



## Review

# Pacemakers and implantable cardioverter defibrillators, unknown to chest radiography: Review, complications and systematic reading



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## ARTICLE INFO

## Article history:

Received 22 October 2014

Received in revised form 3 December 2014

Accepted 6 December 2014

## Keywords:

Pacemaker

Cardiac device

Implantable cardio-defibrillators

Complications

Cardiovascular imaging

## ABSTRACT

Chest X-ray is the imaging technique of choice for an initial study of pacemakers and implantable cardio-defibrillators (ICD). Radiologists have an important role in the evaluation of its initial placement and in the assessment during its follow-up. For this reason, it is necessary to know not only the different existing devices and its components but also the reasons of malfunction or possible complications.

The purpose of this article is to do a systematic review of the different types of pacemakers and ICD. We review their usual radiological appearances, the possible complications which might take place and its causes of malfunctioning.

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## 1. Introduction

There are two types of cardiac conduction devices: pacemakers and implantable cardio-defibrillators (ICDs).

Pacemakers, in general, are indicated for heart rhythm disorders with abnormally low heart rate. The two main causes are sick sinus syndrome or AV block.

Different types of pacemakers exist, the simplest are single-chamber pacemakers which send electrical impulses to one chamber (atrium or ventricle) of the heart, while dual-chamber pacemakers have wires placed in right atrium and right ventricle. Biventricular pacemakers are used to cardiac resynchronization. The electrodes are situated in right ventricle and left ventricle by way of the coronary sinus [1].

The VDD pacemaker is the only exception to this scheme. It is a model that, by a single electrode detects in both chambers (atrium and ventricle) but only stimulates the ventricle.

There are now a new generation of three-chamber pacemakers that add the ability to stimulate the left ventricle of the heart. They are indicated in patients with severe heart failure.

An ICD is an electronic device capable of generating a large amount of energy in order to defibrillate the heart. It is used to treat ventricular arrhythmias and prevent sudden death [2].

The chest X-ray is the elective technique in the initial study of a cardiac device and radiologists participate in the assessment of its insertion and its subsequent follow-up. This is why it is necessary to be familiarized with the various devices and their components in use today, as well as with their normal radiological appearance [3].

Our objective in this work is to offer a systematic review of the different types of existing pacemakers and implantable cardio-defibrillators (ICD), establishing a diagnostic algorithm to evaluate the causes of malfunction and the complications that may arise (Table 1) [4].

For a correct evaluation we advise that the following points should be read and the steps described hereunder should be adhered to: [5]

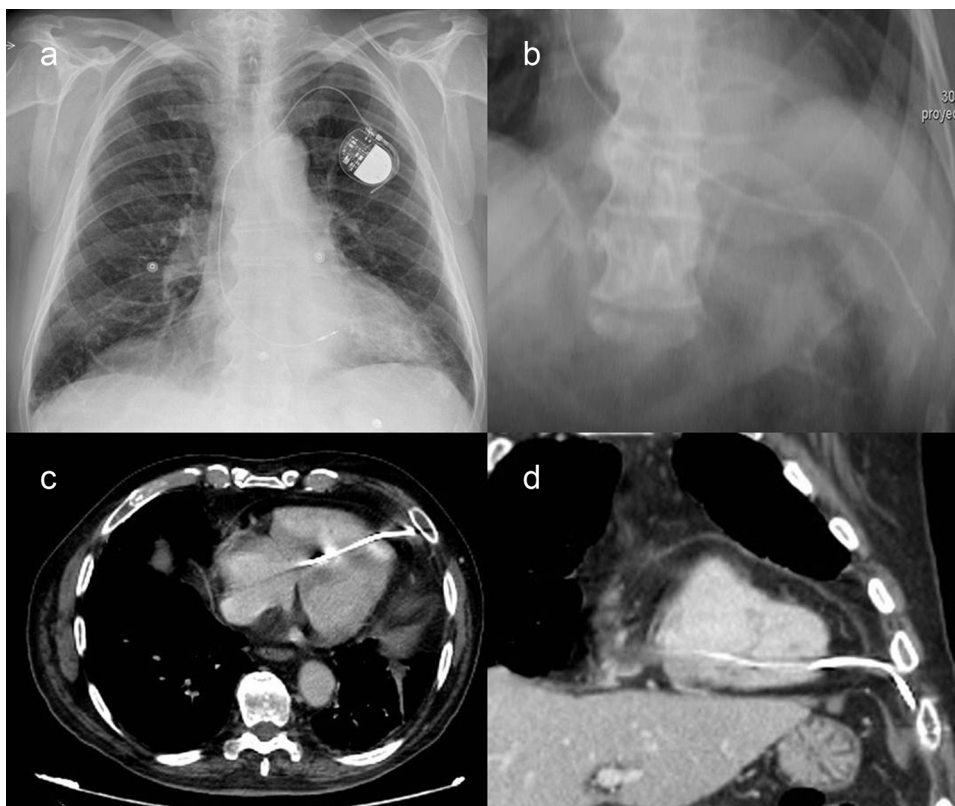
- (A) Immediate complications after the insertion of the device.
- (B) Control and follow up of the device.

## 2. Immediate complications after the insertion of the device

The standard procedure following the insertion of pacemakers involves an immediate fluoroscopic evaluation of the electrode's

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**Fig. 1.** Normal chest X-ray (a) and enlarged image (b) with the tip of the electrode beyond the cardiac silhouette and below the diaphragm. CT axial (c) and coronal (d) images showing cardiac perforation by right ventricle electrode. The tip of the electrode is close to the diaphragm stimulating it.

positioning [6], followed by a chest X-ray 24 h after its insertion [7]. If there are no complications, the patient is discharged and re-evaluated 4 to 6 weeks after with an electrocardiogram and a pacemaker test. A chest X-ray is carried out only if any abnormalities appear in the said check-ups [8].

Early complications that may arise in the initial chest X-ray are:

### 2.1. Myocardial perforation

Myocardial perforation, a potentially serious complication, is relatively rare occurring in less than 1% of cases [9].

A chest X-ray may show up an inappropriate position of the ventricular electrode more caudal than usual (under the diaphragm) (Fig. 1). In cases of doubt, a CT scan can help in determining the electrode's place exactly.

Moreover, in these cases there is a possibility of pleural or pericardial effusion (pericarditis), cardiac tamponade or extracardial stimulation (diaphragm, intercostal or abdominal muscles) (Fig. 2).

**Table 1**

Cardiac devices interpretation: Systematic approach.

Systematic approach
Immediate complications
Myocardial perforation
Pneumothorax, hemothorax
Control and follow-up
Differentiate between pacemaker or ICD
Identify the company's logo
Review the pulse generator site
Inspect the connector block
Check the full length of the electrode
Lead position
Other complications

The use of active fixation (later explained) and old-age are associated with a greater incidence of cardiac perforation. Paradoxically perforation is due mainly to atrial leads [10].

### 2.2. Pneumothorax, hemothorax

Pneumothorax may appear during the procedure or 48 h after insertion [11].

This complication is quite rare (1–2%) and it is associated with the experience of the person performing the procedure and the difficulty of venopuncture of the subclavian vein (Fig. 3).

If the subclavian artery is lacerated, a soft tissue hematoma may appear or in more severe cases a hemothorax may be occurred.

## 3. Control and follow up of the device

### 3.1. Differentiate between a pacemaker and an implantable defibrillator identify the different models

Cardiac devices are generally composed by an impulse generator and one or more electrodes [12].

Impulse generators have a titanium casing containing a lithium battery which is normally implanted into a subcutaneous pocket in the pectoralis major muscle usually placed in the patient's arm opposite to the dominant side for convenience. However another possible location, particularly suitable in pediatric patients, is the abdomen (Fig. 4).

The electrodes are metallic conductors with a silicone or polyurethane insulation layer, they are normally inserted into the cephalic or subclavian vein. The fixing mechanism for the electrodes may be passive or active. In the passive mode, conical structures are attached at the end and these are anchored to the cardiac trabeculae. This method takes between 6 weeks to 3 months

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