Fontan-type operation from a standard, prepectoral approach.

Keywords: Artificial, procedure, cardiac pacemaker, Fontan, transvenous pacing

INTRODUCTION

Patients with functionally univentricular hearts are surgically palliated with a Fontan-type operation; the two most commonly performed variants are the extracardiac total cavopulmonary connection (TCPC) and the intracardiac lateral tunnel (ICLT).[1] When required, epicardial pacing is the standard of care. When epicardial pacing options are exhausted, transvenous atrial and/or ventricular pacing strategies become necessary and have been described both after ICLT and TCPC.[2-9] We report a 1-year follow-up of a novel approach for the placement of transvenous leads from a typical left prepectoral pocket without requiring any additional manipulations described in the previous reports.

CASE REPORT

Patient

An 18-year-old male with hypoplastic left heart syndrome (aortic atresia/mitral stenosis) underwent staged fenestrated lateral tunnel Fontan palliation. At 4 years of age, a dual-chamber epicardial pacemaker was placed for sinus node dysfunction and intermittent high-grade atrioventricular (AV) block. At 10 years, the lateral tunnel fenestration was closed. At 14 years, an epicardial left ventricular lead was added for resynchronization therapy. At 15 years, a new ventricular lead was placed because of lead failure (both ventricular leads) and the generator was changed; dense scarring limited adequate epicardial pacing sites. At 18 years, he presented with ventricular lead failure (progressive increase thresholds) and pacemaker generator battery depletion. Multiple previous sternotomies and surgical history prompted multidisciplinary recommendation for transvenous pacing. A transvenous dual-chamber pacing system from a left prepectoral approach with an atrial lead in the lateral tunnel and a transpulmonary–transatrial lead in the systemic ventricle (across the AV valve) was proposed. Informed consent was obtained from the patient and his family.

Procedural technique

A preprocedure cardiac computerized tomography scan generated a roadmap for the feasibility of the procedure. The procedure was performed under

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general anesthesia after a sterile prep and prophylactic antibiotics. A left-sided prepectoral pocket was created, and the left axillary vein was accessed for the placement of atrial and ventricular leads. A 5 Fr and a 6 Fr sheath were placed in the right femoral artery and vein, respectively. The patient was systemically heparinized. Simultaneous angiography was performed in the superior portion of the lateral Fontan tunnel and the pulmonary venous atrium (PVA) via retrograde arterial catheter into the systemic right ventricle (RV) and across the systemic AV valve into the PVA. This provided landmarks and a trajectory for the transpulmonary–transatrial puncture into the PVA [Figures 1 and 2]. An 8Fr steerable Channel™ sheath (Boston Scientific, MA, USA) was introduced via one of the access sites in the left axillary vein. The sheath was advanced to the floor of the pulmonary artery (PA) adjacent to the PVA and steered such that the trajectory of the sheath would simulate puncture from the right internal jugular vein (IJV) [Figure 3], then locked. A Nykanen radiofrequency (RF) wire (Baylis Medical, ON, CA), coaxial within a 4 Fr vertebral catheter, was advanced through the steerable sheath to the floor of the PA. Five Watts of energy, for 2 s, was used to perforate the floor of the PA (RF wire perforation described previously).[10] The coaxial vertebral catheter was advanced over the RF wire to ensure that the RF wire would continue to be directed to the PVA and not track along the potential space between the lateral tunnel and the PVA [Figure 1]. After three additional energy applications, the atrial wall was traversed, and the RF wire entered the PVA [Figure 3]. A 0.014-inch guidewire was advanced into the PVA, and the tract was dilated with a 4-mm coronary angioplasty catheter. As the balloon was deflated, the sheath was advanced into the PVA and the 0.014-inch guidewire was replaced with a 0.035-inch Amplatz super stiff ST-1 guidewire (Boston Scientific, MA, USA). The Channel sheath was exchanged for an 8Fr steerable SelectSite sheath (Medtronic, MN, USA) and advanced over a balloon-tipped catheter (to avoid entrapment in the systemic AV valve) across the systemic AV valve into the systemic RV. A 4 Fr Medtronic 3830 (Medtronic, MN, USA) active fixation lead was fixed to the mid-septum, and a second Medtronic 3830 lead was fixed to the lateral wall of the intracardiac Fontan tunnel [Figure 4]. Adequate pacing and sensing thresholds were obtained in both leads. The remainder of the procedure was completed in the usual manner. Once hemostasis was achieved, the patient was bridged with low-molecular-weight heparin to coumadin with a targeted international normalized ratio (INR) of 2.5–3 in addition to low-dose aspirin.

At most recent follow-up, 1 year later, the patient has continued to enjoy excellent pacing and sensing thresholds and has not had evidence of progressive systemic AV valve dysfunction or systemic thromboembolism.

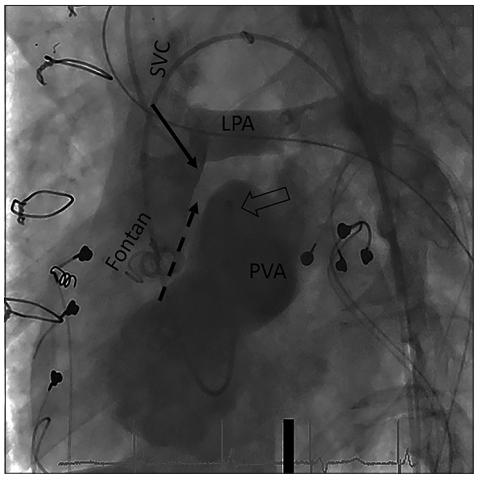

Figure 1: Simultaneous angiography in the Fontan pathway and PVA in the left anterior oblique projection showing the relationship of the PA to the atrium and the simulated puncture trajectory (solid arrow). Dashed arrow shows the potential space; hollow arrow shows the retrograde pigtail in the PVA. LPA: Left pulmonary artery, PVA: Pulmonary venous atrium, SVC: Superior vena cava, PA: Pulmonary artery

DISCUSSION

A growing need for transvenous pacing options has been identified in univentricular hearts palliated with a Fontan-type operation.[2-9] When the Fontan palliation involves an ICLT, transvenous atrial pacing using atrial tissue in the lateral tunnel is now well established.[2] In this population (ICLT Fontan), if the coronary sinus drains into the Fontan pathway, ventricular pacing through the coronary sinus can be achieved.[3,4] However, in the current era, many institutions perform a TCPC type of Fontan operation, and in many cases, they are

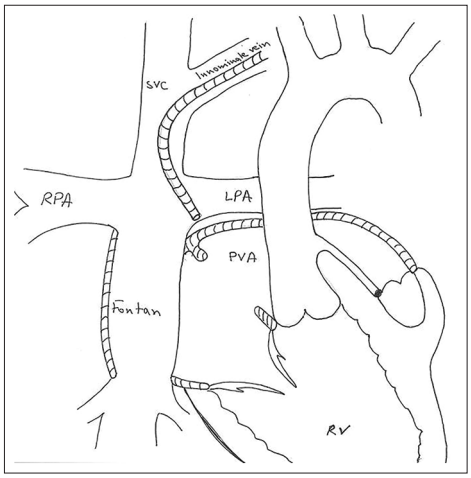

Figure 2: Schematic diagram showing relevant anatomy and adjacent cardiac structures. LPA: Left pulmonary artery, PVA: Pulmonary venous atrium, RPA: Right pulmonary artery, RV: Right ventricle, SVC: Superior vena cava

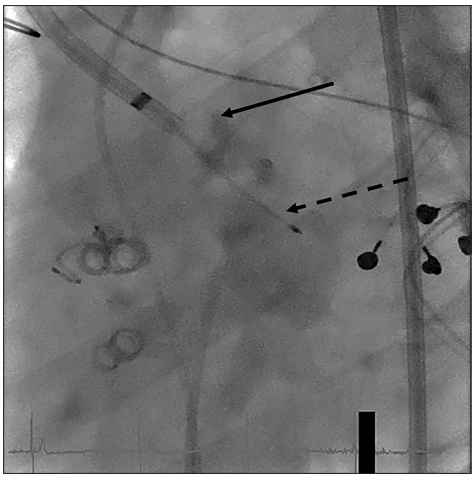

Figure 3: Left anterior oblique projection showing the steerable sheath in the simulated trajectory and the RF wire in the PVA (dashed arrow) after traversing the PA wall, the potential space, and the roof of the PVA (arrow pointing to the contrast in the space). PVA: Pulmonary venous atrium, PA: Pulmonary artery, RF: Radiofrequency

not surgically fenestrated. In this situation (TCPC), except for an island of "paceable" atrial tissue near the anastomotic site (atrial tissue cuff around the inferior vena cava anastomosis),[5] transvenous atrial and/or ventricular pacing requires access to the PVA and/or systemic ventricle.

In the early experience, the authors have described a transhepatic–transbaffle puncture and placement of transvenous pacing leads.[6] While there are concerns about bleeding and lead migration, the largest concern is the unknown long-term risk of the leads in the hepatic veins in a population with universal potential for hepatic dysfunction. More recently, several authors have proposed novel approaches for transpulmonary–transatrial leads.[7-9] This approach requires that the puncture is performed via the IJV, as originally described by Mehta *et al.*[11] Previous case reports have described advancing the lead placed from the IJV into the PVA atrium and tunneling the lead from the IJV to a right infraclavicular pacemaker pocket.[8] Alternatively, the puncture from the IJV is performed through a snare prepositioned from the left subclavian vein so that the lead can be incorporated into a left pocket,[7] or a catheter and wire from the left subclavian vein are used to cross the freshly created transpulmonary–transatrial baffle puncture performed from the IJV.[9]

To obviate the need for any additional maneuvers, additional vascular access, pacing lead tunneling, or crossing the clavicle (IJV approach), we developed and executed a direct technique for transvenous pacing from a standard prepectoral approach. In this direct method, a steerable sheath, advanced from the left subclavian vein, is steered to simulate the trajectory achieved from the IJV [Figures 1 and 2]. A transseptal needle cannot be

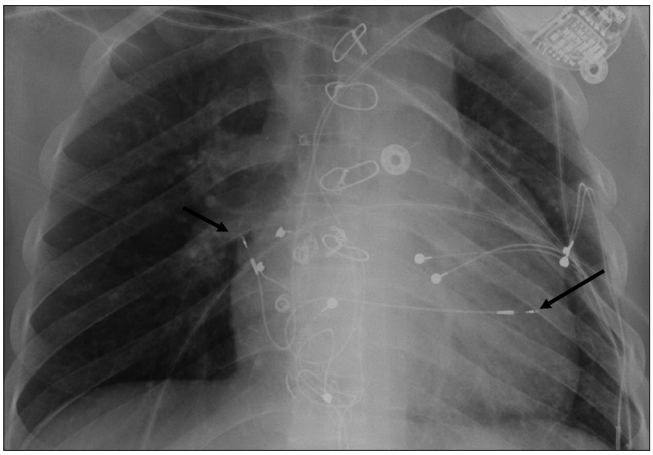

Figure 4: Chest radiograph showing the atrial lead (left arrow) in the lateral tunnel and the ventricular lead across the systemic AV valve in mid-septal position (right arrow). AV: Atrioventricular

used because it will straighten the simulated curve and precludes the generation of directional force necessary to perform the puncture. However, since the tissue to be traversed is native, an RF wire can replace the transseptal needle. The RF wire is flexible, maintains the curve and trajectory of the steerable sheath, and does not require directional force for the puncture. Once across the floor of the PA, the RF wire will tend to track the potential space between the lateral tunnel and the PVA [Figure 1] away from the atrial wall. To prevent this, the RF wire is placed coaxial within a guiding catheter to help redirect the RF wire. Once access is achieved, either an atrial and/or a ventricular pacing lead can be placed. In our patient, the presence of the ICLT allowed us to place the atrial lead in the lateral tunnel, thereby minimizing "hardware" in the systemic circulation.

There are several important considerations whenever a pacing lead is placed in the systemic circulation. Even when anticoagulated, there is a real and persistent risk of systemic thromboembolism. It is recommended to maintain a therapeutic INR of 2.5–3.5, similar to prosthetic AV valve replacement recommendations.[12,13] When the pacing lead traverses the systemic AV valve, there is potential for, and a persistent risk of, AV valve dysfunction. Finally, when lead dysfunction occurs, lead extraction will have its own unique challenges. Although this and other reports show good short-term outcomes, medium- and long-term studies will be needed to determine the efficacy and safety of this procedure.

CONCLUSION

Our novel technique allows direct placement of permanent transvenous atrial or ventricular pacing lead in patients after Fontan palliation, using a standard prepectoral approach, without the need for any additional maneuvers described in previously published reports. The authors would like to stress that

consideration for transvenous pacing for univentricular hearts is a major undertaking and should only be considered when epicardial options have been exhausted. The family and patient should be extensively counseled about the risks of systemic thromboembolism and the need for systemic anticoagulation, the potential for systemic AV valve dysfunction, and the concerns about management of lead failure when it occurs.

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Conflicts of interest

There are no conflicts of interest.

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