Devices for heart failure

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Abstract

Cardiac devices play an important role in the treatment of heart failure. Implantable cardioverter defibrillators prevent sudden cardiac death from ventricular arrhythmias and prolong life in specific subgroups of patients. Cardiac resynchronization pacing can overcome the dyssynchrony resulting from left bundle branch block and improve cardiac output in the failing heart. Both of these therapies are appropriate for carefully selected patients based on randomized controlled trial data. A new advance is the introduction of the subcutaneous ICD. The benefits and challenges of device therapy and current guidelines are discussed in this article.

Keywords Biventricular pacing; cardiac resynchronization therapy; heart failure; implantable cardioverter defibrillator

What's new?

- Remote monitoring of ICDs and CRT: this allows the patient's device to be checked remotely with the patient in their own home. The devices can be programmed to alert the implanting centre automatically whenever abnormal or worrying events occur — for example, episodes of tachycardia requiring therapy, the development of atrial fibrillation or changes in the device parameters suggesting lead failure
- Haemodynamic monitoring: modern devices can detect the development of pulmonary oedema by measuring intrathoracic impedance. In addition, patients can be issued with blood pressure machines and scales. These measurements can then be transmitted remotely from the patient's home to the implanting centre, allowing early detection and treatment of exacerbations of heart failure, and reducing hospital admissions and acute deterioration
- Leadless ICD: new subcutaneous ICDs are being developed that do not require intravascular leads, potentially reducing the risk of long-term complications and increasing the pool of clinicians able to implant devices

Introduction

In the last twenty years there have been significant advances in the use of implantable devices to monitor and treat the symptoms and consequences of heart failure. Implantable cardiac defibrillators (ICDs) improve the prognosis of heart failure by preventing sudden arrhythmic death and cardiac resynchronization therapy (CRT) improves both symptoms and prognosis in selected patients with ventricular dyssynchrony (Table 1). In this article we describe the use of implantable devices in heart failure: how they work, when they should be used and what can go wrong.

Implantable cardiac defibrillators (ICDS)

Many patients with heart failure do not die from progressive pump failure but from sudden cardiac death caused by ventricular tachycardia or fibrillation. Although annual mortality increases with higher NYHA class (more severe heart failure), the proportion of deaths due to arrhythmias decreases. Heart failure medication such as β-blockers may decrease mortality by reducing the incidence of fatal arrhythmia, but only ICDs can offer life-saving therapy once an arrhythmia has started. The key to successful treatment is prompt cardioversion or defibrillation, within minutes or, ideally, seconds.

ICDs consist of a pulse generator that is conventionally sited in a left subcutaneous pre-pectoral pocket, just below the clavicle, with a right ventricular lead that is inserted through the subclavian vein and positioned with the tip in the right

Useful ICD facts

- A pacemaker magnet placed over the ICD generator disables all tachycardia therapies but still allows bradycardia pacing. This is useful emergency treatment for patients receiving multiple shocks for tolerated ventricular tachycardia, inappropriate therapies for atrial arrhythmias or as a result of lead fracture. It is also useful for patients undergoing surgical procedures with diathermy and electrocautery. When the magnet is removed, normal detection and treatment resumes
- Patients with ICDs and pacemakers should not enter MRI scanners unless they have a specific MRI-compatible device that has been programmed accordingly
- Bystanders will not be affected if they touch a patient who is receiving an ICD shock
- If a patient receives a single shock and makes a prompt recovery, it is not necessary to go to hospital. The ICD department should be informed in the next 24—48 hours. Patients should go to hospital immediately if they receive multiple shocks or are otherwise compromised
- In the UK, patients who receive an appropriate shock or symptomatic anti-tachycardia pacing are not allowed to drive for 6 months (2 years if incapacitated). If they receive an inappropriate shock they can drive after 1 month providing the cause has been addressed

Table 1

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ventricular apex (Figure 1). In addition to the ability to sense and stimulate (pace) the ventricle, a defibrillator lead has a shock coil at the distal end and often a more proximal coil at the level of the superior vena cava. Patients in sinus rhythm who may also benefit from bradycardia pacing often have an atrial lead for pacing and sensing. This may also allow for more advanced discrimination between supraventricular arrhythmias (including paroxysmal atrial fibrillation and sinus tachycardia) and genuine ventricular tachycardias.

The ICD constantly monitors the ventricular rate. If the rate exceeds a programmed value (e.g. 188 bpm) for a set number of beats or time period (eg. 8 beats or 2 s), an arrhythmia is formally detected. The ICD may be programmed into one or more tachycardia zones (e.g. VF >240 bpm, fast VT 188–240 bpm and slow VT 160–188 bpm). Having different zones allows tiered therapies such that very fast arrhythmias likely to be poorly tolerated receive prompt defibrillation whereas slower arrhythmias can be treated less aggressively before resorting to shocks. Approximately 85% of monomorphic ventricular tachycardias can be terminated by anti-tachycardia pacing (overdrive pacing using 8 or more beats at a rate 15–20% faster than the tachycardia.[1] This has the advantage of being painless, although a small percentage of tachycardias may be accelerated into a more rapid VT or VF. Shocks for cardioversion can be programmed in for VT zones and are mandatory for the fastest VF zone. The shock vector is between the generator and the shock coils and results in a brief but painful jolt. Shocks almost always restore a normal rhythm. Rarely, the ventricular arrhythmia may re-initiate. If this happens, or the shock is unsuccessful, the ventricular arrhythmia is re-detected and additional shocks are administered, up to a maximum of six shocks per arrhythmia episode.

Problem with ICDs

Inappropriate shocks: a major problem with ICDs is that they are designed as fail-safe devices that err on the side of caution. It is better to deliver a shock that is not needed than to fail to deliver a shock when it is. Around 25% of patients receive an inappropriate shock in the course of their device's lifetime. The most common causes are sinus or atrial tachycardia with a rapid ventricular rate, which the device misinterprets as a ventricular arrhythmia. Another cause is ventricular lead failure, resulting in noise misinterpreted as ventricular fibrillation. Patients receiving multiple shocks should be assessed urgently to determine whether the therapies are appropriate or inappropriate, and to address the underlying cause. The current trend is to delay therapy for as long as possible and reserve it for only the most rapid, life-threatening arrhythmias, as many ventricular arrhythmias are non-sustained or cause symptoms but not collapse.

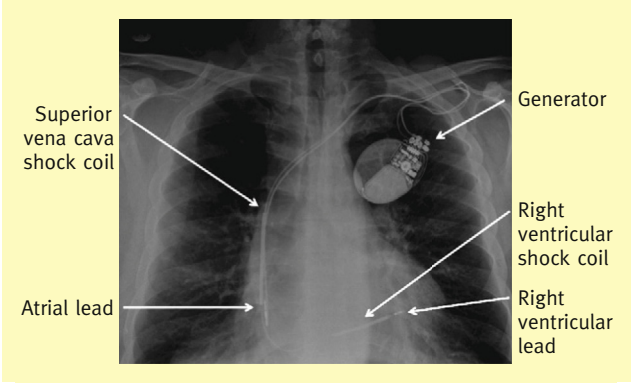

Figure 1 A posteroanterior chest radiograph showing a dual chamber ICD.

Psychological issues: patients who receive shocks can develop severe psychological problems, including anxiety, depression and agoraphobia. The contributory causes are multifactorial and, occasionally, counselling and cognitive behavioural therapy are needed.

Generator changes: ICD generators need replacing after 5–7 years, perhaps sooner if the device has delivered multiple shocks. Each operation, although minor, is associated with a small but significant risk of complications, in particular device infection.

Driving restrictions: this varies between countries. See Table 2 for UK rules.

End-of-life issues: despite optimal medical care, heart failure patients with ICDs eventually progress to severe pump failure or develop another terminal illness. In this situation continuing ICD therapy may be inappropriate and, after careful discussion with the patient and their relatives, the ICD can be disabled.

Indications for ICDs in heart failure

Predicting who may benefit most from an ICD is one of the greatest challenges in heart failure management. The earliest trials and subsequent guidelines were for secondary prevention (i.e. survivors of ventricular arrhythmias and cardiac arrests, the vast majority of who had underlying structurally heart disease as their aetiology).[2,3] Unfortunately, the majority of cardiac arrest victims do not survive their initial episode. A number of randomized controlled trials (RCTs) have looked at the role of primary prevention ICDs in high-risk patient groups. Whereas the earliest trials included the use of invasive risk stratification with programmed ventricular stimulation,[4,5] more recent trials (MADIT2 and SCD-HeFT) showed a benefit when severely impaired left ventricular ejection fraction alone was used as the criterion.[6,7] There are UK and international guidelines for primary and secondary prevention ICD indications for patients who have severely impaired left ventricular systolic function (from ischaemic or non-ischaemic cardiomyopathies) or who have survived a life-threatening ventricular tachyarrhythmia (Table 3). The role of primary prevention ICDs in patients with inherited channelopathies (long QT and Brugada syndromes) or other heart muscle disorders (hypertrophic cardiomyopathy, arrhythmogenic right ventricular dysplasia, cardiac sarcoidosis) is harder to define and requires specialist assessment.

Contraindications for an ICD

Primary prevention ICDs should not be implanted within 1 month of an acute myocardial infarction.[8] Ventricular arrhythmias in this setting should be treated with revascularization and the myocardium allowed to remodel before deciding if an ICD is indicated. Similarly, if a patient presents in a VT storm, the underlying cause of the arrhythmias should be identified and treated with antiarrhythmic drugs or radiofrequency ablation before considering device implantation. ICDs are also contraindicated in those with a terminal disease (prognosis <6 months)