27 Implantable Cardioverter Defibrillators (ICD)

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Indications

Implantable cardiac defibrillators (ICD) are currently indicated for the prevention of sudden cardiac death (SCD). In survivors of ventricular tachycardia (VT) or ventricular fibrillation (VF) cardiac arrest, ICDs are the optimal treatment for secondary prevention of patients. This has been supported by multiple randomized controlled trials that compared ICD to medical therapy.

ICDs are also used as primary prevention in patients with marked reduction of left ventricular function (ejection fraction [EF] ≤ 35%) who are considered to be at high risk for VT/VF. The use of ICDs for primary prevention currently represents more than 80% of total implantations. Current guidelines assign a Class I indication for ischemic cardiomyopathy (ICM) with EF ≤ 35% and NYHA II/III or EF ≤ 30% and NYHA I. There is a class I indication for nonischemic cardiomyopathy with EF ≤ 35% and NYHA II/III. There are other high risk conditions that are known to be associated with SCD, such as in patients with other forms of structural heart disease or inherited channelopathies. Consideration of ICD therapy, particularly those for primary prevention, apply only to patients who are receiving optimal medical therapy, have a reasonable expectation of survival with good functional status for more than 1 year, and after independent risk assessment, including patient preference (See Table 27.1) [1, 2].

Contraindications

Major ICD implantation contraindications are included in the ACC/AHA/HRS guidelines (See Table 27.2). Other contraindications include: in hemodynamically unstable patients, in the setting of acute myocardial ischemia or hypoxia, post coronary artery bypass surgery, in the setting of active infection in the chest wall or bloodstream infections, with electrolyte imbalances, and with drug toxicities [1, 2].

Equipment

The physical components of the implanted system consist of:

1. ICD generator: consist of a battery, capacitor, DC-DC converter, a microprocessor, and telemetry communication coils with their connections (Fig. 27.1).

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Table 27.1 ACC/AHA/HRS 2008 guidelines for device-based therapy of cardiac rhythm abnormalities

CLASS I INDICATIONS evidence and/or general agreement that ICDs are useful and effective
1. Survivors of cardiac arrest due to ventricular fibrillation or hemodynamically unstable sustained VT after evaluation to define the cause of the event and to exclude any completely reversible causes
2. Structural heart disease and spontaneous sustained VT, whether hemodynamically stable or unstable
3. Syncope of undetermined origin with clinically relevant, hemodynamically significant sustained VT or ventricular fibrillation induced at electrophysiological study
4. LVEF less than or equal to 35% due to prior myocardial infarction who are at least 40 days post–myocardial infarction and are in NYHA functional Class II or III
5. Nonischemic dilated Cardiomyopathy who have an LVEF less than or equal to 35% and who are in NYHA functional Class II or III
6. LV dysfunction due to prior myocardial infarction who are at least 40 days post–myocardial infarction, have an LVEF less than or equal to 30%, and are in NYHA functional Class I
7. Nonsustained VT due to prior myocardial infarction, LVEF less than or equal to 40%, and inducible ventricular fibrillation or sustained VT at electrophysiological study
CLASS IIa INDICATIONS conflicting evidence about the usefulness of ICD therapy, with the weight of evidence/opinion in favor of usefulness/efficacy
1. Reasonable for patients with unexplained syncope, significant LV dysfunction, and nonischemic cardiomyopathy
2. Reasonable for patients with sustained VT and normal or near-normal ventricular function
3. Reasonable for patients with hypertrophic cardiomyopathy who have 1 or more major risk factor for SCD
4. Reasonable for the prevention of SCD in patients with arrhythmogenic RV dysplasia who have 1 or more risk factors for SCD
5. Reasonable to reduce SCD in patients with long-QT syndrome who are experiencing syncope and/or VT while receiving beta blockers
6. Reasonable for non hospitalized patients awaiting for transplantation
7. Reasonable for patients with Brugada syndrome with syncope or who have documented VT that has not resulted in cardiac arrest
8. Reasonable for patients with catecholaminergic polymorphic VT who have syncope and/or documented sustained VT while receiving beta blockers
9. Reasonable for patients cardiac sarcoidosis, giant cell myocarditis, or Chagas disease
CLASS IIb INDICATIONS usefulness/efficacy is less well established by evidence/opinion
1. Considered in patients with nonischemic heart disease who have an LVEF of less than or equal to 35% and who are in NYHA functional class I
2. Considered for patients with long-QT syndrome and risk factors for SCD
3. Considered in patients with syncope and advanced structural heart disease in whom through invasive and noninvasive investigations have failed to define a cause
4. Considered in patients with a familial cardiomyopathy associated with SCD
5. Considered in patients with LV noncompaction

From Ref. [1]

Table 27.2 CLASS III conditions for which there is a general agreement that ICDs are not useful and possibly harmful

1. Not indicated for patients who do not have a reasonable expectation of survival with an acceptable functional status for at least 1 year, even if they meet ICD implantation criteria
2. Not indicated for patients with incessant VT or VF
3. Not indicated in patients with significant psychiatric illnesses that may be aggravated by device implantation or that may preclude systematic follow-up
4. Not indicated for NYHA class IV patients with drug-refractory congestive heart failure who are not candidates for cardiac transplantation or CRT-D
5. Not indicated for syncope of undetermined cause in a patient without inducible ventricular tachyarrhythmias and without structural heart disease
6. Not indicated when VF or VT is amenable to surgical or catheter ablation (e.g., atrial arrhythmias associated with the Wolff-Parkinson-White syndrome, RV or LV outflow tract VT, idiopathic VT, or fascicular VT in the absence of structural heart disease)
7. Not indicated for patients with ventricular tachyarrhythmias due to a completely reversible disorder in the absence of structural heart disease (e.g., electrolyte imbalance, drugs, or trauma)

From Ref. [1]

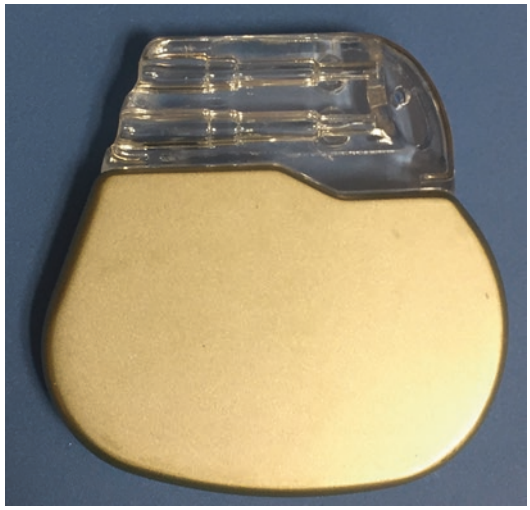

Fig. 27.1 ICD generator that is implanted subcutaneously in the prepectoral region. It is replaced when the battery reaches end of life. The leads are connected in the upper portion of the device

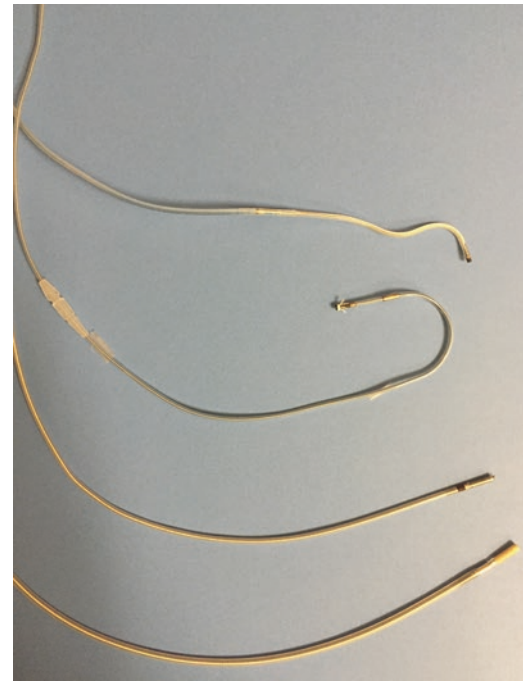

Fig. 27.2 Different examples of leads that has pacing and sensing capabilities, which exist in different shapes according the chamber were they are placed (atrium or ventricles) and distal portions with different end tip electrodes for active or passive fixation

2. Leads: The older DF-1 lead consisted of a bifurcated or trifurcator connected header pin with a pace-sense IS-1 connector and either one or two DF-1 high voltage connectors. These connectors were integrated into a single lead body. The newer D4-4 standard combines the high voltage and pace-sense into one connector. In addition to being smaller, it allows for only a single distal screw into the generator without requiring any additional connectors or yoke [3]. The lead delivers the three essential functions of the ICD: detection, tachycardia therapy and bradycardia pacing (Fig. 27.2) [2, 4].

Technique

Implantation of the ICDs system involves its subcutaneous insertion, positioning of the leads, and finally testing the sensing and pacing functions. Usually, the generator is implanted in the left prepectoral area with the purpose to create a left-to-right vector for defibrillator shocks. Alternatively, the right pectoral area may be used in selected left-handed patients, when left venous access is impeded, or in cases of infection or other abnormalities.

Initially with an standard sterile technique, an incision is made in the left pre-pectoral area to create a pocket. The leads are inserted into the subclavian, cephalic, or axillary veins. Cephalic or axillary vein access is preferred over subclavian because they carry a smaller risk of arterial puncture, pneumothorax and subclavian crush injury (when the inserted leads are trapped within the subclavius muscle or the costoclavicular complex). The leads are advanced under fluoroscopic guidance into the right heart until reaching the pulmonary artery. then the lead is pulled back and fixed in the right ventricle (RV) apex. Subsequently lead positioning, electrocardiogram stability, and adequate sensing and pacing parameters are confirmed. When a dual-chamber ICD is implanted with the insertion of an additional atrial lead, the atrial lead is placed following the insertion of the ventricular lead. It should be placed in the high right atrium or in the superior aspect of the atrial appendage to avoid crosstalk between atrial stimuli and the ventricular

detection circuits. The sleeve of the lead is anchored using silk sutures to the surrounding muscular fascia.

Either before or after vascular access, a pocket is created where the generator will be seated. It should be of adequate size for the device to avoid device erosion, migration, or seroma formation. It is usually placed on the medial aspect anterior to the plane of the pectoral fascia. Additionally, it should be inferior to the clavicle and in a medial position to avoid restriction of movement of the shoulder and the arm. The leads are then connected to the generator header with verification of secure insertion into the correct ports. The pocket is then cleaned for tissue, secretions, and blood that may be interposed. An antibiotic solution is used to irrigate the port, and the generator is placed in the pocket. The device is then tested to confirm adequate pacing and sensing. While once routine, defibrillation threshold testing is no longer commonly performed.[5] Once adequate device function is confirmed the pocket is closed with sterile suture.

The patient's arm is placed into a sling, and the lead position is confirmed by immediate post-operative chest x-ray. This is also performed to rule out complications as pneumothorax. Before discharge, a definitive postero-anterior and lateral chest-x ray are performed to once again confirm position (Fig. 27.3) [4, 6]

In addition to the traditional ICD as discussed above, there is a completely subcutaneous ICD system. This system may avoid complications associated with long term transvenous leads such as infections or venous stenosis. However, long term outcomes are still being studied. The generator is implanted in a subcutaneous pocket in the left lateral, midaxillary thoracic position between the anterior and midaxillary line. The lead is then tunneled subcutaneously until the distal electrode is just below the sternal notch. The subcutaneous ICD can sense and deliver shocks, however, it cannot pace [7, 8].

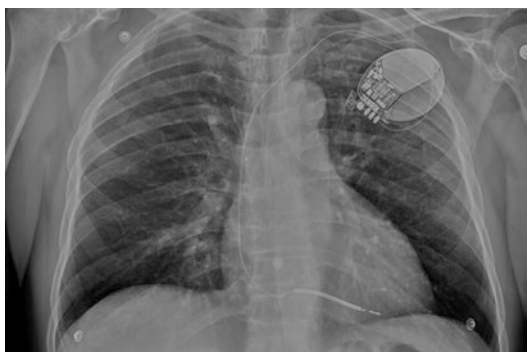

Fig. 27.3 X-ray of a patient post single chamber ICD implantation. All parts of the ICD system can be appreciated, the generator with a single lead directed and attached in position at the apex of the right ventricle

Data Interpretation

Patients are followed with routine clinical visits usually at quarterly intervals which can be performed both in person or remotely. Devices are interrogated to evaluate its function, battery depletion, alarms and events. It also allows for monitoring of arrhythmias and volume status.

Complications

- Surgical related: Ranges between 3 and 5% for single or dual-chamber ICDs. Complications are similar to those of pacemaker implantation: cardiac perforation, tamponade, vascular perforation, pneumothorax, hematoma, infection and lead dislodgement. Pulse generator changes add a 1–4% risk of infection, and complications can increase up to 15% when a new transvenous lead is added at the time of replacement.
- Late complications: less than 4% and include lead fracture, generator migration/erosion, generator failure, thrombosis, and complications related to defibrillation testing as myocardial or cerebral ischemia, electromechanical dissociation and refractory VF [4, 9].

Clinical Vignettes

Case 1

A 55 year old male was admitted with substernal chest pain that radiated to the left arm for 30 min.

Vitals on admission were blood pressure of 88/50, heart rate of 98 and respiratory rate of 22. The electrocardiogram showed ST elevation in anterior leads (V1–V4), and the troponin level was found elevated. Emergent cardiac catheterization was performed with percutaneous intervention of a completely occluded left anterior descending artery by a thrombus. Post myocardial infarction (MI) echocardiogram showed an ejection fraction of 15–20% with severe akinesis of the anterior wall. The patient was discharged with dual antiplatelet agents, beta blocker, statin and ace-inhibitor. Forty days post MI was seen in the clinic, echocardiogram was performed and showed an ejection fraction (EF) of 20–25%.

The patient has ischemic cardiomyopathy with an EF less than 35%, is 40 days post MI, and is functional class II. Therefore, he should receive an ICD for primary prevention of SCD.

Case 2

A 30 year old male with no known medical conditions suddenly collapsed at home, CPR was started by one of his family members. When EMS arrived at the scene, he was found with ventricular fibrillation and was shocked 2 times before the return of spontaneous circulation. He was taken to the hospital, and admitted to the cardiac intensive care unit. Initial echocardiogram showed and EF of 10% with global hypokinesis post cardiac arrest. He progressively recovered over the following 2 weeks without neurological deficits, but the cause of cardiac arrest could not be clarified after extensive cardiac workup. Repeat echocardiogram showed an EF of 55% with a normal ventricular wall motion.

An ICD is indicated in patients such as this, who are survivors of cardiac arrest due to VF. It is also indicated in hemodynamically unstable sustained VT after evaluation to define the cause of the event and to exclude any completely reversible causes.

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