Surgical management of left bundle branch pacing lead causing septal and left ventricular perforation

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Introduction

Despite improvements in procedural technique and lead design, pacemaker lead placement has a 3%–9% complication rate, largely owing to lead displacement, myocardial perforation, and pneumothorax.[1] While right ventricular (RV) perforation after RV lead placement is well documented, left ventricular perforation is not. Recently, left bundle branch pacing (LBBP) effected by RV lead placement on the mid interventricular septum is replacing coronary sinus lead placement for synchronous biventricular pacing in patients with low ejection fraction. LBBP more closely approximates physiologic biventricular conduction and presents an alternative to coronary sinus pacing in patients with unfavorable coronary sinus anatomy, ineffective pacing owing to myocardial scarring, or coronary sinus branch occlusions following lead revisions.[2] We describe a unique case of a newly placed RV septal pacing wire perforating the interventricular septum, left ventricular free wall, and pericardium. The trajectory of the lead lacerated the left lower lobe of the lung, with the lead tip embedded in the chest wall, severing the sixth intercostal artery, with the recipient presenting with massive hemorrhage, hemopericardium, and left hemothorax. The lead was surgically removed. This is one of the few reported cases of significant bleeding and hemodynamic instability secondary to left ventricular perforation from RV pacing lead placement and should be recognized as a complication of new strategies for biventricular pacing.

KEY TEACHING POINTS

- Right ventricular lead perforation of the interventricular septum and left ventricular free wall after left bundle branch pacing wire placement can be a life-threatening event that requires prompt intervention.
- The clinical presentation of right ventricular septal lead perforation can vary depending on the lead tip location, lead type, extent of perforation, injury to the right or left ventricular free walls, and injury to surrounding anatomic structures.
- As the prevalence of implantable cardiac pacemaker devices increases and new biventricular pacing techniques requiring lead fixation to the interventricular septum grow, multidisciplinary teams of cardiac surgeons, cardiologists, and emergency room physicians need to promptly recognize and deal with the sequelae and complications of these technologies.

Case report

An 84-year-old white female patient underwent right atrial (RA) and RV septal pacemaker placement for LBBP at a community hospital for intermittent third-degree atrioventricular (AV) block and low ejection fraction. Active-fixation, exposed helix screw leads were placed on the RA free wall (CapSureFix Novus MRI SureScan 5076-45, diameter 2.0 mm; Medtronic, Minneapolis, MN) using a 7F Safe Sheath (Medtronic) and J stylet, as well as on the RV septum (CapSureFix Novus MRI SureScan 5076-52, diameter 2.0 mm; Medtronic) using a 7F Safe Sheath (Medtronic), with fluoroscopic guidance to the RV outflow tract, with repositioning using a straight stylet into the midventricular septum for LBBP. Leads were connected to a dual-chamber Azure S DR MRI SureScan pacemaker (Medtronic). Before discharge without anticoagulation, the RA wave amplitude was 1.5 mV, with a pacing threshold of 0.6 V at 0.4 ms and a pacing impedance of 551 ohms. The RV wave amplitude was 11.9 mV, with a pacing threshold of 0.5 V at 0.4 ms and a pacing impedance of 684 ohms. Electrocardiography confirmed deep septal LBBB pacing, and chest radiograph (CXR)

KEYWORDS Pacemaker; Pacing wire; Left ventricular perforation; Left bundle branch pacing; Biventricular pacing
(Heart Rhythm Case Reports 2023;9:520–523)

Funding Sources: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Disclosures: None. **Address reprint requests and correspondence:** Dr Patricia A. Thistlethwaite, Division of Cardiothoracic Surgery, University of California, San Diego, 9300 Campus Point Dr, La Jolla, CA 92037-7892. E-mail address: pthistlethwaite@health.ucsd.edu.

https://doi.org/10.1016/j.hrcr.2023.05.001

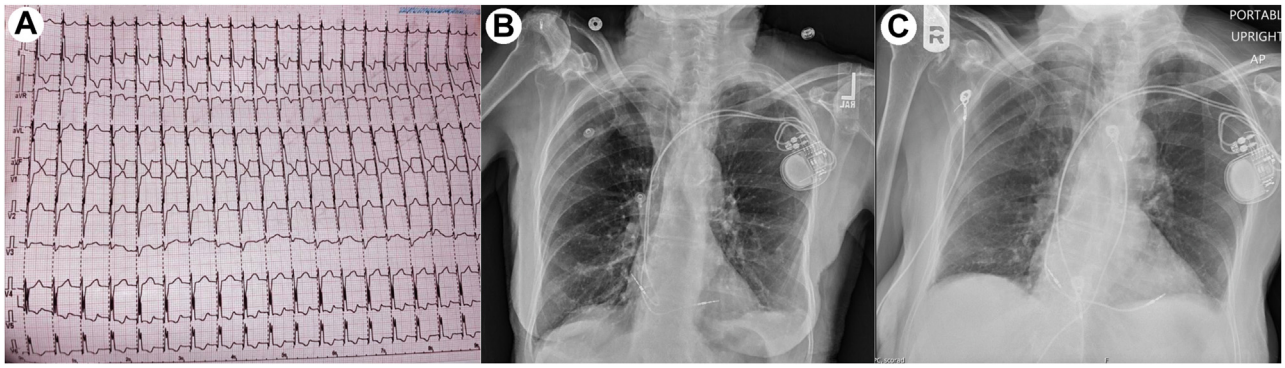

Figure 1 **A, B:** Electrocardiography confirms deep septal left bundle branch pacing (**A**) and anteroposterior chest radiograph (CXR) demonstrates atrioventricular lead placement in the mid distal septum (**B**), immediately post pacemaker implantation. **C:** Anteroposterior CXR on postimplant day 8 shows slight repositioning of right ventricular lead.

demonstrated the RV lead in the mid distal septum (Figure 1A and 1B).

Eight days after pacemaker placement, she presented with chest pain and near-syncope, but was discharged after her electrocardiogram showed pacing at 70 beats per minute with 90% capture. At that time, her CXR suggested slight repositioning of the RV lead (Figure 1C). She returned to the emergency room the following day after a syncopal fall with pacemaker failure in third-degree AV block with bradycardia (Figure 2A), a systolic blood pressure of 70 mm Hg, and a hematocrit of 17%. Chest computed tomography revealed hemopericardium and a large left hemothorax, complete left lung collapse, and the RV septal pacing wire tip outside of the heart (Figure 2B). A left chest tube was placed that drained 3.5 liters of bright red blood, with ongoing output. A follow-up CXR revealed persistent opacification of the left hemithorax (Figure 2C). She was urgently transferred to our hospital, after having received 6 units of packed red blood cells.

During transport, the patient's chest tube drained an additional 1600 mL of bright red blood, suggesting an arterial source. Upon arrival, the patient was hypotensive and confused, with substernal chest pain. Focused assessment with sonography in trauma demonstrated echocardiographic signs of tamponade. Pacemaker interrogation revealed no RV lead capture at maximal threshold. Urgent chest computed tomography, done because outside images were unobtainable, revealed the RV septal pacing lead to exit the anterolateral wall of the left ventricle, traversing the left hemithorax, with the tip terminating in the chest wall at the level of the sixth intercostal space (Figure 3A), where there was active extravasation of contrast within the loculated hemothorax (Figure 3B). She required ongoing transfusion of 4 units packed red blood cells, 2 units fresh frozen plasma, 1 unit platelets, with 1 unit cryoprecipitate and was taken emergently to the operating room to control bleeding.

After median sternotomy, the pericardium was opened and 900 mL of clot and fresh blood were removed. There was active bleeding 1 mm lateral to the left anterior descending artery on the left ventricular wall, where the pacing wire exited the heart (Figure 3C). The pacing wire perforated the left lateral pericardium with laceration of the left lower lobe anterior surface, leading to an air leak and parenchymal bleeding. The pacer tip impaled the lateral sixth intercostal artery, which was actively bleeding. Intraoperatively, 2 liters of blood and clots were removed from the left chest. The left chest wall pacer pocket was opened, the RV pacing wire was cut at the left ventricular surface, and the proximal portion of the pacing wire was removed by gentle traction. Transesophageal echocardiography and intraoperative digital palpation confirmed normal left ventricular wall thickness. The left ventricular puncture site was closed with a single pledgeted, polypropylene horizontal mattress suture placed on both sides of the left anterior descending artery, approximating the myocardium deep to this vessel while preserving vessel patency. The distal end of the RV lead was extracted from the left pleural space and chest wall, and the actively spurting sixth intercostal artery was oversewn. The lower lobe lung laceration was closed by oversewing the parenchyma with a 5-0 polypropylene suture. Temporary epicardial leads were placed and tunneled to an external pacemaker. The patient was extubated, weaned off pressors on postoperative day 1, and underwent right interventricular septal placement of an AV Micra leadless pacemaker (Medtronic) on postoperative day 6. At her follow-up visit 2 weeks after discharge, she had normal pacing parameters and was without symptoms.

Discussion

Cardiac pacemaker devices are well tolerated, with complication rates between 3% and 9% within the first month after implantation.[1] Lead perforation is a rare complication of pacemaker placement, with reported rates of approximately 0.1%–0.8% for pacemakers and 0.6%–5.2% for implantable cardiac defibrillators.[3] Acute RV perforation after pacemaker placement occurs less frequently than atrial perforation, with the most common site of exit at the apex of the right ventricle.[3,4] RV lead migration into the left pleural cavity and lung have been described; however, interventricular

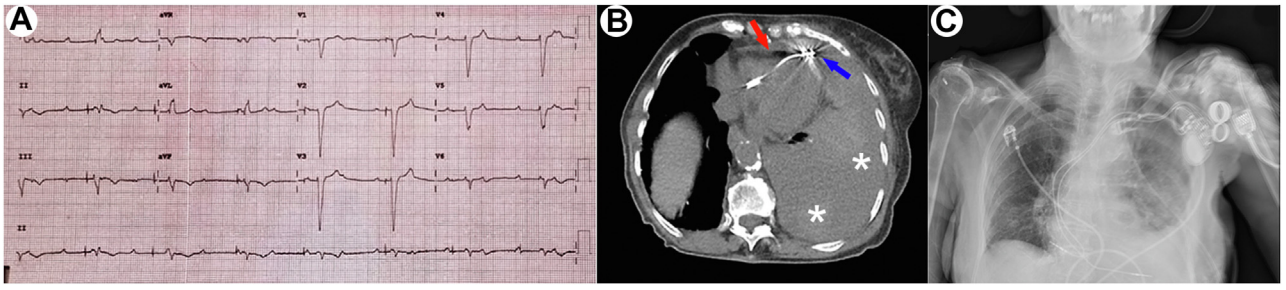

Figure 2 **A:** Electrocardiography shows third-degree atrioventricular block with a ventricular rate of 46 beats/min on postimplantation day 9. **B:** Axial chest computed tomography demonstrates hemopericardium (*red arrow*), large left hemothorax (*asterisks*) with complete left lung collapse, and pacing lead tip outside of the ventricle (*blue arrow*) on postimplant day 9. **C:** Anteroposterior chest radiograph on postimplant day 9 following chest tube placement shows residual left chest collection.

septal and left ventricular perforation resulting in left hemothorax is extremely rare, with only 3 reported cases in the literature in the past 50 years.[4–6] To our knowledge, our case is the first where pacing wire trauma resulted in simultaneous bleeding from the left ventricular free wall, lung, and chest wall.

The clinical presentation of pacemaker lead perforation can vary drastically depending on the lead tip location, lead type, extent of perforation, perforation timing, and injury to surrounding anatomic structures.[7] Although chest pain, dyspnea, dizziness, and syncope are the most commonly reported symptoms, patients may be asymptomatic.[4,8] Lead migration can alter pacing thresholds or result in lack of capture, unmasking underlying arrhythmias, leading to heart failure and death.[8] Damage to adjacent structures can cause life-threatening complications, including pneumothorax, hemothorax, hemopericardium, and cardiac tamponade.[7] Since perforations can have heterogeneous clinical presentations and highly morbid complications, clinicians should maintain a high index of suspicion in patients who present to the hospital with a history of recent pacemaker placement with loss of pacemaker capture with or without a drop in hematocrit.

In our case, the patient had RV septal lead placement for deep septal LBBP, in the setting of heart failure and intermittent third-degree AV block. As LBBP and His bundle pacing are rapidly replacing coronary sinus pacing for biventricular synchronous pacing for the treatment of heart failure,[9] we suspect that more of these types of lead perforation of the interventricular septal will be reported in the future. The pathophysiology of lead perforation has not been clearly defined but is likely multifactorial and related to imbalances between the lead tip and ventricular forces.[8] Risk factors for lead perforation may include female sex, increased age, patient fragility, short stature, low body mass index, decreased ventricular wall or septal thickness, unremoved nonfunctional pacing wires, depressed ejection fraction, and the use of steroids. Pulmonary hypertension and subsequent RV hypertrophy have been associated with decreased rates of lead perforation.[8] Although our patient did not have decreased ventricular wall thickness by palpation, she was elderly and had depressed ejection fraction (35%), low body mass index (18.0), frailty, and short stature (155 cm tall). We suspect our patient had presyncope when pacemaker capture was intermittent and her syncopal fall when left ventricular perforation, complete loss of pacemaker capture, and bleeding occurred. The trauma of her fall may have also contributed to her lead migration. The risk for subacute lead perforation has also been correlated with pacing wire characteristics,

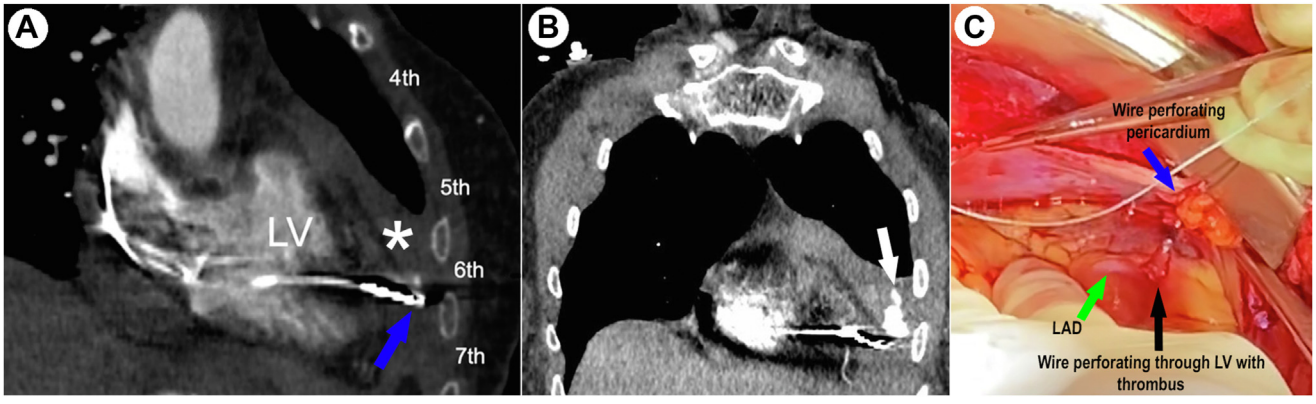

Figure 3 **A:** Coronal chest computed tomography (CT) on postimplant day 9 shows pacing lead exiting the left ventricle (LV) terminating in the chest wall in the sixth intercostal space (*blue arrow*) with adjacent hemothorax (*asterisk*). **B:** Coronal chest CT demonstrates pooling of contrast from the left ventricle within the loculated hemothorax (*white arrow*). **C:** Intraoperative view of anterior wall of the left ventricle, with pacing lead covered with thrombus (*black arrow*) exiting lateral to the left anterior descending artery (LAD) (*green arrow*) and piercing the pericardium (*blue arrow*).

including active-fixation screw leads, small lead diameter, small lead tip surface, apical lead placement, and excessive patient manipulation of the fresh pacer pocket, referred to as Twiddler's syndrome.[5]

Conclusion

As the prevalence of implantable cardiac pacemaker devices increases and new biventricular pacing techniques requiring lead fixation to the interventricular septum grows in the United States, providers need to be prepared to deal with the sequelae and complications of these technologies. Because perforations have heterogenous clinical presentations and highly morbid complications, physicians should maintain a high index of suspicion for perforation despite its being a rare complication of lead placement. Recognition that RV pacing wires can perforate the interventricular septum and left ventricular free wall, resulting in a circuitous migration pattern within the left chest, is crucial for expeditious emergency surgical repair of the unstable patient.

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