Essentials of Pacemakers and ICD’s

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Most Pacemakers Perform Four Functions:

- Stimulate cardiac depolarization
- Sense intrinsic cardiac function
- Respond to increased metabolic demand by providing rate responsive pacing
- Provide diagnostic information stored by the pacemaker
Components

Implantable pulse generator (IPG)

Lead wire(s)
The Pulse Generator:

- Contains a battery that provides the energy for sending electrical impulses to the heart
- Houses the circuitry that controls pacemaker operations
Leads Are Insulated Wires That:

- Deliver electrical impulses from the pulse generator to the heart
- Sense cardiac depolarization
Types of Leads

- Endocardial or transvenous leads
- Myocardial/Epicardial leads
Transvenous Leads Have Different “Fixation” Mechanisms

- Passive fixation
  - The tines become lodged in the trabeculae of the heart
Transvenous Leads

- **Active Fixation**
  - The helix (or screw) extends into the endocardial tissue
  - Allows for lead positioning anywhere in the heart’s chamber
Myocardial and Epicardial Leads

- Leads applied directly to the heart
  - Fixation mechanisms include:
    - Epicardial stab-in
    - Myocardial screw-in
    - Suture-on
Pacemaker Components Combine with Body Tissue to Form a Complete Circuit

- Pulse generator: power source or battery
- Leads or wires
- Cathode (negative electrode)
- Anode (positive electrode)
- Body tissue
During Pacing, the Impulse:

- Begins in the pulse generator
- Flows through the lead and the cathode (−)
- Stimulates the heart
- Returns to the anode (+)
A Unipolar Pacing System Contains a Lead with Only One Electrode Within the Heart; In This System, the Impulse:

- Flows through the tip electrode (cathode)
- Stimulates the heart
- Returns through body fluid and tissue to the IPG (anode)
A Bipolar Pacing System Contains a Lead with Two Electrodes Within the Heart. In This System, the Impulse:

- Flows through the tip electrode located at the end of the lead wire
- Stimulates the heart
- Returns to the ring electrode above the lead tip
Unipolar leads

- Unipolar leads may have a smaller diameter lead body than bipolar leads.
- Unipolar leads usually exhibit larger pacing artifacts on the surface ECG.
Bipolar leads

- Bipolar leads are less susceptible to oversensing noncardiac signals (myopotentials and EMI)
When the need for oxygenated blood increases, the pacemaker ensures that the heart rate increases to provide additional cardiac output.

![Adjusting Heart Rate to Activity](image)
A Variety of Rate Response Sensors Exist

- Those most accepted in the market place are:
  - Activity sensors that detect physical movement and increase the rate according to the level of activity
  - Minute ventilation sensors that measure the change in respiration rate and tidal volume via transthoracic impedance readings
Rate Responsive Pacing

- Activity sensors employ a *piezoelectric crystal* that detects mechanical signals produced by movement.
- The crystal translates the mechanical signals into electrical signals that in turn increase the rate of the pacemaker.
Rate Responsive Pacing

- Minute ventilation can be measured by measuring the changes in electrical impedance across the chest cavity to calculate changes in lung volume over time.
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<thead>
<tr>
<th>Position Function</th>
<th>1 Chambers Paced</th>
<th>2 Chambers Sensed</th>
<th>3 Response to Sensed Stimulus</th>
<th>4 Rate Modulation?</th>
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<td>V (ventricle)</td>
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Problems with Pacemakers

Failure to Capture

Causes:

- Threshold rise (electrolytes, drugs)
- Lead dislodgement
- Lead fracture
- RV infarct

Problems with Pacemakers
Failure to Pace

Causes:
- Oversensing
- Battery failure
- Internal insulation failure
- Conductor coil fracture

Problems with Pacemakers
Failure to Sense

Causes:
- Undersensing
- Lead Fracture

What’s next for pacemakers?

- Leadless Pacemakers
- St. Jude Medical and Medtronic devices are currently in clinical trials
All modern defibrillators have all the functions a pacemaker plus:

- The ability to pace terminate or defibrillate ventricular tachyarrhythmias (VT/VF)

System-wise, the only differences are:

- The RV lead which has 1 or 2 defibrillator coils on it

- The pulse generator is larger to accommodate a larger capacitor and battery
How do ICDs work?
How do ICDs work?

- Constant sensing by the RV lead for the presence of a fast rhythm
- The threshold for detection is user definable
- ICDs can discriminate between SVT and Ventricular based tachyarrhythmia (VT/VF)
How do ICDs work?

- Once VT/VF is detected, the device has a choice:
  - Pace termination
  - Defibrillation
Pace Termination

- Pace Termination
- More commonly known as Anti-tachy pacing (ATP)
- Painless

Ventricular Tachycardia at 230 bpm

Anti-TachyPacing

Sinus
The ICD will charge its capacitor (3-6 seconds) and then deliver therapy.
What’s new?

• Subcutaneous ICD: