Devices for heart failure

PM Haydock

Abstract

Cardiac implantable electronic devices are advanced heart failure therapies, delivered by specialists, that require continuing management from a multidisciplinary team including physicians, cardiac physiologists and specialist nurses. Selected patients with persistent, severe left ventricular systolic dysfunction despite optimal medical therapy with renin–angiotensin–aldosterone system antagonists and appropriate β-adrenoceptor blockers may benefit from an implantable cardioverter-defibrillator to prevent sudden cardiac death. Patients in this category can also benefit from cardiac resynchronization therapy if they have a broad QRS duration on their resting ECG. In addition to prognostic therapies, diuretics are often required to improve symptoms related to congestion. Strategies to recognize decompensation and guide intervention are beneficial to the individual patient and the wider health economy. The recent introduction of an implantable pulmonary artery pressure monitoring system is an exciting development in this field.

Keywords Cardiac resynchronization therapy; devices; heart failure; ICD; MRCP; ventricular fibrillation; ventricular tachycardia

Key points

- Cardiac implantable electronic devices have an important role in the management of heart failure with severe left ventricular systolic dysfunction (left ventricular ejection fraction (LVEF) <35%)
- Sudden cardiac death secondary to ventricular arrhythmia is responsible for up to 50% of all deaths in heart failure patients
- Primary prevention therapy with an implantable cardioverter-defibrillator can reduce the risk of sudden cardiac death by treating ventricular tachycardia/fibrillation
- Patients with an LVEF <35% and a bundle branch block pattern on their resting ECG with a QRS duration >130 ms should be considered for cardiac resynchronization therapy to improve symptoms and prognosis

Implantable cardioverter-defibrillators (ICDs)

Rationale for ICD therapy

Heart failure with reduced ejection fraction is a malignant condition, and two principal modes of death are generally recognized – progressive pump failure and sudden cardiac death. The risk of death from either cause is competitive throughout the lifecourse of the individual and depends heavily on the severity of the heart failure syndrome.

Available data suggest that around 50% of deaths in heart failure are sudden. The pathophysiological milieu in heart failure predisposes to ventricular tachycardia (VT) and ventricular fibrillation (VF); ICDs can offer protection against sudden cardiac death by detecting and treating such events. It is important to recognize that competing risks of death from other causes – particularly progressive pump failure – continues for patients who have an ICD; it is therefore important that discussions regarding options for future device deactivation are introduced before implantation. All patients who have an ICD implanted should be under regular review by a comprehensive, multidisciplinary device service capable of assessing, in collaboration with the patient and their family, the appropriateness of continued ICD therapy.

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Hardware and practical considerations

Most contemporary ICD systems are transvenous. The hardware itself is not dissimilar in appearance to a standard pacemaker, consisting of a pulse generator and a lead in the right ventricle (RV) with or without a right atrial pacing lead (Figure 1). Entirely subcutaneous systems are available and are increasingly used, largely based on the fact they carry no risk of intracardiac infection. Several technical factors, however, limit their applicability in most heart failure patients.

The implant technique for a transvenous system is analogous to that of a pacemaker. It involves formation of a subcutaneous pocket in the left infraclavicular position to accommodate the pulse generator, and establishment of venous access to introduce the lead(s) via the cephalic, axillary or subclavian route.

ICD generators are larger than those of a standard pacemaker – principally relating to battery systems and high-energy capacitors. Leads can comprise either one or two defibrillation coils; most heart failure patients are given a single coil lead (as shown in Figure 1). The final anatomical result sets up a vector between the defibrillation coil on the RV lead and the pulse generator, which delivers the charge across the myocardial mass to effectively defibrillate the heart. Specific situations can necessitate a second coil positioned in the superior vena cava to provide an alternative shock vector.

Procedural complications include haematoma at the pocket site, infection, pneumothorax and pericardial tamponade, with an overall risk of around 4–6%.

Patients in the UK should be made aware that they are obliged to inform the Driver and Vehicle Licensing Authority that they have an ICD implanted, and that there will be a driving restriction associated with the device (See Further reading).

Detection and therapies

Two criteria must be fulfilled for an ICD to reliably prevent sudden cardiac death. First, the device must detect an episode of

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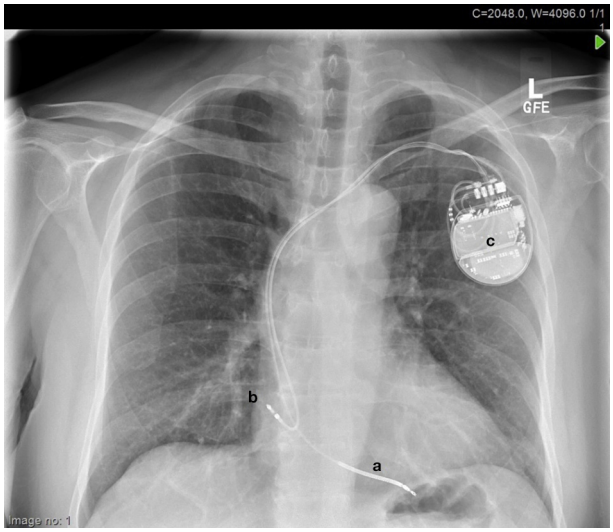

Figure 1 Postero-anterior chest radiograph demonstrating an ICD. (**a**) defibrillation coil, (**b**) right atrial lead, (**c**) ICD pulse generator.

VT/VF, and, second, treatment must be successfully delivered to terminate the arrhythmia.

Reliable detection principally relates to accurate assessment of the ventricular rate according to the sensing of R wave signals (on electrograms) via the ICD lead in direct contact with the myocardium. The frequency of R waves in VT and VF is far higher than in normal cardiac conduction, and forms the basis for detection. In VT, the signals are regular and of a predictable amplitude, as VT represents a cyclical depolarization of the ventricle around a circuit. In VF, the signals are very rapid and of varying intensity, as the electrical depolarization of the ventricle is chaotic. Heart rate intervals monitored by the ICD are programmed by the physician to determine the behaviour of the device in response to sustained episodes of heart rates within that range. Such programming is key to ensuring that the device functions to prevent sudden cardiac death but does not unnecessarily deliver potentially harmful therapies. Other algorithms ('discriminators') can be employed to minimize inappropriate therapies relating to rapidly conducted atrial fibrillation or supraventricular tachycardia.

If VT/VF is detected, this triggers the device to deliver therapies, as either defibrillation shocks (20–40 J) or anti-tachycardia pacing. In non-syncopal cases of sustained VT, anti-tachycardia pacing can be used to terminate the rhythm by 'overdrive pacing' the ventricle at a rate faster than the VT cycle length. This strategy, however, carries a risk of accelerating the VT to cause syncope or even VF.

The principal consideration when deciding on programming is whether the ICD has been implanted for a primary or secondary prevention indication. If no prior documented sustained VT/VF has occurred, primary prevention programming should be used. In survivors of cardiac arrest and individuals with symptomatic VT, programming should take into account any documented arrhythmia and the specific clinical situation.

Most ICDs in heart failure patients are implanted for a primary prevention indication, based on an assessment of risk of sudden cardiac death. Risk stratification is recognized to be imprecise; current practice relies on global assessment of cardiac function, as measured by the left ventricular ejection fraction (LVEF), and estimates of the patient's symptomatology according to New York Heart Association (NYHA) class.[1] Current UK guidelines from the National Institute for Health and Care Excellence (NICE) recommend consideration of primary prevention ICD therapy in all patients with an LVEF of ≤35% if there is a high risk of sudden cardiac death, except in cases of NYHA class IV heart failure (Table 1).[2] Clinical judgement is required to determine who is at 'high risk of sudden cardiac death', and published data suggest that heart failure patients without a background of ischaemic heart disease may be at lower risk.

The benefit of an ICD is not proven in the context of a recent myocardial infarction, and NICE guidelines recommend against ICD implantation within 40 days of a myocardial infarction.

Cardiac resynchronization therapy (CRT)

Rationale for CRT

The hallmark of ventricular dyssynchrony is a prolonged QRS duration on the resting ECG, and it is important to recognize bundle branch block patterns on ECG in heart failure patients in order to determine their eligibility for CRT. CRT improves electromechanical dyssynchrony by pacing both the left and right ventricles to reduce atrioventricular, inter- and intraventricular conduction delays. This improves the efficiency of the cardiac contraction sequence and provides an acute haemodynamic benefit; this is followed by a long-term reduction in left ventricle (LV) volumes and an improvement in LVEF (beneficial reverse remodelling).

CRT can be delivered as a pacing system alone (CRT-P) or in addition to an ICD (CRT-D). Decisions regarding inclusion of an ICD are made with reference to the considerations outlined above (Table 1). Evidence for a benefit of CRT in heart failure with reduced ejection fraction comes from multiple sources. Sixteen randomized trials have investigated its use, but each had different selection criteria and methodologies. All trials, however, have stipulated prolonged QRS width as an inclusion criterion. Two landmark trials — Cardiac-Resynchronization Therapy with or without an Implantable Defibrillator in Advanced

NICE guideline recommendations for device therapy[2]

QRS duration	NYHA Class			
	I	II	III	IV
<120 ms	ICD if there is a high risk of sudden cardiac death			ICD and CRT not clinically indicated
120–149 ms without LBBB	ICD	ICD	ICD	CRTP
120–149 ms with LBBB	ICD	CRT-D	CRT-P or CRT-D	CRT-P
≥150ms	CRT-D	CRT-D	CRT-P or CRT-D	CRT-P

LBBB — left bundle branch block; NYHA — New York Heart Association.

Table 1

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