A broken tine as a possible explanation for rise in pacing threshold in a leadless pacemaker

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Introduction

Leadless pacemakers have demonstrated high implant success rates and excellent electrical parameters and safety profile[1,2] while mitigating the risk of some complications associated with transvenous pacemakers.[3] Thresholds with leadless pacemakers have been demonstrated to be chronically stable after implantation. Elevated thresholds are usually associated with acute injury and manifest soon after implant.[1,2] Currently, the 2 commercially available leadless pacemakers employ 2 distinct mechanisms of fixation: one a passive fixation system employing tines that engage with the myocardium[1] and the other an active fixation system employing an outer helix that requires rotation of the whole device allowing fixation.[2] Both mechanisms have been demonstrated to maintain robust stability,[4,5] although the active fixation mechanism is specifically designed to allow for device retrieval.[6]

We describe a case of a leadless pacemaker implant with an abrupt increase in threshold that, on system revision with device explant, was found to have a broken fixation tine. We postulate that the tine break and change in fixation could possibly explain the rise in threshold.

Case report

A 66-year-old water polo player with complete heart block, symptoms of atrioventricular (AV) dyssynchrony, and low escape rate at rest underwent implantation of a leadless pacemaker (Micra AV™; Medtronic, Minneapolis, MN) in the mid septum. The patient was adamant about receiving a leadless pacemaker and did not want a traditional implant despite concerns for AV synchrony at elevated heart rates. The implant's acute threshold was 1.13 V at 0.24 ms and subsequently decreased to 0.375 V at 0.24 ms with an impedance of 460 ohms (Figure 1). With ventricular pacing, the patient essentially became pacemaker dependent. The threshold at 2 weeks was 1.5 V at 0.24 ms and at 1 month, 1.625 V at 0.4 ms. In addition, there was a failure of AV synchrony at elevated heart rates. Subsequently at 2 months, this increased to 2.88 V at 1.0 ms. Sensing and impedance values remained stable throughout this period (7–8 mV and 430–460 ohms, respectively). The projected device longevity was less than 1 year, and it was deemed appropriate to revise the system with device explant and replacement. The patient underwent system revision 3 ½ months post original implant with explant of the device. The threshold at the time of extraction was 3.5 V at 1.0 ms. A temporary transvenous pacemaker was placed to support the heart rhythm during the procedure. It was noted at the time that the device did exhibit an unusual movement, but clearly remained fixated at the right ventricular mid septum. The device was ensnared and extracted with an Aveir™ extraction catheter (Abbott Medical, Sylmar, CA). During extraction, it was noted that a tine appeared to be separated from the device (Figure 2, Supplemental Videos 1 and 2). The device was easily removed with gentle traction. Fluoroscopic visualization revealed that the same tine was left in place in the right ventricular mid septum (Figure 1, Supplemental Video 3). Device inspection revealed that a tine was missing from the device (Figure 1). Of note, there was no visible myocardial or fibrous tissue on the explanted device (Figure 1). The

KEY TEACHING POINTS

- Broken tines are a possible explanation for pacing threshold elevation or acute dislodgement in passive fixation leadless pacemakers.
- Leadless pacemakers exhibiting broken tines are potentially retrievable.
- Maintenance of atrioventricular synchrony is a challenge for these devices in a VDD mode at elevated heart rates.
- Leadless pacemakers differ in their methods for achieving rate-responsive pacing.

KEYWORDS Leadless pacemaker; Extraction; Passive fixation; AV block; Pacing thresholds
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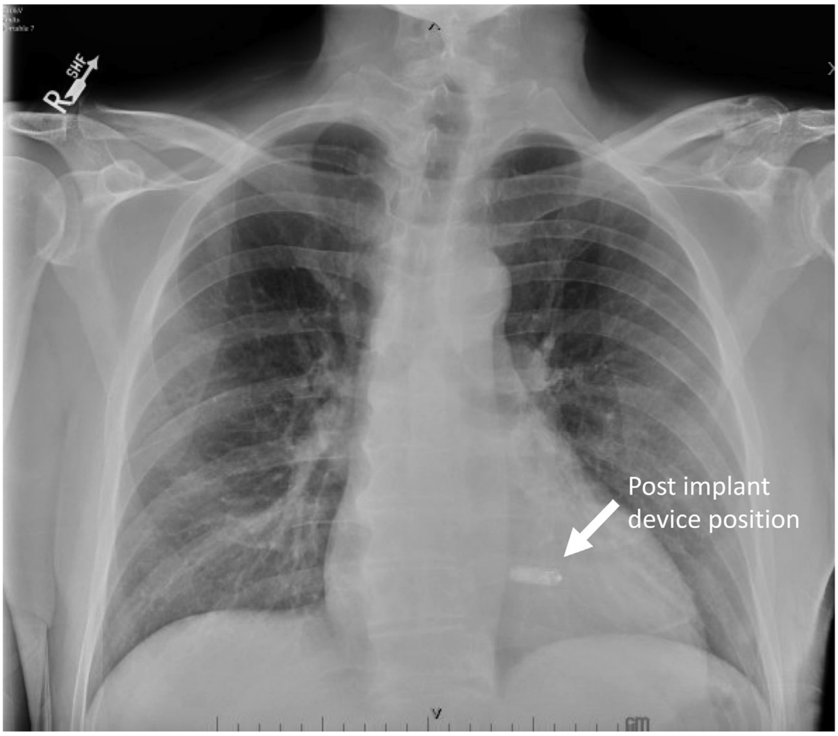

Figure 1 Post–device implant portable chest radiograph showing the device in the right ventricular mid septum.

explanted device was subsequently replaced with an active fixation leadless pacemaker (Aveir VR™; Abbott Medical), given the potential for upgrade to dual chamber. The new device has demonstrated stable electrical parameters and good rate-responsive pacing.

Discussion

A rise in thresholds, beyond the acute implant, is rarely reported in leadless pacemakers, while dislodgement rates are very low and occur acutely.[7] Factors that determine the pacing threshold in voltage have been classically described[8] and give us the mechanisms for why these factors, such as electrode size, contact, resistance, and current density, as well as tissue characteristics such as fibrosis or cellular characteristics that influence excitability, all contribute to stimulation thresholds. Device fixation would likely affect pacing thresholds related to both tissue contact and device mobility, as well as contact stability. In addition, it is conceivable that increased device motion may have contributed to increased tissue injury and potential fibrosis at the implant site.

Predictors of increased pacing threshold in the Micra device have been investigated.[9] Higher acute pacing thresholds and lower impedances at implant predict elevated pacing thresholds, presumed secondary to poor tissue contact. Our patient had an excellent acute threshold and normal impedance at implant.

In addition, the patient did have difficulties with consistent atrial sensing to maintain AV synchrony, as well as rate-responsive pacing. This is despite vector changes and manual atrial mechanical testing. The Micra AV relies on the novel 3-axis accelerometer for both rate-responsive pacing and the detection of atrial contraction.[10] Abnormal device fixation, leading to abnormal device mobility, may have contributed to this finding. The patient is doing better with the current accelerometer response despite VVI pacing, attempting to mirror his own chronotropic response.

Device retrieval for a broken tine with the Micra device has been described. Hu and colleagues[11] report a case of a patient with hypertrophic cardiomyopathy implanted with the Micra device who had stable parameters until abrupt loss of capture at 6 months with device dislodgement. Upon device retrieval, 2 tines were noted to have broken. This report, together with ours, suggests that broken tines can result in both gradual increase in pacing threshold with likely poor contact and complete dislodgement and abrupt loss of function.

It should be noted that the original device choice in this patient is not the optimal device, given the patient's degree of physical activity. The limitations of maintaining AV synchrony at higher heart rates is well described.[12] The decision to implant a leadless pacemaker was based on patient preference. We hope that in the future, true dual-chamber leadless pacing might be possible with more complete maintenance of AV synchrony.

Conclusion

We postulate that a single tine break could affect both contact and mobility and cause a rise in pacing thresholds. To our knowledge this is the first reported case of a spontaneous tine break associated with increased pacing thresholds without dislodgement.

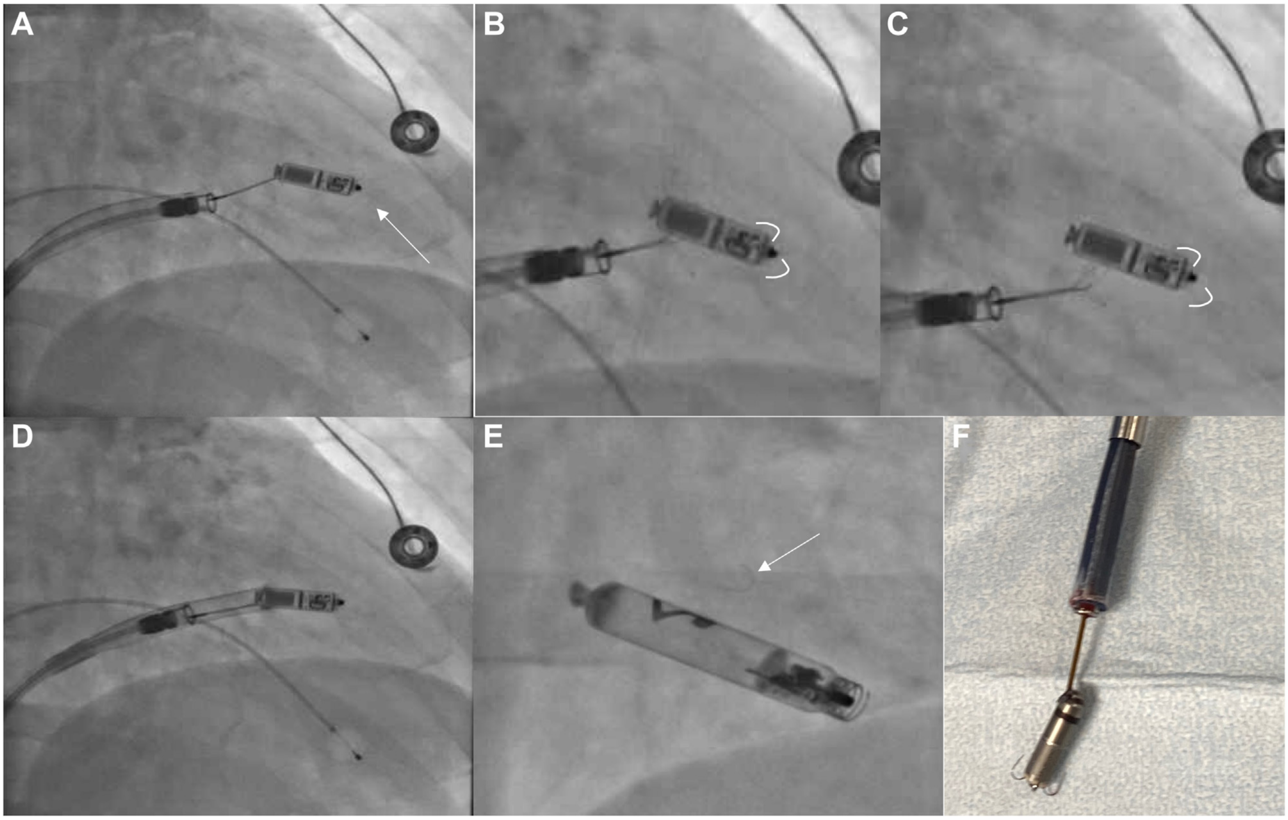

Figure 2 **A:** Snaring device with free tine visible. **B:** Outline of visible tine on first snare over device. **C:** Outline of visible tines after initial snare slipped off proximal button. **D:** Sleeve over proximal device. **E:** Visible retained tine with new device. **F:** Explanted device free of capsular material missing a tine.

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Appendix

Supplementary Data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2023.05.017.

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