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# Escape-Noncapture Bigeminy



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## Introduction

Escape-capture bigeminy is a persistent form of bigeminal rhythm that is occasionally observed and depends on 2 automatic foci with different escape intervals. We recently encountered a patient presenting with pacemaker failure, who nevertheless manifested a persistent apparent bigeminal rhythm that can be explained by the same principles that govern escape-capture bigeminy. We have dubbed this phenomenon “escape-noncapture bigeminy.”

## Case report

A 12-year-old girl with a history of congenital complete atrioventricular block had implantation of a single-chamber epicardial pacemaker in infancy using a unipolar lead (Medtronic 4965-25). She underwent 2 generator changes with retention of the original lead, the last 5 years prior (Medtronic Adapta ADSR01). She was followed but moved out of state for several years, and on moving back to our area, her first CareLink transmission noted a ventricular lead programmed output 5.00 V at 1.00 ms in unipolar mode, with the generator at the recommended replacement time. There had been a sudden rise in lead impedance from an average lead impedance of 303 to 1891 ohms 2 months previously, and the current transmission reported an impedance of 3827 ohms. The patient had largely been asymptomatic aside from a 1-time complaint of shortness of breath with exertion, for which she was evaluated in a local emergency room. The device was not interrogated at that time.

Owing to our concerns for possible lead failure, we brought the patient in for evaluation and interrogation of her device. Her initial electrocardiogram (ECG) showed complete heart block with a junctional or ventricular escape rhythm of 45 beats per minute (bpm) with noncapturing

## KEY TEACHING POINTS

- Escape-capture bigeminy is a persistent form of bigeminal rhythm that is occasionally observed and depends on 2 automatic foci with different escape intervals.
- In this case, a novel bigeminal rhythm occurred when capture was lost owing to lead fracture, but sensing remains in unipolar programming.
- Electrocardiographic findings may lead to false presumption of exit block when pacing in a unipolar lead fracture.

ventricular pacing stimulus artifacts (Figure 1). Upon interrogation of her device, the pacemaker was at the elective replacement indicator and the mode had been automatically reset from VVIR at a lower rate limit of 75 to VVI at a rate of 65. The lead impedance was 2904 ohms, but the device failed to capture at maximum output. Pacing continued with pacemaker spikes occurring at a fixed interval following each native QRS. A chest radiograph demonstrated probable lead fracture. A preprocedure transthoracic echocardiogram showed a structurally normal heart with normal ventricular function.

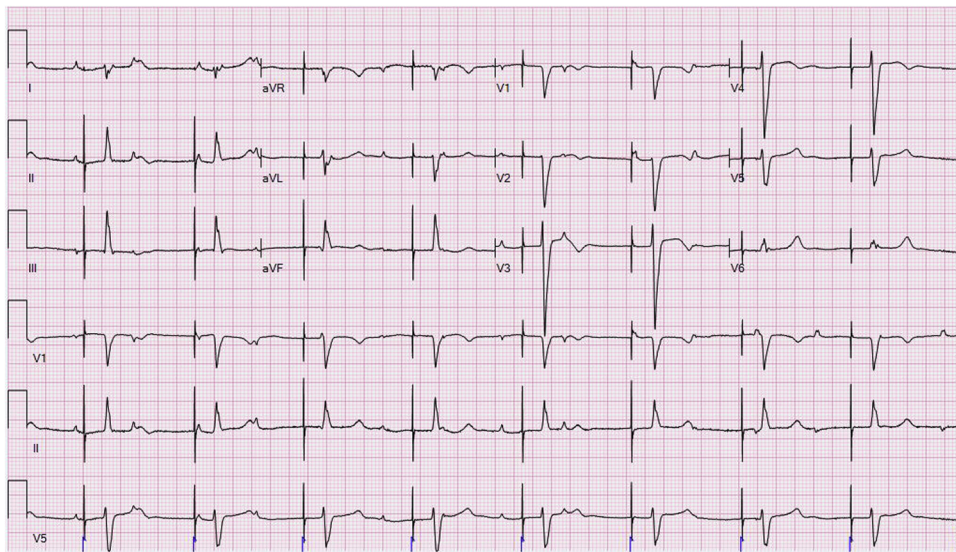
The patient remained clinically stable and was admitted to our telemetry unit and subsequently underwent placement of a transvenous single-chamber pacemaker placement with explantation of her epicardial generator. Fluoroscopy during the procedure showed a clear lead fracture with complete separation of the lead just below the diaphragm.

## Discussion

This case is interesting because on presentation, pacemaker failure was obvious but the presenting ECG suggested not fracture, but exit block because the device was clearly continuing to sense the underlying rhythm. In addition, the measured lead impedance of 2904 ohms was not typical for complete lead fracture. Once it became apparent that there was a complete fracture, the fixed interval of noncapturing

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**Figure 1** The patient's presenting 12-lead electrocardiogram.

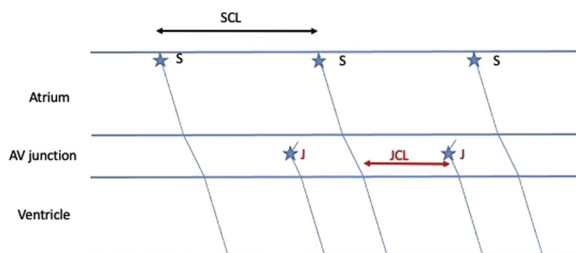
pacemaker spikes in relation to the underlying rhythm was initially mysterious.

Bigeminal rhythms are simply rhythms in which heartbeats occur persistently in groups of 2. They are common and can occur owing to 3 principal broad mechanisms.<sup>1</sup> First, and most commonly, bigeminal rhythms are a result of premature ectopic beats, which can arise from the ventricle but may also arise from the atrium or the atrioventricular node, and produce ventricular bigeminy, atrial bigeminy, or junctional bigeminy, respectively. Atrial bigeminy can also manifest as blocked atrial bigeminy. The second category is bigeminy due to 3:2 conduction. For example, with 3:2 Wenckebach conduction through the atrioventricular node, one gets a bigeminal rhythm because the 2 conducted beats are followed by a pause owing to every third atrial beat being blocked. The second beat will occasionally be aberrated owing to the Ashman phenomenon, and this can be misconstrued as ventricular bigeminy. The third and most interesting mechanism is a so-called escape-capture bigeminy.<sup>2</sup> This is most commonly seen in patients with sinus node dysfunction and a junctional escape rhythm in which the junctional escape rate is faster

than the underlying sinus rate. One observes a bigeminal rhythm in which there are alternating long and short R-R intervals, the shorter R-R interval containing a sinus P wave (Figure 2). This is a persistent and stable rhythm because, while the junction has a faster intrinsic rate, it never resets the sinus node owing to lack of VA conduction from the junctional focus. The sinus node, while having a slower intrinsic rate, always resets the junction.

The current case, which we have described as “escape-noncapture bigeminy,” is an apparent bigeminal rhythm based on essentially the same mechanism as typical escape-capture bigeminy. The pacemaker, attached to a fractured unipolar lead, had switched to VVI mode with an escape rate of 65 bpm owing to its battery status having reached the elective replacement indicator. Despite the complete lead fracture, the fact that it was programmed to unipolar mode means that the pulse generator and lead were still able to sense intrinsic heartbeats, most likely using the dipole created between the pulse generator and the fractured lead, which most likely also escaped the insulation. This explains the persistent timing of the noncapturing pacemaker spikes approximately 925 ms after each QRS. Because of ventricular noncapture, however, the pacemaker is unable to reset the ventricular escape focus, analogous to the inability of a junctional focus to reset the sinus node in typical escape-capture bigeminy. Therefore, the ventricular rate continues at approximately 50 bpm.

A similar phenomenon was reported more than 40 years ago by Salem and colleagues<sup>3</sup> involving a unipolar transvenous pacing lead that had fractured and was repaired. In their case, the observation of loss of capture with intact sensing was associated with a decrease in amplitude of the stimulus artifact, initially suggesting exit block. In our case, we also initially suspected exit block. Whereas in the 1970s unipolar pacing was the rule, it is rarely encountered now. It is interesting to note that in our case, this rhythm would not have been observed if the device was connected



**Figure 2** Ladder diagram drawing, illustrating the mechanism of common escape-capture bigeminy due to sinus node dysfunction and junctional escape focus without retrograde conduction. The slower mechanism (the slow sinus rate) resets the faster mechanism (the junctional focus) because the junctional focus does not conduct retrograde to the sinus node. J = junctional focus; JCL = junctional cycle length; S = sinus node; SCL = sinus cycle length.

to a fractured bipolar lead, as in that situation the pulse generator would not be part of the sensing circuit. Similarly, one would not observe large pacemaker spikes on the surface ECG, as these are typical unipolar pacemaker spikes. If one observed any pacemaker spikes, they would likely be completely dissociated from the underlying rhythm, as sensing would not be intact.

### Conclusion

In summary, we have presented a case of pacemaker failure in which capture was lost owing to lead fracture, but sensing

was retained owing to the unipolar pacing configuration. This allowed an apparent bigeminal rhythm that was persistent, based on the same fundamental mechanism as seen in typical escape-capture bigeminy.

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