

Radiation-free nonselective His pacing lead implantation in a pregnant patient with congenitally corrected transposition of the great arteries



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Introduction

His-bundle pacing may offer a more physiologic ventricular activation sequence and avoid some of the adverse effects associated with chronic right ventricular (RV) pacing.¹ This may be of particular importance in the context of reduced systemic ventricular function. There is a strong motivation to reduce radiation exposure during pregnancy to minimize the risk of adverse events resulting from fetal radiation exposure.² We present a patient with L-type congenitally corrected transposition of the great arteries (L-CCTGA) who presented with symptomatic atrioventricular (AV) conduction block at 25 weeks' gestation. We elected to proceed to His-bundle pacemaker implant with minimal use of fluoroscopy to achieve physiologic pacing while minimizing the risk to the developing fetus.

Case report

A 34-year-old female patient with a medical history of L-CCTGA presented following an episode of collapse at 25 weeks' gestation during her second pregnancy. Other past history included previous cesarean section following a well-tolerated pregnancy approximately a year earlier and asthma. During her first pregnancy, which had been otherwise uncomplicated, she had experienced orthostatic symptoms that were typical of vagally mediated presyncope without collapse. The descriptions of the presenting symptom by the patient and her husband, who witnessed

KEY TEACHING POINTS

- His-bundle pacemaker lead placement is feasible without the use of fluoroscopy, which may be of particular benefit in patient populations who present with AV conduction block at young ages, which may coincide with pregnancy.
- The use of the NavX system (Abbott, St Paul, MN) to guide radiation-free lead placement allows visualization of a pacemaker lead tip through impedance-based localization.
- At present, in the absence of adequate echocardiographic images, fluoroscopy is still required to assess lead slack prior to fixation.

the collapse, were consistent with a cardiac cause of syncope.

She was assessed in hospital, at which point 12-lead electrocardiogram (ECG) (Figure 1A) demonstrated sinus rhythm at rate of 85 beats per minute. PR interval was 202 ms. QRS was 114 ms in duration with axes -25 degrees and left bundle branch block morphology interventricular conduction defect. This was consistent with her previous ECGs.

She underwent repeat transthoracic echocardiogram, which confirmed the previously known AV discordance, ventriculoarterial discordance, and subpulmonic ventricle. The left (pulmonary circulation) ventricular cavity size, wall thickness, and systolic function were normal. The systemic right ventricle (RV) was mildly dilated with systolic function at the lower limits of normal. The left atrium was severely dilated and systolic flow reversal was noted in the pulmonary veins, consistent with severe mitral (systemic AV valve) regurgitation. The right atrium (RA) was normal in size and the inferior vena-cava (IVC) demonstrated normal collapse with inspiration consistent with normal RA pressure. There was evidence of severe tricuspid (systemic AV valve) regurgitation.

KEYWORDS Congenital heart disease; Complete AV conduction block; His-bundle pacing; Interventions in pregnancy; Radiation-free device implantation

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Conflicts of Interest: Mr J. Barge is an employee of Abbott Medical, whose products are referenced in this report. Dr S. Kapur receives consulting fees/honoraria from Abbot Inc, Medtronic Inc, and Novartis Pharmaceuticals Inc. Dr J. Whitaker, Dr O. Kreidieh, Dr M. Singh, and Dr B. Koplan have no conflict of interest related to this article. **Address reprint requests and correspondence:** Dr Sunil Kapur, Cardiovascular Division, Brigham and Women's Hospital, 75 Francis St, Boston, MA 02115. E-mail address: skapur@bwh.harvard.edu.

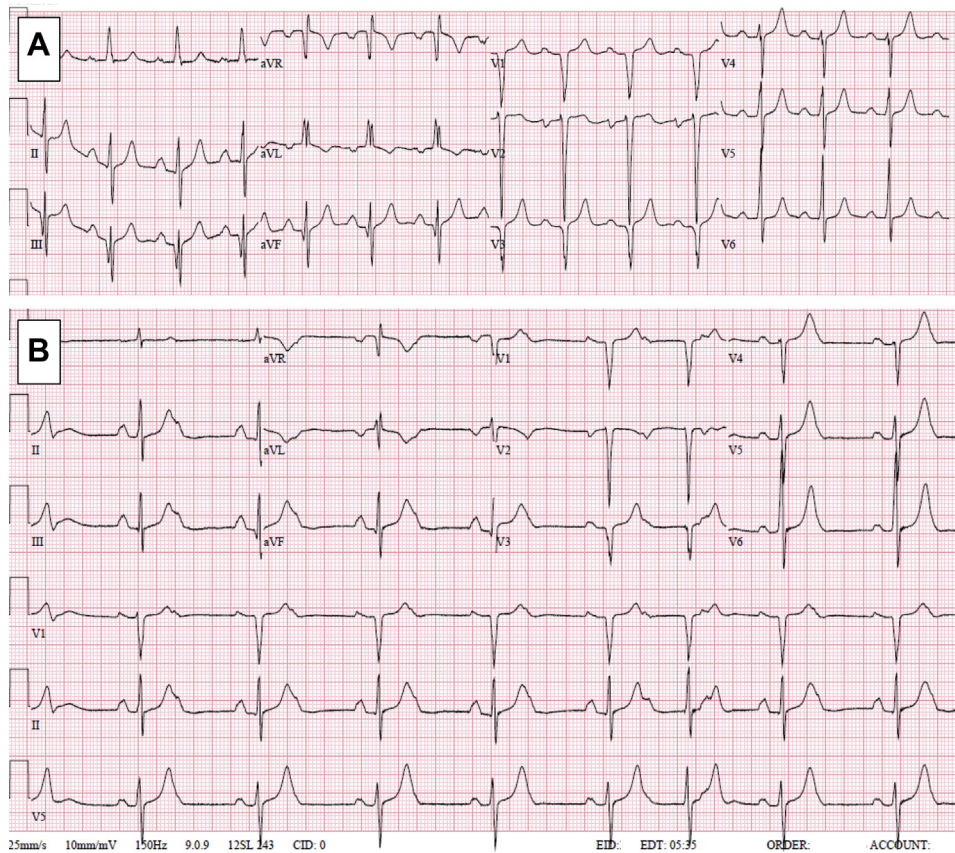


Figure 1 A: Twelve-lead electrocardiogram (ECG) at presentation. B: Twelve-lead ECG during inpatient stay demonstrating 2:1 AV conduction block.

Twenty-four hours following admission, telemetry demonstrated 2:1 AV conduction block with a ventricular rate of 60 beats per minute. Twelve-lead ECG confirmed sinus rhythm with 2:1 AV conduction block (Figure 1B). PR interval was 210 ms on conducted beats.

Following discussion with the Adult Congenital Heart Disease team and the Obstetrics team, a decision was made to proceed to dual-chamber pacemaker implantation. As per national guidelines, the obstetric team advised that fluoroscopy resulting in an absorbed radiation dose (rad) of below 0.5 Gy would not be expected to be associated with non-cancer fetal health effects.² Abdominal lead protection and minimal fluoroscopy required for safe device implantation were advised.

The patient received prophylactic intravenous cefazolin prior to the procedure and was positioned in the dorsal supine position with a slight leftward tilt to relieve pressure on the vena cava. Continuous fetal heart rate and uterine contraction monitoring was maintained throughout the procedure. Ultrasound guidance with a micropuncture needle was used to access the axillary vein. The micropuncture sheath was exchanged for a 6F sheath and 2 guidewires inserted. The 6F sheath was then removed and an 8F sheath inserted via 1 of the guidewires while the other was secured. A LiveWire duodecapolar (Abbott, St Paul, MN) catheter (2-2-2 mm electrode spacing) was advanced to obtain an anatomic map using the NavX (Precision; Abbott) Electroanatomic Mapping System (EAMS; Abbott). The course of the

superior vena cava (SVC), the SVC/RA junction, the IVC/RA junction, and the IVC were identified (Figure 2). An RA and RV geometry were generated using impedance mapping via the EAMS and the location of a His-bundle electrogram noted. Once an adequate RA and RV shell had been acquired, the decapolar catheter was retracted. A 3830 Select-Secure Medtronic MRI SureScan lead was advanced within a C315HIS (Medtronic, Minneapolis, MN) sheath. The lead was connected via alligator clips to the EAMS to allow visualization of the lead tip in relation to the obtained RA and RV geometries via impedance-based localization. The sheath was then advanced into the RV and slowly retracted and anteriorly deflected until the region of the His bundle potential was located. Pace mapping was performed via the pacing lead until the narrowest QRS complex was located. The lead was then actively fixed in the region of the right bundle branch and the sheath retracted. Testing was repeated and revealed a relatively narrow QRS complex (Figure 3). In the final position there was a sensed R wave of 3.6 mV, a capture threshold of 0.25 at 0.4 ms, and a lead impedance of 456 ohms.

Following positioning of the ventricular lead, a 7F hemostatic sheath was advanced over the second guidewire, following which the guidewire was retracted. Removing the holding wire resulted in a significant change in the impedance field in which the geometries had been generated, and remapping was required to accurately localize the atrial lead. A

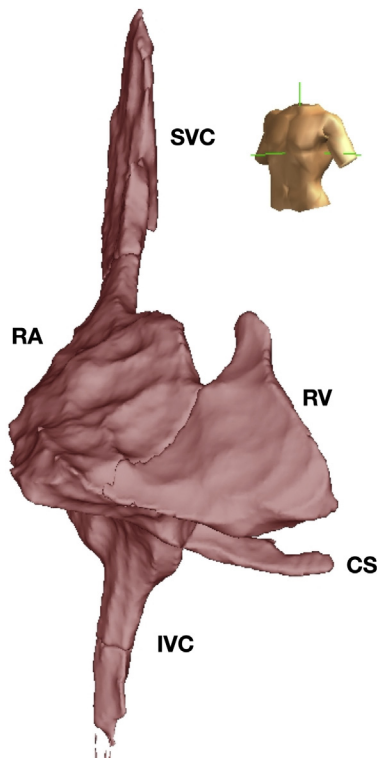


Figure 2 Geometry collected through the impedance-based NavX electro-anatomic mapping system (Abbott, St Paul, MN). CS = coronary sinus; IVC = inferior vena cava; RA = right atrium; RV = right ventricle; SVC = superior vena cava.

3830 SelectSecure MRI SureScan Medtronic lead was advanced over a C315HIS sheath while connected via alligator clips to the mapping system. This time the lead tip was positioned in a mid-atrial septal position as identified on the EAMS. In this position there was a clear current of injury, a sensed P wave of 3.3 mV, a capture threshold of 0.625 V at 0.4 ms, and a lead impedance of 532 ohms.

Prior to suturing the leads in place, an attempt was made visualize both leads using transthoracic echocardiography

to determine the amount of slack; however, obtained images were inadequate, so fluoroscopy was used to visualize the leads and slack was adjusted appropriately. The estimated dose area product was 3.5 cGycm², which was below the minimum detection threshold for absorbed radiation dose (<0.01 Gy).

The patient recovered well from the procedure. At 2 weeks follow-up the percentage atrial pacing was 0.3% and the percentage ventricular pacing was 99.8%. Systemic AV valve replacement will need consideration in the future. A provisional plan has been made for discussion of epicardial pacemaker lead placement at this time. A multidisciplinary team discussion, including a detailed discussion of the risks and benefits with the patient, will happen at this time to consider placement of a prophylactic shock coil.

Discussion

In this report we describe fluoroscopy-free implant of a dual-chamber pacemaker comprising a nonselective His-bundle pacing lead and a septal atrial lead without femoral venous access. The NavX EAMS was used to directly guide the implanted lead to the position of the His-bundle potential with a resulting narrow QRS complex in a patient with congenitally correct transposition of the great arteries and complete AV conduction block.

Complete AV conduction block is a recognized complication of L-CCTGA.³ An AV node situated on the anterior aspect of the right AV orifice, giving rise to an AV bundle that penetrated the fibrous valvular ring and emerged on the anterior aspect of the interventricular septum, was seen in 11 of 11 specimens examined at autopsy.⁴ In the older of these specimens extensive fibrosis was noted in the AV bundle, indicating the mechanism of acquired complete AV conduction block in this condition. A posterior AV node, located on the interatrial septum anterior to the orifice of the coronary sinus, was also observed in all patients; however, in 10 of these 11 patients it was hypoplastic and

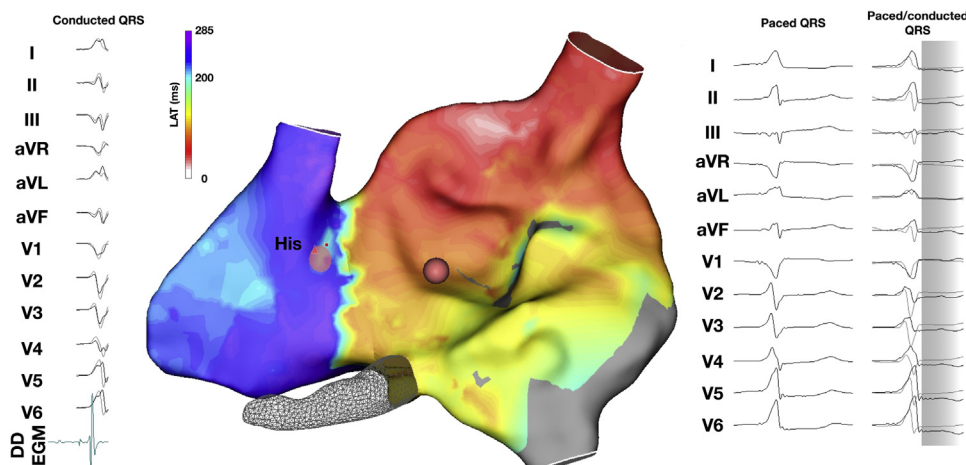


Figure 3 A: Twelve-lead electrocardiogram and electrogram from duodecapolar catheter at location of His bundle. B: Right atrial and ventricular geometry and activation timing during sinus rhythm. C: Conducted QRS during sinus rhythm. D: Paced QRS morphology (dark gray) superimposed on conducted QRS (light gray) showing narrow QRS during pacing.

did not give rise to a penetrating AV bundle. In 1 of these specimens dual AV nodes with penetrating bundles were seen, consistent with the electrophysiological observation of dual AV nodes and associated arrhythmias in L-CCTGA.⁵

With the increasing use of radiation during interventional procedures there is an incentive to minimize the radiation dose that patients receive. When radiation use is necessary the principle of “as low as reasonably achievable” should be applied in order to minimize the radiation dose required to complete the procedure.⁶ Specific circumstances including pregnancy, in which the fetus as well as the patient has the potential for adverse effects of excess radiation exposure, further motivate attempts to minimize the radiation dose. EAMS have been used to guide fluoroscopy-free interventional electrophysiology procedures⁷ and, even when used as an adjunct to fluoroscopy, have been reported to dramatically decrease the radiation exposure.⁸ Device implants now represent the greatest source of radiation exposure among electrophysiologists.⁶

Previous studies have reported the safe and effective use of the NavX EAMS as an adjunct to fluoroscopy during complex device implant procedures, including cardiac resynchronization therapy with implantable cardioverter-defibrillator⁹ comprising right ventricular (RV) apical lead placement as well as single- and dual-chamber implantable cardioverter-defibrillator implantation^{10,11} with consequent reduction in fluoroscopy use. Previous reports have described the use of NavX to guide fluoroscopy-free single- and dual-chamber pacemaker implantation in pregnant patients¹² and the use of Carto to guide fluoroscopy-free single-chamber pacemaker implantation in a pregnant patient with tetralogy of Fallot.¹³ In the pediatric population, pace mapping using the NavX system has been used as an adjunct to fluoroscopy to identify RV sites with optimal QRS morphologies and duration, and the geometry then used to guide the pacing lead to the same location.¹⁴ On some occasions additional femoral venous access has been used for EAMS geometry creation prior to lead placement, which may be associated with an increased risk of early device infection. We believe that this is the first report of fluoroscopy-free His-bundle lead placement under NavX guidance without the use of femoral venous access.

The use of NavX to guide device lead placement has the specific advantage of not requiring a magnet-enabled catheter to generate the cardiac geometry and allow for direct visualization of the lead tip within the acquired geometry. In this case, the use of impedance mapping was associated with the limitation of being sensitive to the withdrawal of the non-insulated, exposed stainless steel guidewire used to retain vascular access during placement of the RV lead, which necessitated adjustment of the map following removal of the guidewire for placement of the atrial lead. Options that could be considered to overcome this limitation include placement of both vascular sheaths following puncture, such that no retaining wire was required. The geometry could

then be acquired without the presence of a retaining wire, which would then be expected to be stable throughout placement of the ventricular and atrial leads. Alternatively, the change in the impedance field could be accepted and a new geometry collected following removal of the retaining vascular access wire, or a manual correction of the existing geometry could be performed; however, this would likely be associated with a significant increase in the duration of the procedure. It is possible that the change in impedance field would have been less marked if a shielded wire had been used as a holding wire.

The Medtronic SelectSecure lead has a fixed helix screw for active fixation and was chosen for the atrial lead as well as the ventricular lead. A septal atrial lead position was chosen to allow aggressive torque of the lead for fixation while reducing the risk of perforation owing to the anatomic location chosen. In this case the presence of a clear current of injury following fixation of both the ventricular and atrial leads was reassuring for tissue contact and stability.

Assessing the length of redundant lead (“slack”) is an important consideration during device implantation and at present remains a significant limitation to completely fluoroscopy-free device implantation. Echocardiography may be used to assess in some cases; however, in this case owing to the gravid uterus adequate transthoracic images were not possible. As with previous reports of fluoroless lead implantation, a fluoroscopy run was acquired toward the end of the procedure to assess the amount of slack on the lead. In the absence of adequate echocardiographic images to confirm appropriate lead slack, it is appropriate to accept a small dose of radiation to avoid the increased risk of lead dislodgement or other complications if the degree of slack on the leads is inappreciate.¹⁵

Conclusion

In summary, a fluoroscopy-free dual-chamber pacemaker implant comprising nonselective His-bundle pacing in a pregnant patient with congenitally corrected transposition of the great arteries is reported. Fluoroscopy free lead placement, including precise identification of optimal physiological pacing sites, is feasible without the use of radiation even in unusual anatomical configurations. At present, in the absence of adequate transthoracic echocardiographic images, fluoroscopy is likely to be required to assess lead slack; however, the radiation exposure required for this confirmation is low.

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