

Leadless ventricular pacemaker implant with atrial sensing in levo-transposition of the great arteries



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Introduction

Levo-transposition of the great arteries (L-TGA) is a rare form of congenital heart disease with an incidence of 2–7 per 100,000 live births and accounts for less than 1% of all congenital heart diseases.¹ It is characterized by both atrio-ventricular (AV) and ventriculoarterial discordance, thus earning the synonymous term “congenitally corrected” TGA. The morphologic left ventricle (LV) and mitral valve support flow to the pulmonic valve, and the morphologic right ventricle (RV) and tricuspid valve support flow to the systemic aortic valve. Additionally, more than 90% of patients have associated anomalies, including Ebstein-like malformation of the tricuspid valve, pulmonic stenosis, ventricular septal defect, and conduction defects.² Many patients who require a cardiac implantable electronic device, owing to their young age at implant, will likely experience multiple cardiac implantable electronic device–related procedures and are at high risk for complications. Herein, we describe a case of leadless Medtronic Micra AV pacemaker implantation in a patient with L-TGA in the setting of normal sinus rhythm with complete heart block (CHB) and a junctional escape rhythm at 55 beats per minute (bpm).

Case report

Our patient is a 27-year-old Hispanic woman with morbid obesity, pre-diabetes, and L-TGA. Her congenital heart disease was complicated by CHB requiring epicardial dual-chamber permanent pacemaker placement within the first year of life, ventricular septal defect requiring patch-closure at 5 years of age, and severe valvular and subvalvular pulmonic stenosis requiring valvuloplasty and subsequent

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KEY TEACHING POINTS

- Micra AV (Medtronic, Dublin, Ireland) implantation is feasible and safe in patients with levo-transposition of the great arteries.
- Anatomic differences of mitral valve anatomy and mitral inflow could potentially affect atrial sensing by the device accelerometer.
- Periprocedural imaging is safe and beneficial during device implantation.

valve replacement at ages 6 and 15 years, respectively. She underwent transvenous dual-chamber permanent pacemaker implantation at 16 years of age, presumably owing to failing epicardial lead capture, and subsequently required RV lead abandonment and RV lead replacement at 24 years of age owing to RV lead fracture. Three months following device revision, she developed (what was felt to be) a superficial skin infection. Over a period of 3 years she underwent multiple rounds of antibiotics, pocket revision, and washout before evaluation in our clinic. Upon evaluation, she was found to have a draining sinus tract and thus underwent laser lead extraction (LLE) of all transvenous leads with pocket revision, wound vac placement, and temporary pacemaker placement at 26 years of age. A subsequent transthoracic echocardiogram (TTE) demonstrated a new decrease in the systemic ventricular function with an ejection fraction (EF) of 30%. After a week of antibiotics and negative cultures, she underwent implantation of a new right-sided cardiac resynchronization therapy defibrillator device. Her systemic ventricular EF did not improve despite greater than 95% bi-ventricular pacing. A subsequent TTE 6 months post-implant showed her EF was still 30%–35%. She did well for 6 months, but she subsequently developed a stitch abscess along the medial border with repeated infection and dehiscence. She presented again for LLE, and given her repeated infections and complicated wound healing, it was decided that her case may be best managed by leadless Micra AV (Medtronic, Dublin, Ireland) placement with long-term intravenous antibiotics and wearable cardioverter-defibrillator

with subsequent subcutaneous implantable cardioverter-defibrillator (ICD) implantation at a later date, acknowledging the possible lack of biventricular pacing given clinical limitations. Micra AV placement and LLE were performed during the same procedure. A transesophageal echocardiogram (TEE) was performed pre-procedure to assess the leads for vegetation and assess the nonsystemic LV, mitral valve, systemic RV function, and septal anatomy.

TEE guidance was not utilized for device placement. Access was obtained in the right femoral vein and upsized to the 23F Micra introducer sheath in standard fashion. Deployment of the device was performed using standard right anterior oblique and left anterior oblique fluoroscopy views (Figure 1). A midseptal deployment site was chosen in hopes of minimizing ventricular dyssynchrony during pacing and avoiding potential apical perforation at implantation. Navigation into the right atrium, across the right-sided mitral valve, and into the non-systemic LV was uncomplicated and performed in standard fashion. Contrast injection via the Micra delivery sheath demonstrated a lack of significant trabeculae, but sufficient contact with the compact myocardium (Figure 1). The device was successfully deployed on the first attempt, and a tug test demonstrated engagement of all 4 tines with adequate stability. Pacing and sensing thresholds were exceptional at 0.5 V @ 0.24 ms and 2.4 mV (nonpaced), respectively. Impedance was normal at 950 ohms. Testing of atrial mechanical sensing demonstrated poor A4 sensing with a very low amplitude deflection. The underlying atrial rate was determined to be between 70 and 80 bpm; however, the device was unable to sense the A4

signal despite all efforts to expand the A4 window and to increase sensitivity to the signal. A postimplant TEE was performed to reassess the position of the device, which demonstrated an acceptable low septal position (Figure 2). The device was programmed to VVI with a lower rate limit of 50 bpm. Overnight telemetry demonstrated AV dyssynchrony; however, the following morning the atrial mechanical sensing settings were reprogrammed and the device demonstrated consistent atrial sensing and ventricular tracking and pacing (Figure 3).

The day following device implantation, TTE revealed systemic right ventricular EF of 40%–50%. The device continues to function properly at 3 months post-implant, with a 98% A-sensed, V-paced rhythm. She was screened in clinic for a subcutaneous ICD, but failed owing to T-wave oversensing. Given the improvement in ventricular function, lack of prior ventricular arrhythmias, and increased risk for infection, the patient opted against ICD placement after discussion of risks and benefits.

Discussion

This case illustrates the feasibility of Micra AV implant in a case of L-TGA. To date, there have only been 2 reported case of leadless pacemaker implant in the setting of TGA, both Micra VR. In the first case, the patient had L-TGA³ and in the second case the Micra VR was placed through a baffle into the nonsystemic LV in a patient with dextro-TGA and subsequent Mustard repair.⁴ Our case is the first description of a Micra AV implantation in an L-TGA patient, causing

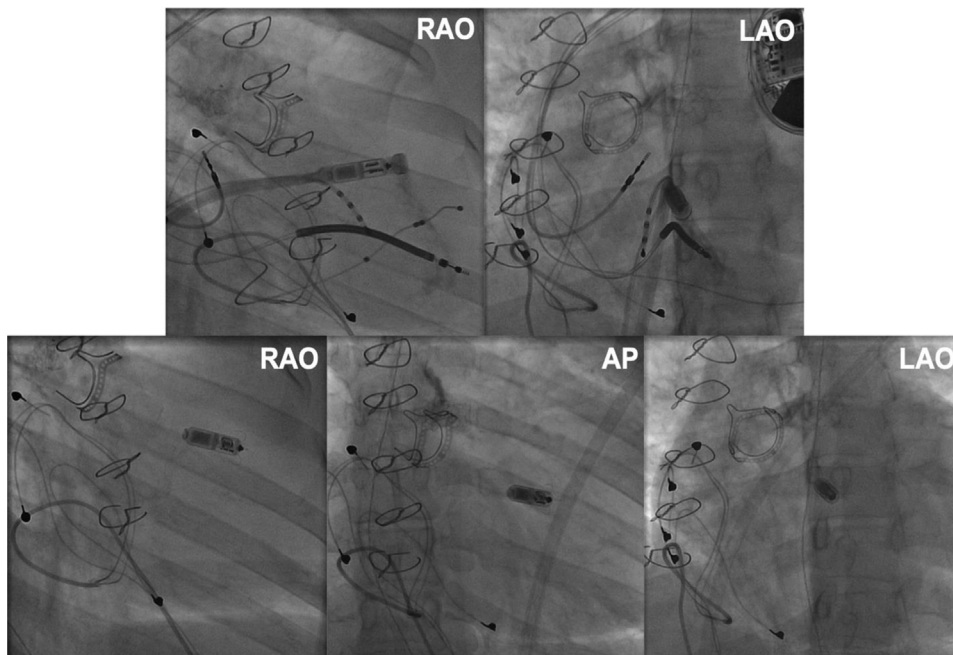


Figure 1 Intraprocedural fluoroscopic views demonstrated the presence and position of abandoned epicardial pacing wires, cardiac resynchronization therapy defibrillator (CRT-D) intravenous pacing leads, temporary transvenous right ventricular pacing lead, and pulmonic valve replacement. In the upper 2 images, the Micra (Medtronic, Dublin, Ireland) delivery sheath is seen crossing the mitral valve and abutting the mid anterior septum during contrast injection through the sheath. The bottom 3 images demonstrate the Micra AV positioning post-implant and post-extraction of the CRT-D system. AP = anteroposterior; LAO = left anterior oblique; RAO = right anterior oblique.

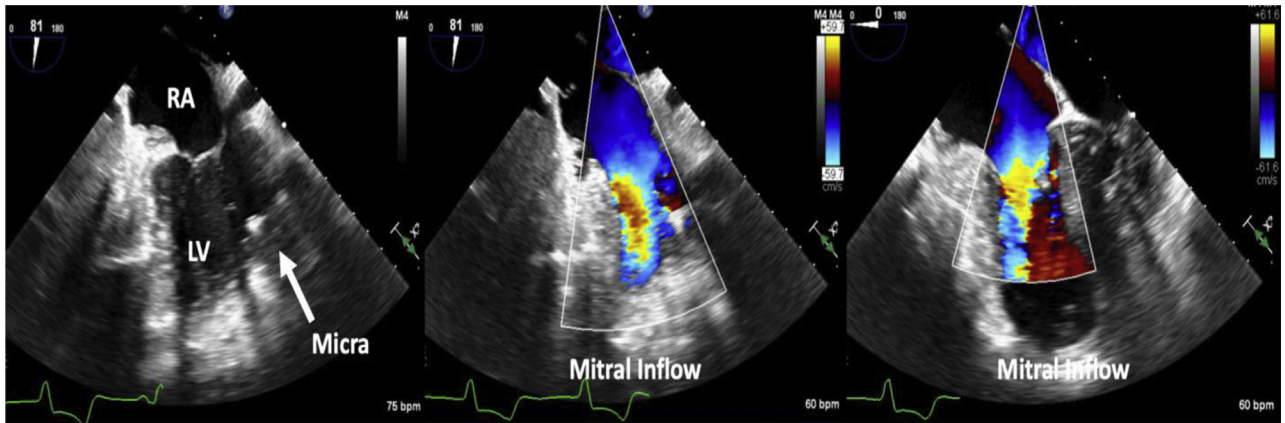


Figure 2 Postprocedure transesophageal echocardiogram demonstrated a low septal position of the Micra (Medtronic, Dublin, Ireland) leadless pacemaker. Atrioventricular and ventriculosystolic discordance were present. The anterior mitral valve leaflet was oriented toward the septum. The mitral inflow was directed away from the device. LV = left ventricle; RA = right atrium.

unique atrial sensing challenges and requiring additional considerations prior to successful implantation. First, the Micra delivery sheath was designed for crossing a tricuspid valve, which is typically 20% larger in orifice area and more apically displaced than a mitral valve.⁵ However, in this case, the hinge point of the delivery sheath and maximal deflection proved to be adequate for crossing the valve and did not require special maneuvering. Additionally, it is standard practice to release the curve after crossing the valve prior to implantation. Given that the valve is not as apically displaced, it is feasible to consider that this may result in a more basal implantation site with less maneuverability; however, this was not observed in practice.

Secondly, we considered the lack of trabeculae within the nonsystemic LV to present a challenge for stability, as the nitinol tines of the device are typically well seated deep into the recesses. However, there was no demonstrable differ-

ence in the ease of delivery, and all 4 times appeared to easily deploy into the compact septal myocardium.

Third, we considered a prior septal patch repair to have some potential effect on both the sensing and capture threshold of the device, and we felt it was necessary to obtain a preprocedure TEE and consider TEE guidance for device deployment. However, this imaging did not reveal an appreciable scar or visible patch. Given that the repair occurred more than 20 years prior, it is likely that myocardial tissue ingrowth covered the prior surgical site.

Lastly, we did not consider that variation in the AV valve anatomy (mitral valve) and the inflow pattern from the right atrium to the nonsystemic LV would have an effect on the device. While we did not observe any complications at the time of implantation, it must be noted that the anterior mitral leaflet is typically 21 ± 3 mm long, is highly mobile, and has numerous chordal attachments to the papillary muscles.^{6,7}



Figure 3 Micra AV (Medtronic, Dublin, Ireland) interrogation postoperative day 1 demonstrates improved sensing of atrial contraction (A4). Marker channels show the timing indicating end of ventricular diastole (A3), labeled as VE (ventricular end). AM (atrial mechanical) is the detection of A4 by the accelerometer, and the delivered right ventricular pacing is VP (ventricular pace).

In stark contrast, the septal tricuspid valve leaflet is the smallest of the 3 tricuspid leaflets and largely immobile.⁵ Fortunately, we implanted the device apically enough to avoid potential anterior leaflet contact with the device during diastole. A more basal implant position could have resulted in diastolic leaflet contact with the device, which may have resulted in a significant increase in risk for instability, variations in capture threshold, and/or negative effects on accelerometer sensing. We also did not consider that the differences in valvular anatomy could result in redirection of the mitral inflow away from the device. Although we cannot prove that this resulted in difficulty with atrial mechanical sensing, it could theoretically have a significant impact, as A4 sensing is dependent on inflow directed at the device in order to cause sufficient deflection of the accelerometer.

Conclusion

In conclusion, this case illustrates that Micra AV implantation for the treatment of CHB in a patient with L-TGA is feasible, although differences in the AV valve anatomy and subsequent ventricular inflow may present unique challenges. Special

considerations should be taken during implantation to maximize A4 sensing in order to maintain AV synchrony. As potential exists for the anatomical abnormalities to negatively impact short- and long-term device stability and performance, the addition of both preprocedural and intraprocedural imaging may improve outcomes.

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