

# Gradual rise in lead impedance – A “rocky” course



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## Introduction

Lead parameter measurements and trends can help to recognize lead dysfunction and provide critical clues as to its etiology. Early identification of lead-related abnormalities is particularly important in patients who are pacemaker-dependent, with subsequent revision strategies taking into account various risk factors. We present a case of a patient with renal failure who was found to have an elevated pacing impedance and capture threshold suggestive of lead fracture and was subsequently referred for lead revision including transvenous lead extraction (TLE). Review of lead measurement trends as well as the appearance of the lead tip upon intracardiac echocardiography (ICE) suggested that the etiology was not a conductor fracture, but rather lead tip mineralization, resulting in a dense adhesion of the lead tip to the myocardium and subsequent exit block. The lead was also seen adhered to one of the right ventricular (RV) papillary muscles. TLE was deferred and lead revision was performed with addition of a left bundle branch area lead.

## Case report

A 73-year-old man with a history of hypertension, end-stage renal disease on hemodialysis, and sinus node dysfunction underwent implantation of a dual-chamber pacemaker (Abbott Laboratories, Chicago, IL) 6 years prior. Baseline lead parameters were stable for 5 years until a gradual rise in bipolar pacing impedance and capture threshold of the RV lead (1688T; Abbott) was noted (Figure 1A). Appropriate device programming was performed at each subsequent visit until he was found to have complete noncapture of the RV lead at maximal pacing output. Given RV lead malfunction and increased battery drainage from high-output pacing, TLE with implantation of a new pacing lead was decided upon within a shared decision-making framework.

The patient presented to the lab in a fasting nonabsorptive state and was placed under general anesthesia. Femoral venous

## KEY TEACHING POINTS

- Percutaneous lead extraction risk can be guided by various imaging modalities such as chest radiography, computed tomography, and ultrasound-based technologies (eg, intracardiac echocardiography).
- Lead tip mineralization presents as a gradual rise in lead impedance and capture threshold, and is typically secondary to a biological process such as fibrosis or calcification at the myocardial–lead tip interface.
- The risk of lead extraction in the presence of lead tip mineralization is unclear and requires further study.

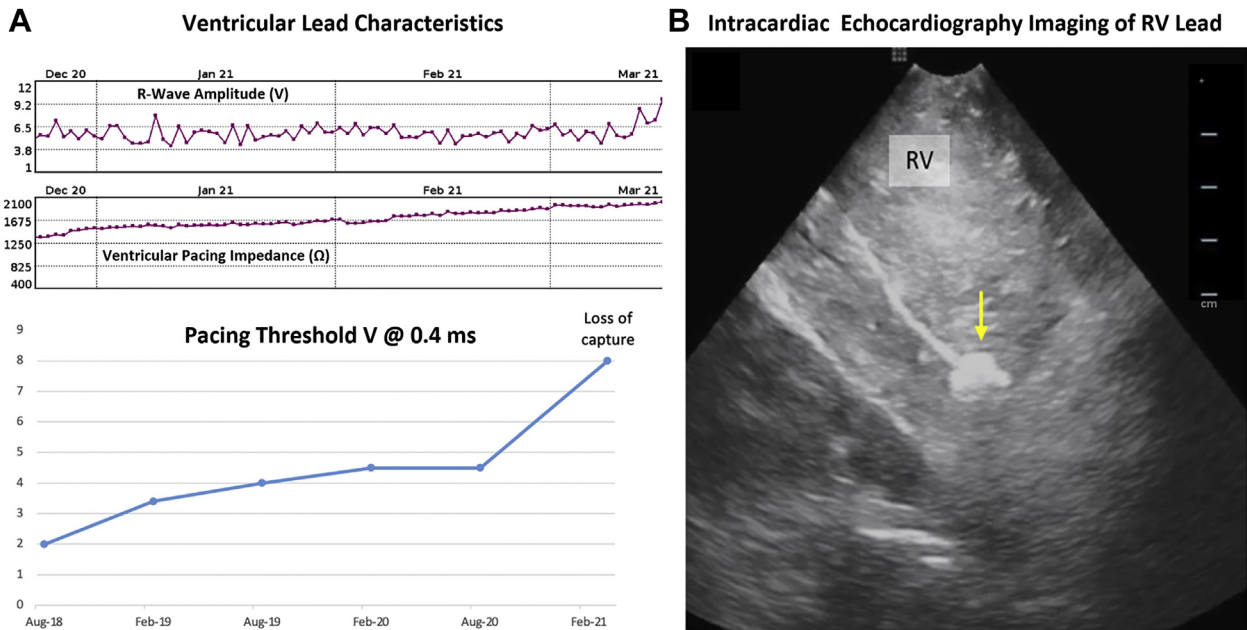
access was obtained according to our standard TLE workflow and a stiff wire was advanced to the internal jugular vein for rapid advancement of a vascular occlusion balloon if needed. An ICE catheter was advanced to the RV to aid in risk assessment and monitor for complications, which we have previously described.<sup>1</sup> During the initial ICE survey, a 1 cm dense region of calcification was noted surrounding the tip of the RV lead at the apex (Figures 1B and 2A, Supplemental Video). In addition, significant adhesions of the lead to a papillary muscle in the right ventricle was also noted (Figure 2B). Given the dense calcification, which could increase the risk of myocardial avulsion injury, along with an increased risk of tricuspid valve injury, lead extraction was deferred. Ultrasound-guided axillary venous access was obtained and a new pacing lead (3830; Medtronic, Minneapolis, MN) was implanted within the septum in the region of the left bundle branch. Of note, the patient's calcium level was normal (9.5 mg/dL) while phosphate (7.1 mg/dL) and parathyroid hormone (382 pg/mL) levels were slightly elevated at the time of the procedure.

**KEYWORDS** Extraction; Impedance; Lead fracture; Mineralization; Pacing (Heart Rhythm Case Reports 2021;7:833–835)

Conflict of Interest/Disclosures: None. Funding/Support: This study was funded in part by the David & Karen Kovalcik Fund in Electrophysiology. **Address reprint requests and correspondence:** Dr Robert D. Schaller, Associate Professor of Clinical Medicine, Hospital of the University of Pennsylvania, 9 Founders Pavilion, 3400 Spruce St, Philadelphia, PA 19104. E-mail address: [robert.schaller@pennmedicine.upenn.edu](mailto:robert.schaller@pennmedicine.upenn.edu).

## Discussion

Graphical trends in lead parameters can be used to remotely surveil leads as well as provide clues as to the etiology of lead malfunction.<sup>2</sup> Insulation breaches and lead fractures typically show a characteristic abrupt decrease or increase,

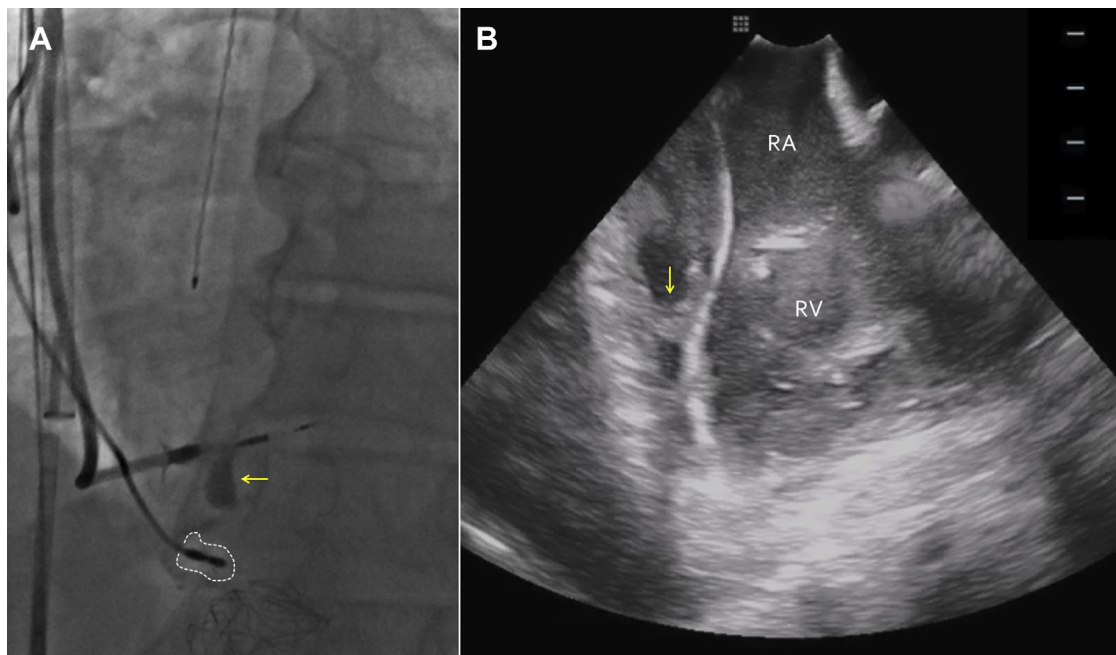


**Figure 1** A: Ventricular lead trends including amplitude, pacing impedance, and threshold. B: Intracardiac echocardiography of the right ventricular (RV) lead surrounded by a 1 cm dense region of calcification.

respectively, outside of the normal values of 300–1500 ohms. These sudden changes can be detected by either a percentage change or a fixed change criterion, depending on the manufacturer. A gradual rise in lead impedance and capture threshold, however, is less common and is usually secondary to a biological process such as fibrosis or calcification at the myocardial–lead tip interface.<sup>2,3</sup> This phenomenon,

termed “lead tip mineralization,” occurs owing to deposition of calcium in the form of hydroxyapatite crystals and is frequently a diagnosis of exclusion.

Patients with renal failure may be prone to accelerated lead tip calcification owing to altered calcium homeostasis, and this should be considered with progressive changes in lead parameters.<sup>4</sup> Hauser and colleagues<sup>5</sup> reported the



**Figure 2** A: Left anterior oblique fluoroscopic image of lead tip calcification, which appears opaque (white dashed line), and a new left bundle branch area lead that was placed. A contrast injection through the sheath (yellow arrow) shows the lead deep within the septum. Note how leftward the lead is compared to the lead in the right ventricle (RV) apex. B: Intracardiac echocardiography of the chronic lead within the right atrium (RA) and RV. The yellow arrow highlights an adhesion of the lead to a papillary muscle, increasing risk during transvenous lead extraction. Note that calcification of the lead tip is not visible in this view because of the imaging angle.

prevalence and presentation of calcified defibrillation leads from the Manufacturer and User Facility Device Experience (MAUDE) database. In this study of 113 leads (dwell time of  $7.4 \pm 3.1$  years) that were extracted and analyzed, they found the distal pacing electrode calcified earlier than the shocking coils and longer implant times were associated with more extensive calcification. The predominant clinical presentation was a gradual rise in both pacing and shock lead impedance with or without rises in capture threshold, which can be variable and lead to exit block. A wider safety margin of device output and/or early intervention should be considered in patients who are pacemaker-dependent and have a gradual change in lead impedance owing to the poor prediction of threshold variations. Changes in sensing with lead tip mineralization have not been well described. In our case, measured R-wave amplitude remained relatively stable, and whether a percentage reduction in amplitude can result from lead tip calcification is unclear.

Intraoperative ICE imaging is an emerging technique during TLE, with binding sites noted in approximately one-third of patients presenting for TLE, and has been shown to predict procedural challenges.<sup>1</sup> Additionally, calcification of the lead apparatus, especially at the lead tip–myocardial interface, is a recognized risk factor for avulsion injuries during TLE<sup>6</sup> and could limit advancement of rotational and laser sheaths used during TLE. Intraoperative ICE during TLE has also been shown to identify a binding site within the tricuspid valve–papillary muscle complex that avoided a catastrophic complication.<sup>7</sup> Whether transesophageal echocardiography, a commonly used modality during TLE with limited near-field visualization, can be used in the same way is unknown. Similarly, this degree of calcification would likely be appreciated during preoperative computed tomography, a modality that has been shown to help to guide risk prior to TLE.<sup>8</sup> Although implantation of additional intravascular hardware is not desired in patients on hemodialysis, we opted to defer TLE based on the ICE findings and performed lead revision with conduction system pacing by way of the left bundle branch (Figure 2A).

## Conclusion

Lead tip mineralization is a common cause of chronic gradual rise in lead impedance but is typically a presumed

diagnosis based on lead parameter trends. Although this phenomenon has been described, this is the first known image correlate of this phenomenon that provides visual confirmation of the mechanism of lead malfunction. Changes in pacing thresholds in this scenario can be unpredictable, and device programming with appropriate safety margins is critical in pacemaker-dependent patients. Lead management in patients with cardiac implantable electronic devices should involve consideration of the relative risks and benefits of different approaches, with ICE providing unique information that may alter lead-revision strategies.

## Appendix Supplementary data

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.hrcr.2021.09.008>.

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