Implantation of a transmural atrial pacing lead in an adult with postoperative congenital heart disease and delayed chest closure

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Informed consent was waived since project did not meet "Common Rule" definition of human subjects research as stipulated by our IRB.

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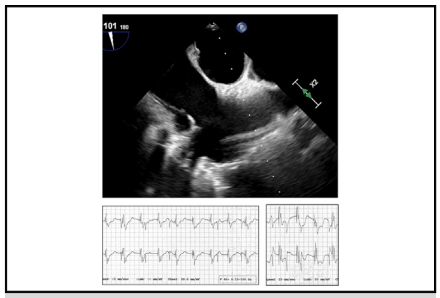

Novel transmural atrial lead implantation.

CENTRAL MESSAGE

Permanent transmural atrial pacing lead implantation can be accomplished through an open chest via novel approaches off cardiopulmonary bypass with TEE imaging and temporary pacing wire recordings.

Implantation of permanent pacing leads in patients after surgery for congenital heart disease is generally accomplished via transvenous approach provided patent systemic venous and intracardiac access and no intracardiac shunts.[1] When a transvenous approach is not feasible or recommended, most patients undergo implantation of an epicardial system via an open chest. When mapping for an optimal epicardial site fails to reveal an acceptable site for lead implantation, a transmural (or transatrial) approach may be pursued, guided by direct visualization in a patient already on bypass[2,3] or via subsequent thoracotomy or sternotomy guided by fluoroscopy.[4,5] We recently implanted a transmural atrial pacing lead in a patient with delayed chest closure after heart surgery, guiding lead tip position using transesophageal echocardiography (TEE) without reimplementing bypass, and confirming acute lead performance using existing temporary atrial pacing wires (institutional review board approval: 23.0709; September 19, 2023). Informed consent was waived because the project did not meet the Common Rule definition of human subjects research as stipulated by our institutional review board.

CASE REPORT

A 66-year-old patient who underwent subaortic membrane resection 17 years earlier developed progressive multilevel left ventricular outflow tract obstruction, mitral stenosis and insufficiency, and severe tricuspid insufficiency; in addition, she was in permanent atrial fibrillation. We performed complex reoperative surgery, including aortic valve replacement with Konno annular enlargement, mitral and tricuspid valve replacement, and biatrial maze procedure. After separating from bypass, the patient's atrial rhythm was 60 beats/minute and regular, and there was complete atrioventricular block with wide QRS escape rhythm ~35 beats/minute. Mapping for permanent epicardial atrial and ventricular pacing leads proved challenging. Ultimately, 2 unipolar screw-in leads (Medtronic 5071) were implanted on the right ventricle, Y'd together in a bipolar configuration. An epicardial Medtronic 4968 bipolar lead was implanted on the lateral right atrium but showed very high capture thresholds. Both permanent leads were connected to an abdominal Medtronic Azure pulse generator. Temporary epicardial atrial and ventricular pacing wires (TPWs) were placed and had acceptable function. Due to the magnitude of her surgery, the chest was left open. The temporary pacemaker was programmed DDD 90 beats/minute and the permanent pacemaker VVI 80 for backup.

On postoperative day 1, the patient's rhythm remained complete atrioventricular block (CAVB) with a stable atrial

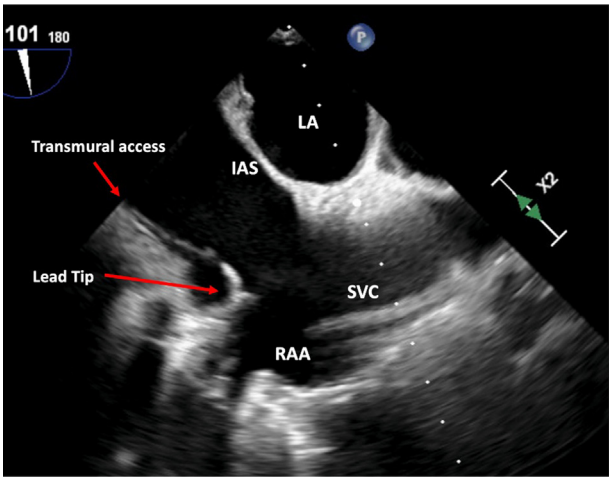

FIGURE 1. Transesophageal echocardiographic imaging used to guide transmural implantation of a Medtronic 5076 transvenous pacing lead to the base of the resected right atrial appendage in a patient after surgery for adult congenital heart disease with an open chest. *IAS*, Interatrial septum; *LA*, left atrium; *RAA*, right atrial appendage; *SVC*, superior vena cava.

rhythm. The permanent ventricular lead capture threshold was 1.25 V at 0.4 ms (688 ohms), and the 4968 atrial lead showed poor sensing and no capture at maximum outputs (8 V at 1 ms) in bipolar and unipolar configurations. Given persistent complete atrioventricular block, history of atrial fibrillation, and residual hemodynamic challenges, a permanent dual chamber pacing system with acceptable atrial lead performance was desired. Options included reexploring for an optimal atrial epicardial site, or a percutaneous transvenous approach via the left subclavian/innominate vein, tunneling the lead to the abdominal generator. A less common but reasonable approach involved placing a transmural atrial pacing lead in the operating room at the time of chest closure.

On postoperative day 4, the patient was transferred to the operating room, where extensive mapping again failed to find an optimal atrial epicardial position. We proceeded with transmural implantation of a right atrial lead, guided by TEE (Figure 1) given challenges of *C*-arm fluoroscopy in this situation. A Medtronic 5076 lead was advanced via stab incision and purse string in the right atrial free wall, advanced using straight and *J*-shaped stylets. The lead tip was implanted near the base of the excised right atrial appendage and secured by active fixation, tightening the purse string, and placing a loose epicardial suture around the lead proximal to tip electrodes. Atrial capture threshold was quite acceptable (0.5 V at 0.4 ms), confirmed in this patient with low amplitude surface P waves and CAVB via electrograms simultaneously recorded from atrial TPW connected to an electrocardiography machine (Figure 2). The 5076 lead was connected to the existing abdominal generator. The patient's rhythm was then supported with the permanent pacemaker programmed DDD 80; the epicardial atrial 4968 lead was capped. The patient's chest was explored, washed, and closed. Testing of the transmural atrial lead the following day showed capture threshold 0.5 V at 0.4 ms, atrial electrogram 1.1 mV, and lead impedance 880 ohms. The permanent pacing system continued to work well for the next several days. Unfortunately, the patient developed progressive hypotension requiring

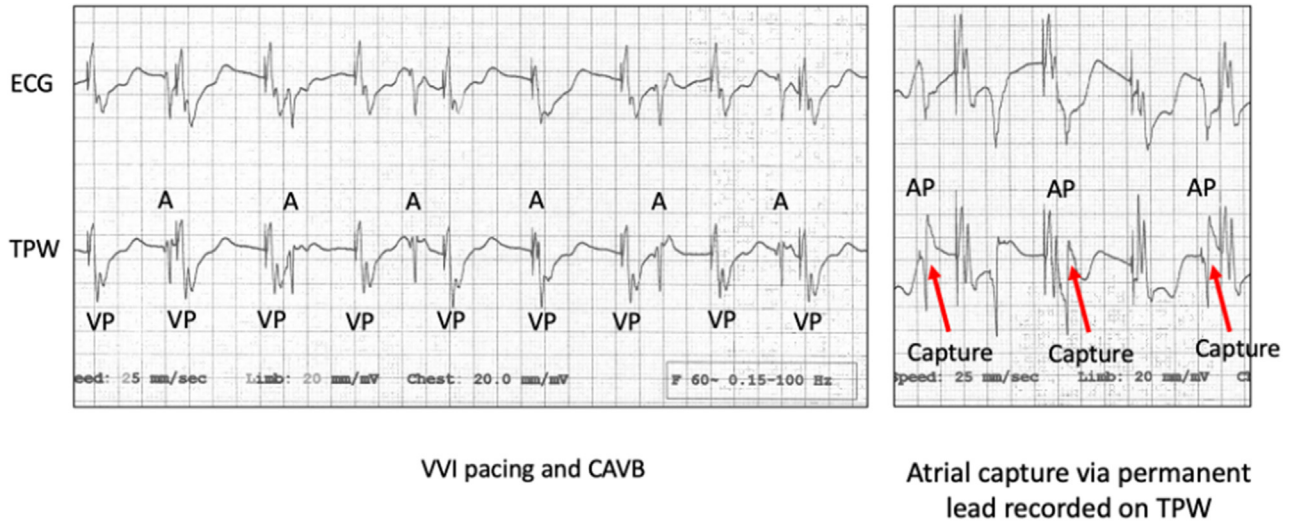

FIGURE 2. (*Left image*) Simultaneous recordings from surface echocardiogram and atrial temporary pacing wires (*TPW*) during VVI pacing at 80 beats/minute confirm VA dissociation related to patient's postoperative complete atrioventricular block and stable post-maze atrial rhythm ~55 beats/minute. (*Right image*) Recordings confirm atrial capture during intraoperative testing of the new transmural 5076 pacing lead. *Red arrows* indicate atrial electrograms on TPW recordings confirming atrial capture via the 5076 lead. *A*, Spontaneous atrial electrograms recorded on the TPWs; *VP*, ventricular pacing from the permanent ventricular leads; *AP*, atrial pacing from the 5076 transmural lead; *VVI*, ventricular demand pacing; *VA*, ventriculoatrial.

venoarterial extracorporeal membrane oxygenation, and ultimately succumbed to refractory sepsis.

This experience shows the feasibility of implanting a transmural atrial lead in a patient with adult congenital heart disease several days after complex surgery with the chest still open, using TEE guidance rather than fluoroscopy. In addition, the challenge of accurately confirming atrial capture in the setting of low amplitude P waves on surface echocardiogram and persistent CAVB was overcome using existing epicardial atrial TPWs. This procedure was greatly facilitated by close collaboration among the cardiac surgeon, electrophysiologist, and echocardiographer.

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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