Is this pacemaker working? Can you tell from the ECG appearance?

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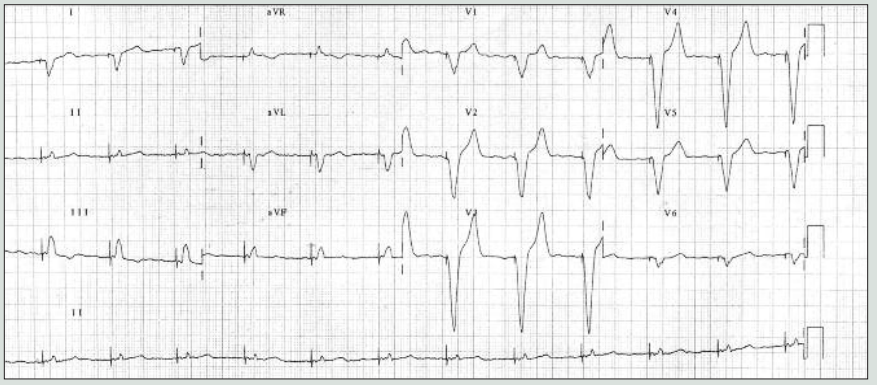
A 77-year-old man comes to see you accompanied by his daughter. He has had a fall this morning. He thinks he lost consciousness because he recalls feeling suddenly weak and then waking up, luckily on the carpet. He has no injuries. He is not well known to you so you take a full history and examination. You note he has a permanent pacemaker in his left chest wall, and he is sure this is not a defibrillator. You perform an ECG.



Question 1. What does this ECG show?
The ECG shows a paced ventricular rhythm. Pacing spikes are present and there is also atrial fibrillation. Note the uneven baseline between the QRS complexes, as opposed to the discrete P-waves and otherwise flat baseline of sinus rhythm.

Question 2. What types of permanent pacemaker are there?
There are several types of permanent pacemaker. In single-chamber pacemakers, the pacing lead is placed into either the atrium or, more commonly, the ventricle. In dual-chamber pacemakers, one pacing lead is in the atrium and one is in the ventricle. In biventricular pacemakers, which are used in patients with heart failure, there are three leads: one to each of the right atrium and right ventricle and a third that passes through the coronary sinus to the left ventricle. This attempts to resynchronise contractions in patients who have left ventricular impairment associated with a wide QRS complex.

Most pacemakers have the option of rate-responsiveness, in which sensors adjust the pacing rate according to physical need.

Each of these types of pacemaker capability can be included in an implanted defibrillator system for appropriate patients.

Question 3. What are the basic constituents of a permanent pacemaker?
The pacemaker consists of a titanium case (a 'box' or 'generator') containing a lithium battery and other circuitry and one or more leads that connect the generator to the heart. The system can sense any 'intrinsic' beats and stimulate or 'pace' when necessary to speed up or resynchronise the heartbeat. The titanium case is used because this is inert within the body. The pacemaker is placed in the subcutaneous fat above muscles, usually the pectoral muscle in the left chest. A fibrous tissue reaction then occurs around the casing.

Question 4. What might you find on auscultation that suggests a patient has a permanent pacemaker?
There are mostly no signs found on auscultation that suggest a permanent pacemaker. If there is diaphragmatic pacing, one can feel the pacing by putting a hand on the epigastrium. A pleural rub may also be heard. Underlying cardiac conditions, such as left ventricular dysfunction or valve disease, can still be noted on auscultation.

Several differences in the splitting of the second heart sound have been described in patients with permanent pacing compared with no pacing. These vary with the position and type of the pacemaker but are beyond the scope of this article.

Question 5. What do pacing and pacemaker malfunction look like on ECGs?
Pacing 'spikes' are very thin, spiky vertical lines on the ECG. They can be quite tall, as in so-called 'unipolar pacing' (when the pacemaker

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case is used as one electrode), but are mostly quite small, due to so-called 'bipolar pacing' between two electrodes near each other on the pacemaker lead inside the heart.

If the atria are being paced, pacing spikes are seen at the start of P-waves. If the ventricles are being paced, pacing spikes are seen at the start of the QRS complexes. The shape of a paced complex is generally different from that of a natural or 'intrinsic' complex. For example, pacing at the traditional apical site in the right ventricle causes a paced QRS that is negative in leads V1 (similar to left bundle branch block), II, III and aVF.

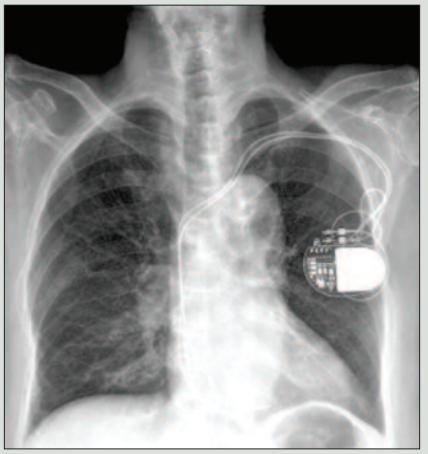
Failure of a pacemaker to sense an intrinsic heartbeat is suggested by the appearance of a pacing spike during the ST segment or T-wave. Failure to capture is suggested by the lack of an evoked beat on the ECG immediately after a pacing spike. This is an emergency situation if the patient has reported syncope or is known to be pacemaker-dependent.

It should be remembered that many ECG tracings show a small vertical line, similar to a pacing spike, when the trace switches between ECG leads. This may be confused with pacing spikes if not carefully interpreted.

Question 6. Could the pacemaker be responsible for this patient's loss of consciousness?

If the pacemaker were not working, the patient may have lost consciousness due to significant bradycardia causing hypotension and cerebral insufficiency.

Battery failure is unlikely if the pacemaker is serviced regularly (usually twice a year) and the battery is relatively new. Lead failure is also uncommon but can occur in patients who frequently feel their pacemaker out of habit ('twiddler's syndrome') or when there is a large amount of movement around the pacemaker site (such as may occur with exercise or trauma). Device malfunction for other reasons is rare.



Home items such as microwave ovens do not affect pacemaker function. Arc welding may do so, but this is an unlikely cause in this patient. Incorrect earthing of house wiring to house plumbing can cause pacemaker inhibition. Mobile phones can potentially interfere with pacemaker function and for this reason should not be kept in the top left-hand pocket of a patient's shirt or within 20 cm of the pacemaker.

It is unlikely that the above causes are responsible for the patient's fall, and other causes should be also considered. Although his pacemaker is pacing at the time the shown ECG was taken, it might not be sensing correctly or capturing correctly. The presence of pacing spikes alone on this ECG is not enough for reassurance and it would be wise to discuss the checking of the pacemaker with the cardiologist or local hospital. If the rate–response settings are not adjusting heart rate sufficiently, they may need to be adjusted.

If the atrial fibrillation is new, it may be a cause of syncope. It also raises the question of whether the patient should be (or is already) taking anticoagulant medication. This is not only relevant to the current presentation but anticoagulation would add to the risks if this patient were to fall again. **CT**

Key points

- **The basic types of permanent pacemakers are single chambered, dual-chambered and biventricular.**
- **The ECG can provide valuable information about pacemaker function and interaction with the patient's heart.**
- **Both the atrial and the ventricular rhythms and their interaction or lack thereof need to be considered when assessing a patient with a pacemaker.**
- **Battery and lead failures are rare causes of permanent pacemaker malfunction.**
- **Incorrect earthing of house wiring to house plumbing may cause pacemaker inhibition.**
- **Mobile phones can interfere with pacemaker function and should be kept more than 20 cm away from a pacemaker and not be placed in the top left-hand pocket of a shirt.**