Lead extraction and upgrade to a biventricular device with concomitant systemic tricuspid valve replacement in an adult with congenitally corrected transposition: A hybrid approach

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Introduction

Lead extraction has emerged as an important procedure for upgrading devices by maintaining venous access and removing redundant leads.[1] Although most lead extractions are performed percutaneously, hybrid approaches that involve minimally invasive surgical techniques along with percutaneous extraction have been reported.[2–4] In rare circumstances, patients may require open heart surgery for valvular dysfunction, which affords the opportunity for concomitant lead extraction and reimplantation. The approach to lead management in these clinical situations can be complex and must be individualized.

We report a unique clinical dilemma of a patient with congenitally corrected transposition of the great arteries (cc-TGA) whose medical course was complicated by complete heart block necessitating transvenous dual-chamber pacemaker implantation in childhood. He later developed severe systemic atrioventricular valve (tricuspid valve [TV]) regurgitation complicated by systemic ventricular dysfunction requiring surgical TV replacement and lead extraction with upgrade to a biventricular implantable cardioverter-defibrillator (BiV-ICD). In this report, we describe the rationale and approach for safely and effectively performing these procedures in a hybrid manner.

KEYWORDS Congenitally corrected transposition of the great arteries; Complete heart block; Hybrid procedure; Lead extraction; Valve regurgitation
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Case report

A 26-year-old man with history of cc-TGA with ventricular septal defect and subpulmonary stenosis presented with worsening dyspnea on exertion. At age 3 years, he had undergone surgical repair including ventricular septal defect patch closure and resection of subpulmonary stenosis. The procedure was complicated by complete heart block requiring an epicardial single-chamber pacemaker placement. At age 5 years, the epicardial lead became infected, requiring removal and replacement with a dual-chamber transvenous pacemaker (placement of the leads in the right atrium and subpulmonic left ventricle [LV]). At age 17 years, he developed ventricular lead malfunction and required placement of a new lead; the old LV lead was abandoned and capped. At age 26 years, he presented with severe TV regurgitation complicated by systemic ventricular failure. He was completely dependent on ventricular pacing with a paced QRS duration of 160 ms. Chest radiograph showed a dual-chamber pacemaker with an abandoned transvenous ventricular lead (Figure 1A). Transthoracic echocardiography revealed severely dilated right ventricle (RV) with reduced systolic function (right ventricular ejection fraction = 20%–25%) and evidence of electromechanical dyssynchrony. There was severe systemic TV regurgitation with an eccentric regurgitant jet (Figure 1B).

After a multidisciplinary team discussion, the proposed management strategy included surgical TV replacement with upgrade to a BiV-ICD system. The rationale for BiV-ICD upgrade was based on the underlying electromechanical dyssynchrony and consideration of the sudden cardiac death risk in the setting of severe TV regurgitation, severe systemic RV dysfunction, and NYHA class III symptoms (class IIB, level of evidence: C).[5] Because he already had 2 ventricular pacing leads, and considering his young age, it was felt that complete system extraction and implantation of a BiV-ICD

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KEY TEACHING POINTS

- Patients with congenitally corrected transposition of the great arteries can have complete heart block requiring pacemaker implantation, and can also develop systemic atrioventricular valve regurgitation with ventricular dysfunction later in life; this may necessitate concomitant valve replacement, as well as upgrade to a biventricular implantable cardioverter-defibrillator.
- Lead extraction of redundant leads along with reimplantation can be performed concomitantly at the time of cardiac surgery, and requires collaboration between the electrophysiology and cardiac surgery teams.
- The risks associated with the increased duration of performing a hybrid procedure involving lead extraction, reimplantation, and cardiac surgery need to be balanced against that of performing 2 separate, relatively long procedures.

was a superior approach rather than leaving yet another abandoned pacemaker lead in place. We considered a staged approach involving surgical TV replacement followed by lead extraction/reimplantation as 2 separate procedures. However, it was decided to proceed with a single procedure using a hybrid approach as follows:

(1) Open surgical/on pump: After sternotomy and cardiopulmonary bypass, TV replacement was performed using a mechanical valve (On-X, On-X Life Technologies Inc, Austin, TX). The intracardiac portions of the LV leads were removed (Figure 2A and B). The right atrial (RA) lead was freed from cardiac tissue but left intact. The distal tip of this lead was then brought through the RA free wall via a purse-string suture opening, anticipating the need for manual counter-traction to ensure retention of venous access during lead extraction sheath advancement (Figures 2B and 3A and B). A temporary LV epicardial pacemaker wire was placed at this point.

(2) Percutaneous lead extraction/off pump with fluoroscopy: The patient was taken off pump and heparin was reversed. The pacemaker pocket was then opened, and the residual ventricular pacemaker lead fragments were first extracted (Figure 3C) using a 13 French Tightrail (Phillips, Amsterdam, Netherlands). The RA lead was prepped, and while manual counter-traction was being held by the second operator, a mechanical extraction sheath was advanced to the superior vena cava–RA junction (Figures 2C and 3D). Once it was felt that the lead had been fully dissected free of all binding fibrotic tissue, the distal, external segment of the RA lead was cut and removed. The proximal RA lead fragment was completely removed via the extraction sheath and the purse-string suture was used to surgically close the hole in the RA (Figure 2D). Two glide wires (Cook, Bloomington, Indiana) were then advanced through the extraction sheath to retain venous access.

(3) Percutaneous lead reimplantation/off pump with fluoroscopy: A single-coil ventricular ICD lead was placed on the LV septum, and a RA lead was placed in the RA appendage.

(4) Open surgical/off pump: A bipolar epicardial pacing lead was placed on the posterolateral aspect of the systemic RV and was tunneled toward the device pocket in the left pectoral area. The leads were attached to a BiV-ICD generator (Figures 2E and 3E) followed by closure of all incisions. The total procedural time was approximately 8 hours.

The patient had an uncomplicated postoperative course and was discharged on postoperative day 7. At 8 months follow-up, the patient has reported significantly improved functional level—NYHA II compared to symptoms of

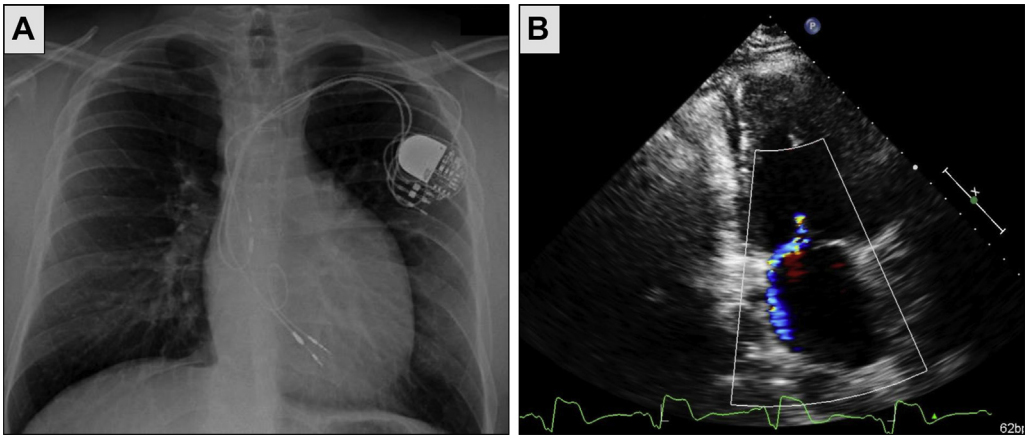

Figure 1 **A:** Chest radiograph showing dual-chamber pacemaker system with an abandoned right ventricular lead, and a newer functioning ventricular lead that has a loop of redundant slack at the level of the pulmonic mitral valve. **B:** Apical long-axis echocardiography view showing severe eccentric regurgitation involving the systemic atrioventricular (tricuspid) valve.

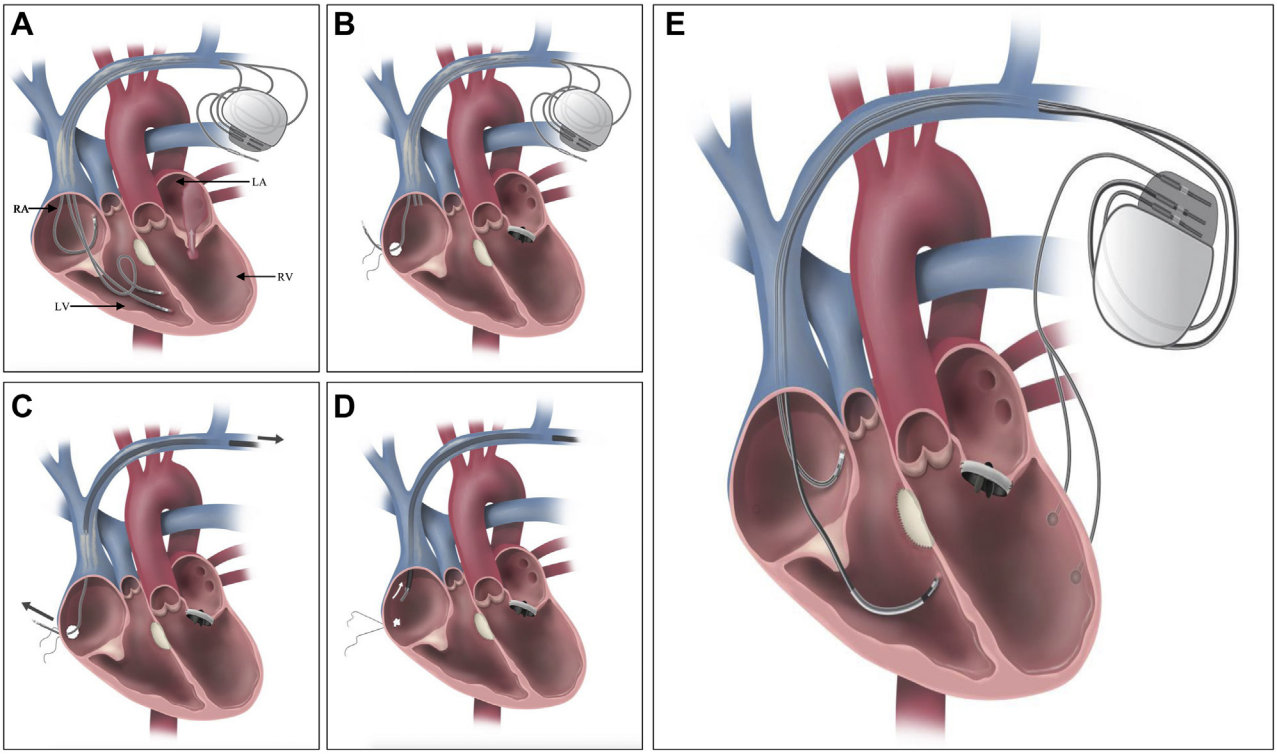

Figure 2 Representation of steps for the hybrid procedure. **A:** At the start of the procedure. LA = left atrium; LV = left ventricle; RA = right atrium; RV = right ventricle. **B:** Completion of atrioventricular valve replacement as well as removal of intracardiac aspects of the pulmonic left ventricular leads. The right atrial lead has been freed from the right atrial free wall and is taken out via an atriotomy with a purse-string suture. **C:** After extraction of the cut intravascular fragments of the ventricular leads, extraction of the right atrial lead is performed while ensuring retention of venous access by holding manual countertraction on the lead tip. **D:** After dissecting the lead free of the binding fibrotic tissue, the distal segment of the lead was cut and removed while the proximal fragment was removed via the extraction sheath, following which the purse-string was tied, achieving hemostasis. **E:** Final result with systemic atrioventricular valve replacement, complete pacemaker system removal, and implantation of a biventricular implantable cardioverter-defibrillator system with an epicardial bipolar systemic right ventricular lead.

NYHA III prior to intervention. All device and lead parameters have been stable. Follow-up echocardiography revealed a decrease in RV volume, improvement in systemic RV function (right ventricular ejection fraction = 30%–35%), and normal prosthetic valve function (Supplementary Figure S1).

Discussion

Lead extraction is usually performed exclusively via a percutaneous approach with need for additional minimally invasive surgery on occasion.[2,3] Concomitant lead extraction without device upgrade in patients requiring open heart surgery for valvular or other indications has been described.[4] The aforementioned complex scenario, which required surgical TV replacement with removal of redundant leads and device upgrade, necessitated multidisciplinary collaboration to accomplish all clinical goals in a single procedure.

Heart block can occur at a rate of 2% per year in patients with cc-TGA, resulting in pacemaker implantation at a relatively young age.[6] Systemic RV failure is a common clinical presentation in adult patients with cc-TGA and is related to multiple factors, including poor adaptation of RV to systemic circulation, commonly accompanied by TV regurgitation, and dyssynchrony from single-site ventricular pacing. Although outcomes of cardiac resynchronization therapy in previous studies of congenital heart disease patients that included cc-TGA have been variable, a more recent study that only included cc-TGA patients (n = 20) showed favorable outcomes in 67% of the patients with favorable electrical remodeling (shortened QRS duration) and improvement in RV function, particularly in patients requiring chronic LV pacing.[7] In patients with systemic RV failure with high burden of single-site ventricular pacing and associated severe TV regurgitation, BiV-ICD placement should thus be considered at the time of valve surgery.

In the current era, most extractions are performed via a superior percutaneous approach using laser and/or mechanical extraction sheaths. In difficult cases, an inferior percutaneous approach is necessary, and this typically involves the use of snaring tools.[8] When a percutaneous approach is felt to be high risk (large complex vegetations, perforated leads) or technically challenging (retained segments that cannot be snared), concomitant minimally invasive surgery has been described.[2,3] In patients requiring open heart surgery for other indications, such as valvular heart disease or coronary artery disease, simultaneous lead extraction may be performed at the same time. Azarrafiy and Carrillo[4] reported a series of 28 patients who underwent concomitant open heart

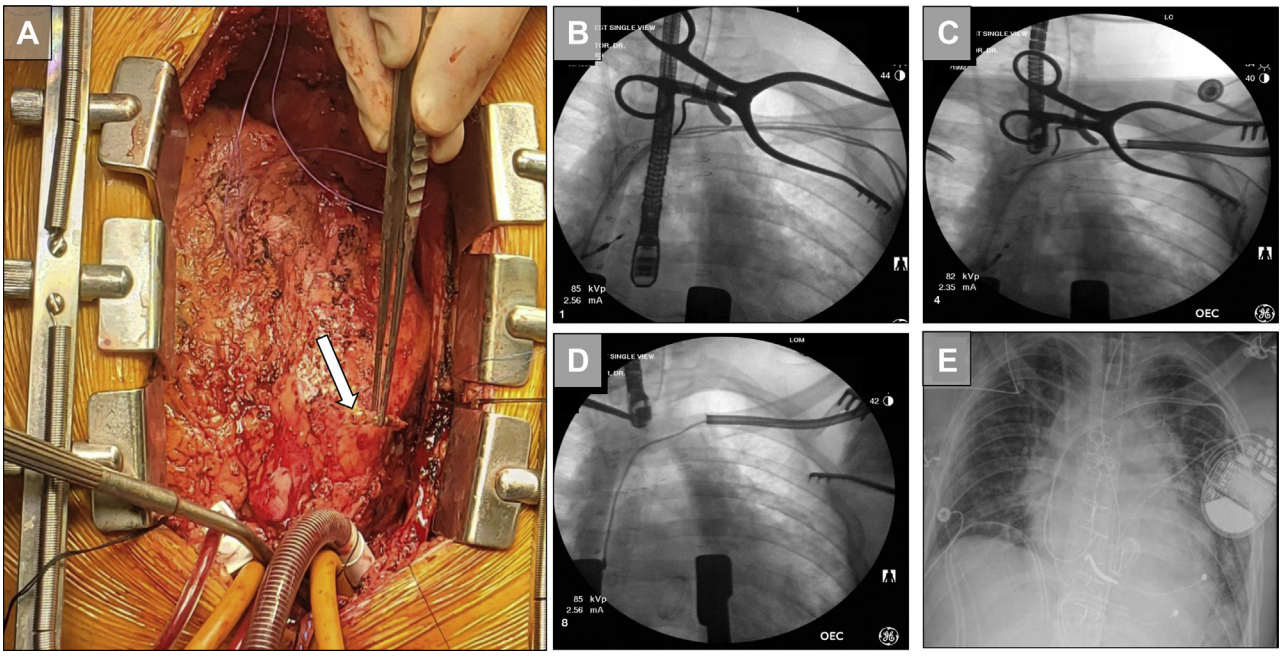

Figure 3 **A:** Photograph taken during the surgery after completion of the atrioventricular valve replacement as well as removal of intracardiac aspects of the right ventricular pacemaker leads; the right atrial lead was freed from the right atrial wall, and was brought out through a purse-string atriotomy (*arrow*), allowing a second operator to hold counter-traction during lead extraction. **B:** Intraoperative C-arm fluoroscopy image depicting start of the percutaneous extraction procedure, showing cut right ventricular lead fragments and an intact right atrial lead with its lead tip already exiting the right atrium (RA) via the atriotomy. **C:** Extraction of the ventricular lead fragments. **D:** Extraction of the right atrial lead, while manual counter-traction was being held so as to ensure retention of venous access to the RA. **E:** Postoperative chest radiograph depicting biventricular implantable cardioverter-defibrillator system with an epicardial bipolar ventricular lead.

surgery (predominantly for mitral valve replacement or coronary artery bypass grafting) and lead extraction. Reimplantation of new leads at the time of open heart surgery was not described in this series. In contrast, this case is the first report of a hybrid approach where valve replacement, lead extraction, and lead reimplantation were all performed in the same setting.

A major limitation of performing a hybrid procedure for valve replacement and lead extraction with device upgrade is the time and logistics involved. A staged procedure done on different days would be an alternative, but this would then require 2 relatively long procedures in a short span of time. We felt that the additional time taken to consolidate the interventions into a single procedure was a worthwhile trade-off to avoid 2 separate procedures. The other alternative that could be considered in such a clinical situation is lead extraction at the time of surgery with implantation of a completely epicardial biventricular pacemaker system with 3 bipolar leads, and then the addition of a separate subcutaneous ICD system in the future. We preferred to avoid an additional implanted device in this young patient and hence did not choose this latter approach.

Conclusion

In conclusion, we describe a rare case of a patient with congenital heart disease that required systemic atrioventricular valve replacement as well as lead extraction with a device upgrade at the same time. In a single, hybrid procedure with a planned stepwise approach that capitalized on an open chest and participation of the cardiothoracic surgical and electrophysiology teams, valve replacement, lead extraction, and device upgrade were safely and effectively performed. National registries and multicenter collaborative networks are warranted to further explore the utility of similar approach in an adult congenital heart disease population.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2020.05.008.

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