ADVANCES IN PERIOPERATIVE CARE

NARRATIVE ARTICLE

Implantable cardiac devices and the chest radiograph: what can we learn?

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Abstract

This narrative vignette illustrates how a plain chest radiograph can be useful in identifying implantable cardiac devices and, therefore, informing clinical management. We present a fictitious case of a 72-year-old gentleman who attends the emergency department with acute severe abdominal pain and clinical signs of sepsis. Following imaging and surgical review, he is booked for an emergency laparotomy. In view of the patient being too unwell to give a full history, the information available is very limited. It soon transpires that he has an implantable cardiac device. In the context of emergency surgery being required, we illustrate how a systematic approach to analysing the appearance of an implantable cardiac device on a plain chest radiograph can provide valuable information and help inform perioperative management. We also discuss limitations in the amount of information that can be obtained from chest radiographs, for instance, battery status or specific details of device programming, such as pacing rate threshold, cannot be acquired by these means. We discuss various devices and their common appearance on chest radiographs to demonstrate how, in emergency surgical settings where patient information may be limited, chest radiography serves as a useful tool for identifying implantable cardiac devices and guiding perioperative management. We illustrate how, through a systematic approach to interpretating radiographs, decisions can be informed with regard to device interrogation, magnet application and intraoperative precautions, thereby effecting greater patient safety.

Keywords: chest radiograph, cardiac implantable electronic devices, emergency laparotomy, emergency surgery, implantable cardioverter defibrillator, implantable cardiac device, pacemaker

Case history

A 72-year-old gentleman presents to the emergency department with acute abdominal pain, hypotension and clinical signs of peritonitis. On examination, he is febrile, tachycardic, hypotensive and overtly confused. An arterial blood gas demonstrates a metabolic acidosis and a lactate level of 6 mmol/L. He is reviewed by the surgical team and scheduled for CT (computed tomography) imaging and an emergency laparotomy. At this time, no electronic records are available, but there is a vague patient-reported history of a 'heart device' having been implanted, which is confirmed on clinical examination. Due to the acuity of his case, a full device interrogation is not feasible pre-operatively. A chest radiograph is performed and confirms a cardiac device *in situ*.

What is the clinical question?

What valuable information can the clinical team obtain from the review of this patient's chest radiograph to help manage care in the perioperative period?

Discussion

Cardiac implantable electronic devices

In the absence of information definitively identifying the device *in situ*, valuable information can be obtained from a plain anteroposterior (A-P) chest radiograph. Accurate identification and a basic understanding of such devices are important first steps for planning safe perioperative care.

Figures 1–9 demonstrate the appearance of a range of implantable caridiac devices on chest radiographs.

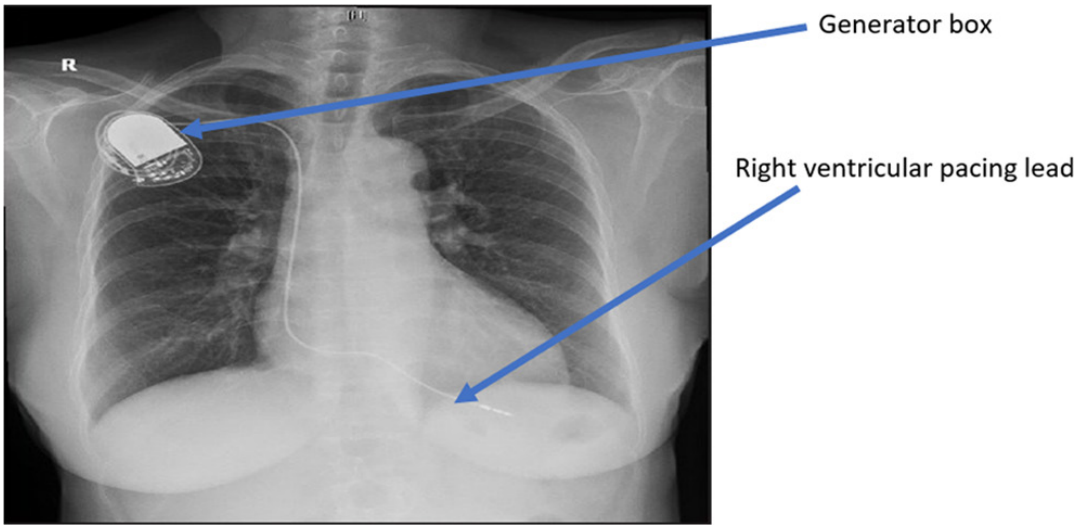

Figure 1

Chest radiograph - a single-lead pacemaker is used for bradyarrhythmia in older patients with persistent atrial fibrillation.

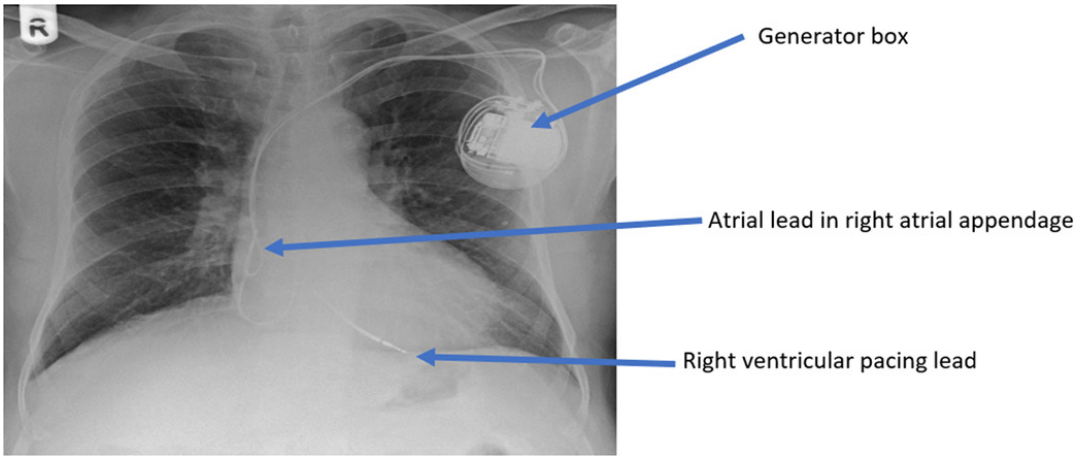

Figure 2

Chest radiograph - dual-chamber pacemakers are the most commonly encountered pacing devices for bradyarrhythmias. The atrial lead provides atrioventricular (A-V) synchrony and allows detection of atrial arrhythmias, which if detected will cause the pacemaker to mode switch to single-lead ventricular pacing.

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Cardiac implantable electronic devices (CIEDs) are an established treatment used to manage bradyarrhythmias (pacemakers) and tachyarrhythmias (defibrillators), and optimise myocardial contractile function in patients with heart failure [cardiac resynchronisation therapies (CRT)] [1]. CIEDs are increasingly prevalent in the surgical population [2].

Perioperative investigations

In this clinical setting, a chest radiograph and a 12-lead electrocardiogram (ECG) are commonly requested and can serve as useful diagnostic adjuncts [3].

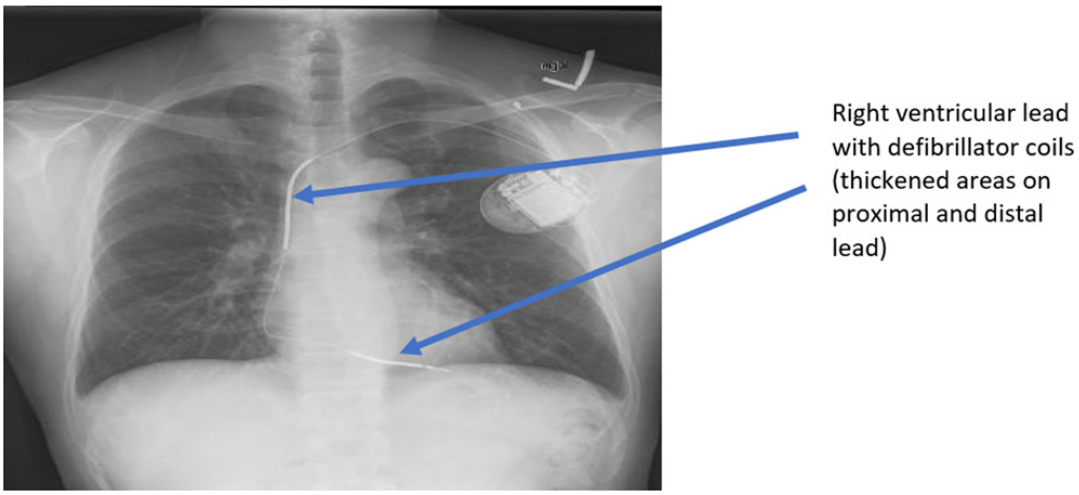

Figure 3

Chest radiograph - single-lead implantable cardioverter defibrillators are used for primary and secondary prevention of ventricular dysrhythmias. They can be used as a pacing function to terminate ventricular dysrhythmias or deliver a DC shock if pacing fails to restore sinus rhythm.

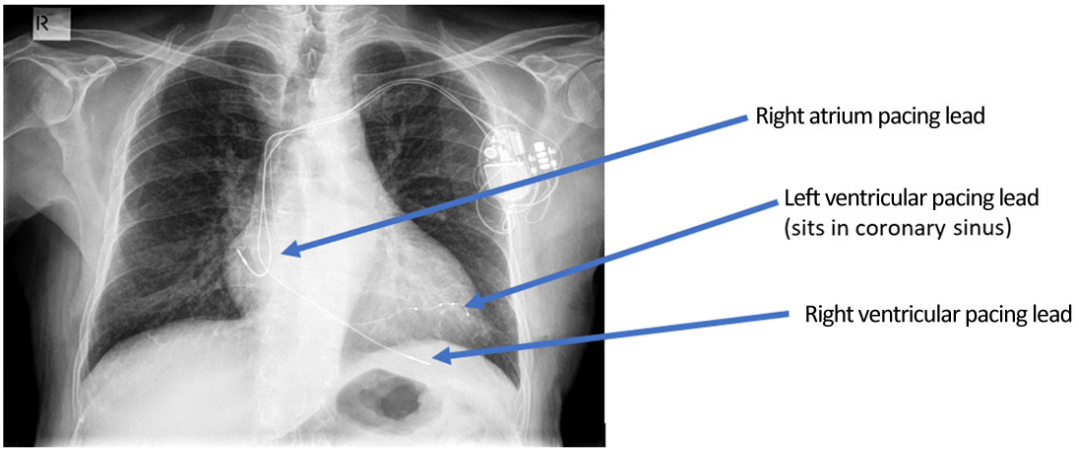

Figure 4

Chest radiograph - a cardiac resynchronization therapy (CRT) device is used to resynchronise cardiac contraction by pacing, in those with heart failure, a wide ECG QRS complex and left ventricular ejection fraction (LVEF) <30%.

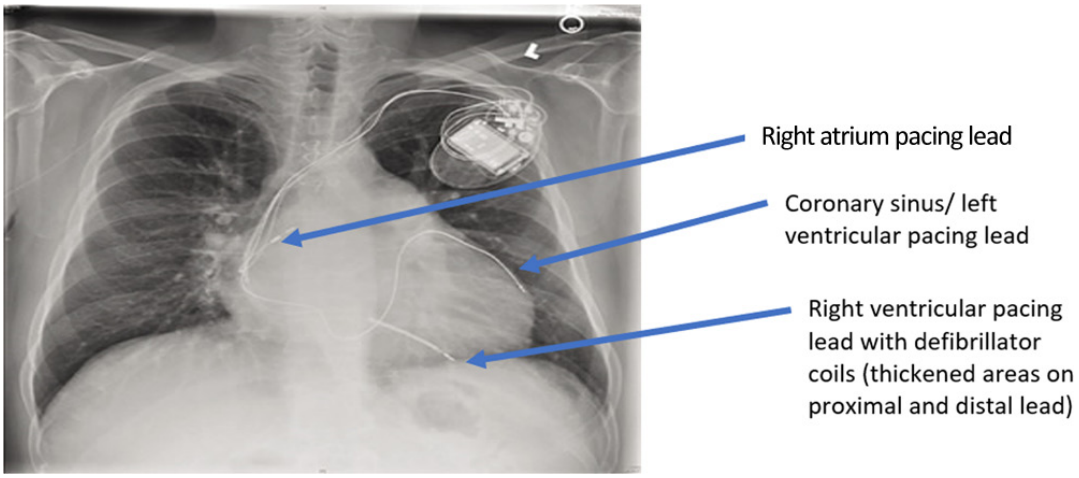

Figure 5

This chest radiograph shows a CRT-D device, which provides cardiac resynchronisation by pacing and can defibrillate in the event of a malignant ventricular dysrhythmia. It is used in those with heart failure, wide ECG QRS complex and an LVEF <30%, and who have experienced ventricular dysrhythmias or are considered high risk for ventricular dysrhythmias.

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How can a chest X-ray help with device identification and support safe perioperative planning?

CIEDs in the current era recognise and respond to arrhythmias, improve prognosis in those with complete atrio-ventricular block, prevent sudden cardiac death from ventricular arrhythmias and improve symptom status in patients with heart failure. The chest radiograph can aid in the identification of the CIED *in situ*, which in turn provides some information regarding the nature of the underlying heart disease [4].

In this clinical scenario, the patient appears to have undergone implantation of a CRT-defibrillator (CRT-D) device (Fig. 5), which would imply that he has poor left ventricular function (ejection fraction (EF) < 30%). The CRT-D device also implies that the patient has suffered/or is at high risk of ventricular dysrhythmias. This knowledge provides clinicians with valuable information in the perioperative period and will allow a detailed discussion concerning circulatory support and the allocation of a high-dependency bed, and help inform specific device management in the perioperative period. The British Heart Rhythm Society guidelines [4], can be referred to, to further guide management.

Although a device can be identified with a chest radiograph [5], it provides no information on the battery status or the specific device programming, e.g. the pacing rate threshold. Some devices may be set with a back-up pacing heart rate of <50 beats per minute, which reduces the relative percentage burden of right ventricular pacing, but will also mean that a pacing spike will not be visible on the ECG unless the underlying heart rate falls below the set threshold of 50 beats per minute [3].

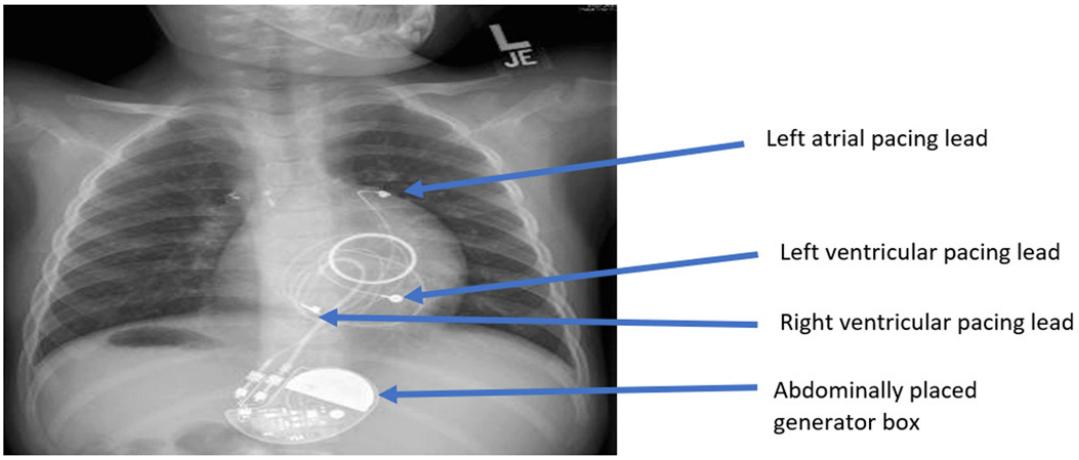

Figure 6

This chest radiograph shows an abdominal generator with dual-chamber extracardiac/epicardial pacing leads. These devices are often implanted in children who develop bradyarrhythmias either *de novo* or due to complications of corrective congenital heart disease surgery.

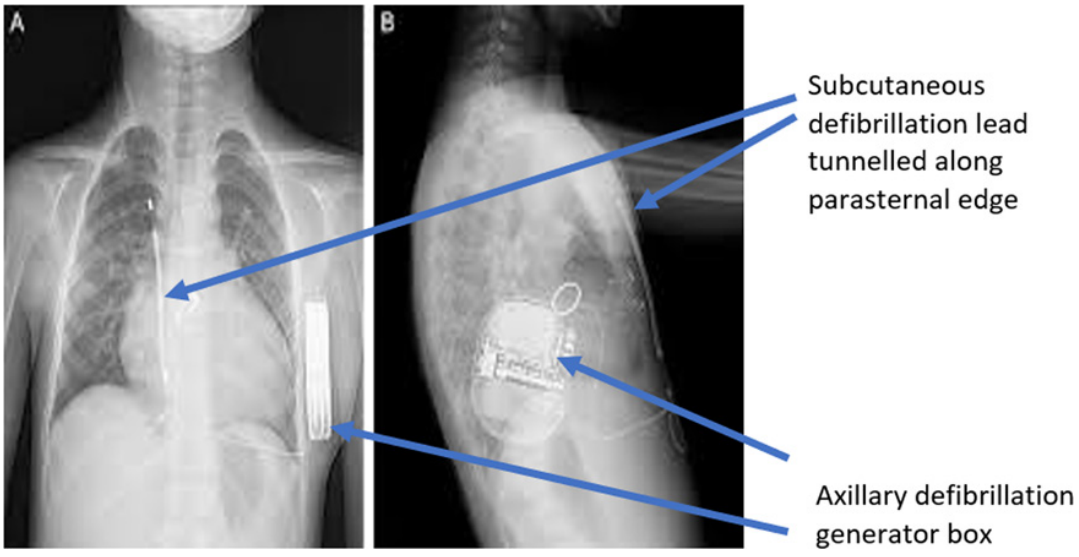

Figure 7

Chest radiograph - a subcutaneous implantable cardioverter defibrillator is a defibrillator with no pacing function. In essence, a '*Shock box*', which negates the need for intracardiac leads. It is used in patients for primary and secondary prevention of ventricular arrhythmias.

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Figure 8

Chest radiograph - an implantable loop recorder (ILR) is used to continually record heart rhythm (for up to 3 years) in those patients with symptoms of palpitations or pre-syncope/syncope that have not been documented on standard Holter monitoring. The image also shows the device and its introducer.

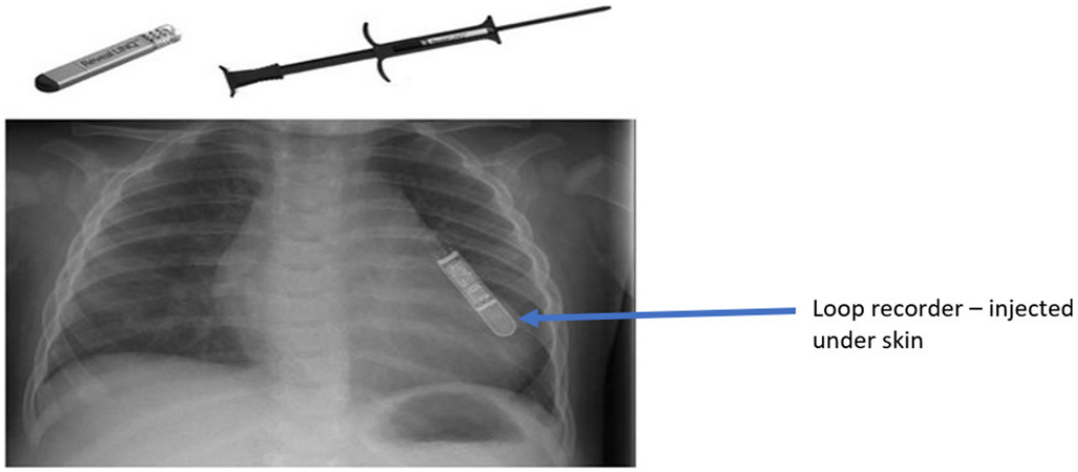
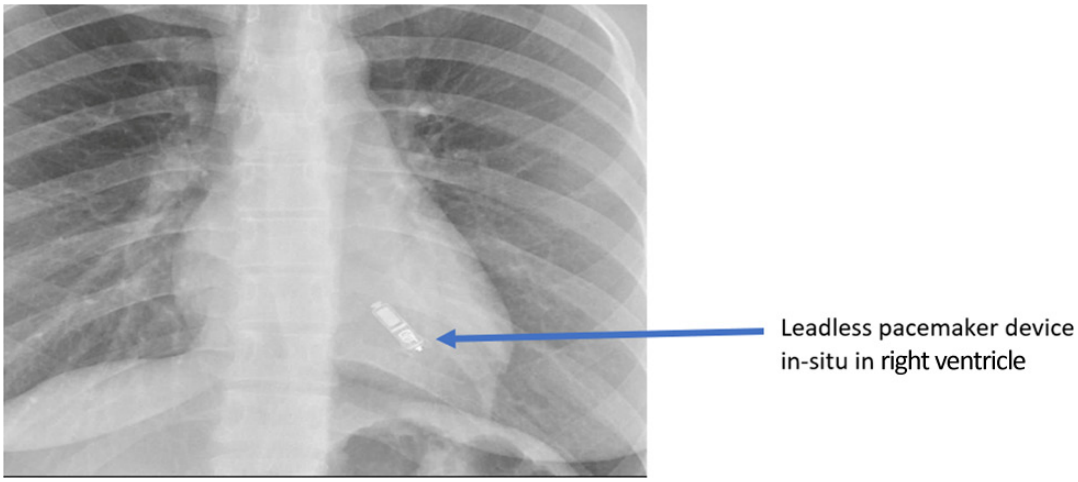


Figure 9

Chest radiograph - a Micra device is a leadless single-chamber pacemaker implanted into the right ventricle. It is used for bradyarrhythmias, negating the need for intracardiac leads.



Conclusion

In emergency surgical settings, where comprehensive patient information may be limited, chest radiography serves as a useful tool for identifying implantable cardiac devices and guiding perioperative management. A systematic approach to interpreting chest radiographic findings can inform decisions regarding device interrogation, magnet application and intraoperative precautions, thereby effecting greater patient safety.

Declarations and conflicts of interest

Research ethics statement

Not applicable to this article.

Consent for publication statement

Narrative articles are based on clinical vignettes and created to provide a framework for discussion and maximise learning. These are not based on real individual patients and do not describe discrete patient interactions or outcomes. The objective is to summarise an interesting topic in perioperative medicine in response to a specific clinical question posed by the authors.

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Conflicts of interest statement

Ewa Prusak is an Editorial Board Member for *Advances in Perioperative Care*. The authors declare no further conflicts of interest.

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