Is This Pacemaker Functioning Abnormally?

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ECG CHALLENGE

An 85-year-old man with a history of ischemic heart disease and a single-chamber pacemaker implanted 6 months earlier because of atrial fibrillation with slow ventricular response was admitted to the emergency department with complaints of lightheadedness. A 12-lead ECG was obtained to assess pacemaker function as part of the initial diagnostic evaluation (Figure 1). Pacing stimuli follow an irregular pattern, as can be observed in the ECG tracing. Some pacing outputs are delivered right after the QRS complex. As a result, concerns about pacemaker malfunction arose. What is the current pacing mode in this case?

1. Normal VVI function with true fusion and pseudofusion complexes, or
2. Normal VVT function

Please turn the page to read the diagnosis.

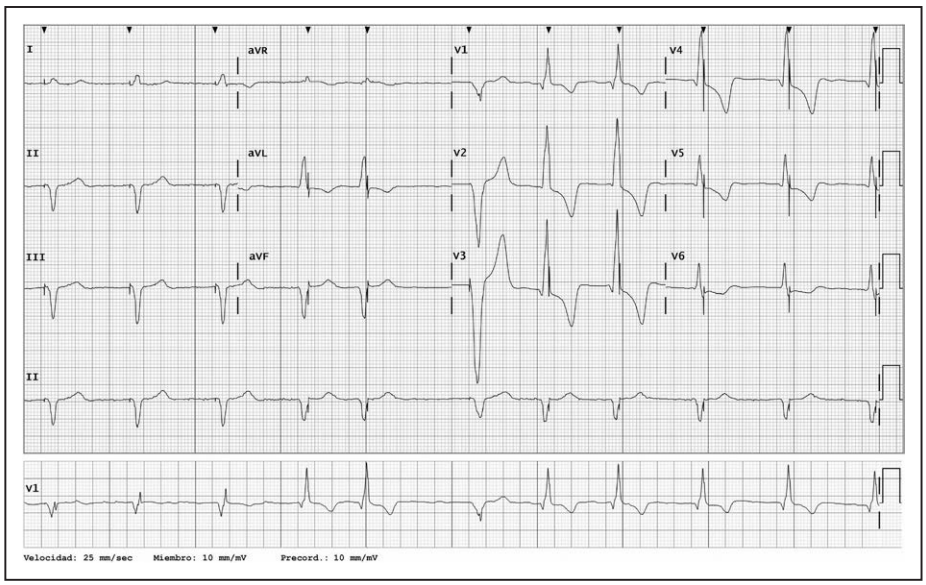

Figure 1. Twelve-lead ECG obtained at the emergency department.

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- electrocardiography
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RESPONSE TO ECG CHALLENGE

The rhythm is irregular without any evidence of P wave consistent with underlying atrial fibrillation. Pacing stimuli can be seen (annotated by black inverted triangles located at the top of the image in Figure 2), and QRS complexes show different morphologies according to the relationship that exists between intrinsic beats and each pacing stimulus.

QRS complexes marked with V are spontaneous beats with underlying right bundle-branch block and left anterior fascicular block. Note that the pacing stimulus falls in the last part of each QRS complex and does not follow a regular pattern, as would be expected in VVI mode.

The first 3 QRS complexes (*) are preceded by pacing stimulus at a rate of 60 bpm (⌴), which is the base rate programmed in this device. The 6th QRS complex (+) is wider (0.20 second) and is also preceded by a pacing stimulus.

The differences in morphology are explained by the fact that the first 3 beats (*) are fusion beats, in which depolarization occurs partially as a result of intrinsic activation and partially as a result of capture from the pacemaker stimulus because both events are happening simultaneously, whereas the 6th-beat morphology is the result of complete pacemaker capture without fusion. Note that this 6th-beat stimulus arises at a slower heart rate (1.2 seconds=50 bpm) from the previous one (⌟); this corresponds to a lower hysteresis rate that is programmed in this case. Hysteresis is a programmable feature that allows the pacemaker to begin ventricular pacing only if the spontaneous rate falls below a set rate (in this case, 50 bpm); then pacing continues at the programmed base rate (60 bpm) unless intrinsic ventricular activity is sensed. The purpose of hysteresis is to allow a slight delay before stimulation at the base rate (ie, more time for a spontaneous QRS to occur), which preserves battery life and avoids unnecessary pacing.

The key to a correct interpretation of this ECG is given by the spontaneous QRS complexes (V). The pacing stimuli occur at the point of intrinsic QRS sensing, meaning that every spontaneous event sensed within the ventricular chamber triggers ventricular pacing. This triggered mode is called VVT (pacing the ventricle, sensing the ventricle, trigger in response to sensed event). In this mode, pacing occurs at a fixed rate (in this case, 60 bpm), but in response to a sensed ventricular beat, instead of inhibiting pacing as in the VVI mode, the VVT pacemaker immediately "releases" or "triggers" a pacing stimulus. Stand-alone VVT pacemakers are now obsolete, but the VVT mode remains as a programmable option in many modern systems. In the past, the VVT mode was used to avoid inappropriate device inhibition caused by external interference. It is important to note that this stimulus produces a "functional noncapture" because the output pulse

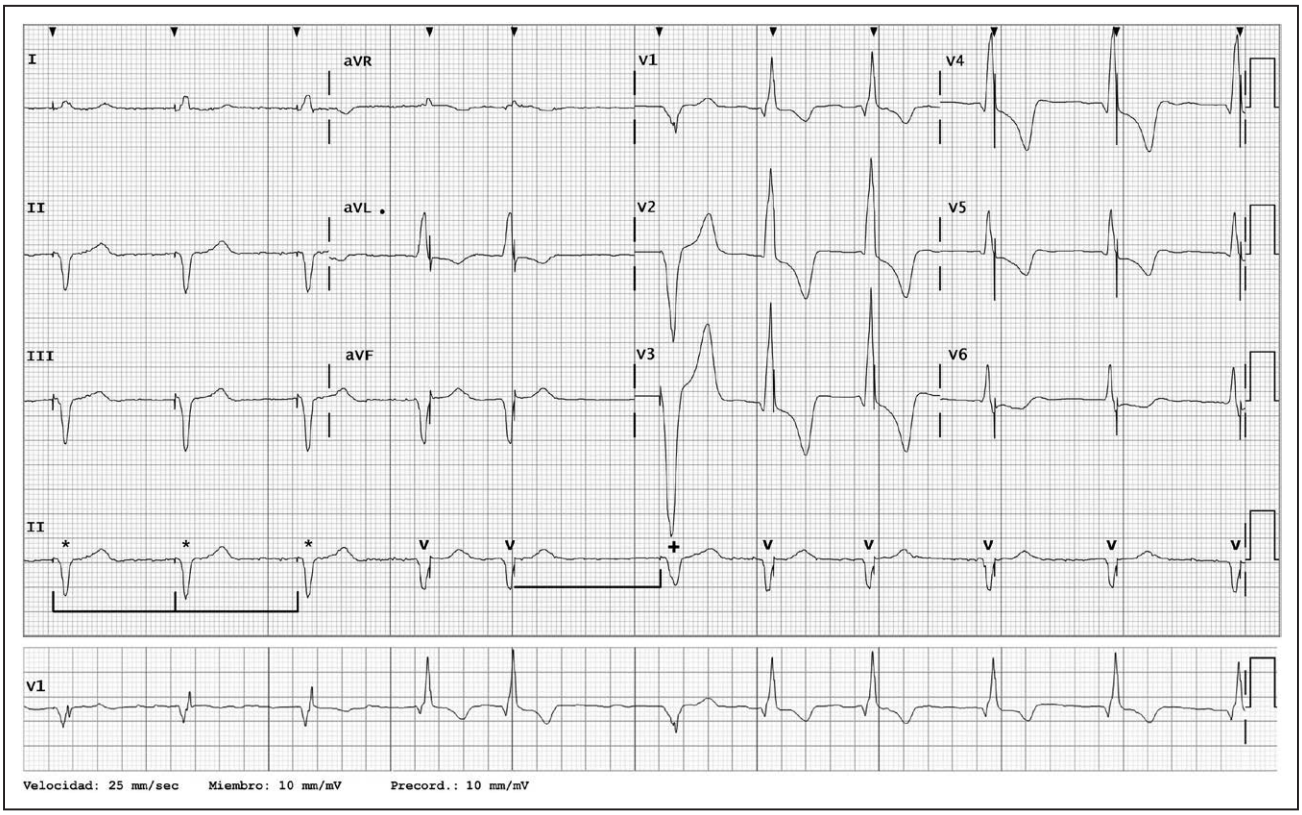

Figure 2. Twelve-lead ECG obtained at the emergency department. Annotations have been added to help interpretation.

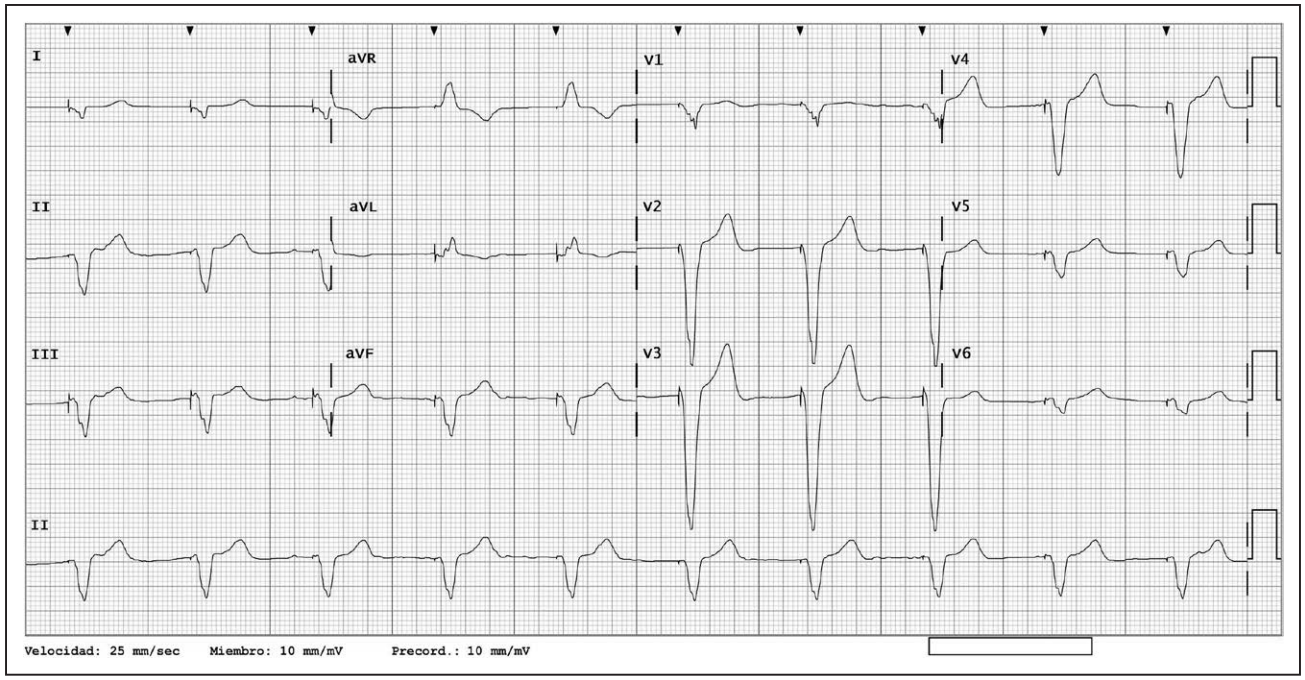

Figure 3. Twelve-lead ECG performed after changing pacing mode to VVI with a base rate of 60 bpm.

falls within the absolute refractory period of the ventricle. Similarly, pseudofusion beats may also produce "functional noncapture," in which the pacemaker stimulus does not alter the intrinsic QRS morphology on the surface ECG. However, as opposed to the VVT mode, the pacing stimulus in pseudofusion would occur at a regular programmed base rate and would fall earlier in the QRS.

This patient's pacemaker, although mistakenly programmed in the VVT mode after implantation, was functioning normally. The pacing mode was then changed to VVIR to avoid excessive battery drainage, as can be seen in Figure 3.

DISCLOSURES

None.

AFFILIATIONS

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FOOTNOTES

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