**EnTrust D154ATG**
Dual Chamber ICD
35J delivered
8 seconds BOL, 11 seconds ERI
7.7 years**
35cc***, 68g
Programmable Active Can®

**EnTrust D154VRC**
Single Chamber ICD
35J delivered
8 seconds BOL, 11.8 seconds ERI
10.7 years****
35cc, 68g
Programmable Active Can®
A defibrillator system with biventricular (BiV) pacemaker capability

- The presence of "shock" conductors on the RV lead, called coils, in the RV and the superior vena cava (SVC) distinguish a defibrillation system from a conventional pacemaking system.

- Typically, the SVC shock coil is electrically identical to the defibrillator case, called the can. When the defibrillation circuitry includes the ICD case, it is called an active can configuration.
Single Chamber ICD
Antitachycardia pacing (ATP)
- less energy use
- better tolerated by patient

Shock
- an internal capacitor is charged
- Charging time is dependent upon the desired output
  - It can be 6 to 15 seconds for a maximum shock.
  - Charging time is lengthened by lower battery voltage, time from last charge, and lower temperature.

Most ICDs can be programmed to "reconfirm" VT or VF after charging in order to prevent inappropriate shock therapy.

Typically, ICDs deliver 6-18 shocks per event.

Supraventricular tachycardia remains the most common etiology of inappropriate shock therapy.
The capacitor in an ICD “deforms” during inactivity, which leads to increased time needed to charge the capacitor.

To mitigate the effects of deformation, all ICDs perform nontherapeutic charging of their capacitor (called “reforming”) at a programmable periodic interval (usually 1 to 6 months).

**TABLE 31–14: Implantable Cardioverter-Defibrillator Therapy**

<table>
<thead>
<tr>
<th>Zone</th>
<th>Tachycardia Rate (beats/min)</th>
<th>Sequence of Therapy Delivered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>126-160</td>
<td>ATP-1, ATP-2, 1 J, 5 J, 34 J</td>
</tr>
<tr>
<td>2</td>
<td>161-200</td>
<td>ATP, 10 J, 34 J</td>
</tr>
<tr>
<td>3</td>
<td>&gt;200</td>
<td>34 J</td>
</tr>
</tbody>
</table>

ATP = antitachycardia pacing therapy; ATP-1 = first ATP; ATP-2 = second (and different) ATP.
Preanesthesia Evaluation

- Evaluation and optimization of coexisting diseases.
- No special laboratory tests or radiographs are needed for the patient with a conventional pacemaker.
- A patient with a BiV PM or ICD might need a chest film to document the position of the coronary sinus (CS) lead, especially if central line placement is planned.
- In the setting of a coronary sinus lead, since these leads have no fixation, they might be more easily dislodged than a standard pacemaker or ICD lead.
Preanesthesia Evaluation

- Current guidelines include:
  - telephonic evaluation every 4-12 weeks (depending upon device type and age)
  - at least one direct evaluation (i.e., a device interrogation with a programmer) at least once per year.
- Special attention should be paid to patients from countries where pacemakers might be reused
  - since battery life (typically 5-7 years) might not be related to length of implantation in the current patient.
- The possible need for elective replacement of the device prior to the delivery of an anesthetic or surgery if:
  - battery voltage less than 2.6 volts
  - battery impedance greater than 3000 ohms
- Reprogramming a device will not protect the device from internal damage or reset caused by electromagnetic interference.
- Asynchronous mode causes the pacemaker to ignore premature atrial or ventricular systoles might create a malignant rhythm
Preanesthesia Pulse Generator Evaluation
I: Preoperative evaluation of CIED patients

1. Establishing whether a patient has a CIED
2. Identifying the type of device (PM, ICD, CRT)
3. Determining whether a patient is CIED-dependent for antibradycardia pacing function
4. Determining device function
5. Consult with the patient’s EPS cardiologist
II. Preoperative Preparation

1. Changing to an asynchronous pacing mode in pacemaker-dependent patients
2. Suspending special algorithms, including rate-adaptive functions
3. Suspending antitachyarrhythmia functions if present
II. Preoperative Preparation

4. Advising the individual performing the procedure to consider use of a bipolar electrocautery system or an ultrasonic scalpel to minimize potential adverse effects of EMI on the pulse generator or leads.

5. Assuring the availability of temporary pacing and defibrillation equipment.

6. Place external defibrillation/pacing pads on the patient and keep them connected to a portable monitor/defibrillator.

7. Evaluating the possible effects of anesthetic techniques on CIED function
   - avoid hyperventilation, which will abruptly lower serum potassium levels.
   - myocardial ischemia and high blood levels of local anesthetics may increase electrophysiologic thresholds.
A magnet applied to a pacemaker

- Often results in asynchronous pacemaker function at a predetermined rate without rate responsiveness.
- The specific mode of asynchronous pacing (e.g., AOO, VOO, DOO) depends entirely on the configuration of the patient’s device.
- The asynchronous mode will persist as long as the magnet remains in place over the pulse generator.
- Removal of the magnet will result in reversion to baseline device programming.
- The magnet rate and response vary by manufacturer.
- Some pacemakers may have no magnet response.
Magnet application to an ICD

- Rarely alters bradycardia pacing rate and function.
- Often results in suspension of tachyarrhythmia therapy.
- Application of a magnet to a combined CRMD will deactivate the ICD, but neither primary pacemaker function nor backup “postshock therapy” will be affected by magnet application.
- Thus, patients who are pacemaker-dependent should have their devices reprogrammed to an asynchronous pacing mode.
- In addition, reprogramming is recommended in surgical procedures within 15 cm of the ICD generator.
- Some ICDs may have no magnet response.
- Some ICDs can be permanently disabled by magnet application.
Preoperative considerations in a patient with an implanted cardioverter defibrillator

**Is EMI likely?**
- **No** → Proceed with surgery
- **Yes**
  - **Is the patient pacemaker dependent?**
    - **Yes** → Reprogram ICD
    - **No** →
      - **Is the surgical procedure <15cm from generator?** → Reprogram ICD
      - **Is the surgical procedure >15cm from generator?** → Consider magnet use
Magnet application to an ICD

- Medtronic, St Jude, and Biotronik devices always require that the magnet remain on the device to keep it deactivated. Subsequent removal of the magnet will promptly reactivate the ICD.
- Deactivation of a Boston Scientific (formerly Guidant) ICD with a magnet is different:
  - magnet application will elicit audible R-wave synchronous tones
  - If the R-wave synchronous tones persist, tachy therapies will be suspended for as long as the magnet remains on the device.
  - If the R-wave synchronous tones convert to a solid tone, the device is permanently deactivated and the magnet can be safely removed. To reactivate the ICD, replace the magnet for 30 seconds, until R-wave synchronous tones are again heard.
  - If no audible signals are heard with magnet application, the device is programmed to ignore magnet application.
III. Intraoperative Management

• Monitoring the operation of the device
  1. continuous electrocardiographic monitoring
     • The artifact filter on the ECG monitor should be disabled
  2. continuous peripheral pulse monitoring
• Preventing potential CIED dysfunction
  – Procedures using electrocautery, radiofrequency ablation, lithotripsy, MRI, or radiation therapy may damage CIEDs or interfere with CIED function.
• Performing emergency defibrillation, cardioversion, or heart rate support.
Disabling the pacemaker artifact filter on a digitally processed electrocardiographic (ECG) monitor results in the "painting" of environmental interference (EMI) as pacemaker artifacts.

The top tracing is ECG lead II, the middle tracing is the pulse oximeter plethysmogram, and the bottom tracing is the invasive arterial pressure waveform.
Electromagnetic Interference (EMI)

- Anything that emits radiofrequency waves between 0 and 109 Hz can generate EMI and cause interference of proper device function.
- Higher frequency waves such as X-rays, γ rays, and infrared and ultraviolet light do not acutely cause interference with CRMD function.
Factors associated with the generation of EMI

- Electrocautery
- Nerve stimulators
- Evoked potential monitors
- Fasciculations
- Shivering
- Large tidal volumes
- External defibrillation
- Magnetic resonance imaging
- Radiofrequency ablation or lesioning
- Extracorporeal shock wave lithotripsy
- Electroconvulsive therapy
1. The most common effect of ESU on pacemakers is ventricular oversensing which causes pacemaker inhibition.
2. Avoiding proximity of the cautery’s electrical field to the pulse generator or leads
3. Using short, intermittent, and irregular bursts at the lowest feasible energy levels
4. Using more “cutting” than “coagulating” current.
5. Using a bipolar electrocautery system or an ultrasonic (harmonic) scalpel if possible.
5. In addition, the grounding pad should be placed such that the current flow will not intersect the pacing system.
   – For example, patients undergoing head–neck surgery should have the grounding pad placed on the shoulder contralateral to the device (not the thigh)
   – whereas those undergoing breast and axillary surgery should have the pad placed on the upper arm.
Electromagnetic interference (EMI) from the monopolar electrosurgery unit (ESU; “Bovie”) caused an implantable cardioverter-defibrillator (ICD) to detect ventricular fibrillation (VF) but it could not actually deliver therapy because activating the “monitor only” mode preoperatively.
1. The lithotripsy beam should not be focused near the pulse generator.
2. If the lithotripsy system triggers on the R-wave, atrial pacing might need to be disabled before the procedure.
3. ICD should be disabled.
Managing EMI from MRI

- An MRI is generally contraindicated for CIED patients due to the generation of heat and unacceptably high rates of pacing.
- If an MRI must be performed, consult with the specialist, and the CIED manufacturer.
- There are some centers, however, that are starting to perform limited MRI scanning of the extremities in patients with CRMDs.
Managing EMI from Radiation Therapy

1. Radiation therapy can be safely performed for CIED patients, however, ionizing radiation may cause cumulative damage to the insulation of the leads and the semiconductor circuitry in the pulse generator.

2. Assuming appropriate shielding is used, radiation therapy is not contraindicated in patients with CRMDs.

3. The device must be outside the field of radiation.

4. Therefore, some pulse generators will require surgical relocation before commencing radiation.

5. Most manufacturers recommend verification of pulse generator function during and at the completion of radiation.

6. Problems may include pacemaker failure and runaway pacemaker.
Managing EMI from Electroconvulsive Therapy

1. Consult with the patient’s cardiologist to plan for the first and subsequent ECT’S.
2. ICD functions should be disabled for shock therapy during ECT.
3. However, be prepared to treat ventricular arrhythmias that occur secondary to the hemodynamic effects of ECT.
4. CIED-dependent patients may require a temporary pacing system.
5. The CIED may require programming to asynchronous activity to avoid myopotential inhibition of the device in pacemaker-dependent patients.