Review of Pacemakers and ICD Therapy: Overview and Patient Management

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Disclosures

• Consultant, Research Support, Honoraria
  • Boston Scientific
  • Cook Medical
  • Deringer-Ney
  • LeadExx
  • Medtronic
  • Spectranetics
  • St. Jude Medical
  • W.L. Gore
• Legal Consultant/Expert Witness

The Pacemaker System

• Patient
• Lead
• Pacemaker
• Programmer
Nuclear Battery

Pacemaker Implantation

Nuclear Battery
Lithium Battery

Leads

- Endocardial
- Epicardial

Unipolar

Unipolar

Bipolar
<table>
<thead>
<tr>
<th>Bipolar Configuration</th>
<th>Leads; The Weak Link</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Bipolar Configuration" /></td>
<td><img src="image2.png" alt="Leads; The Weak Link" /></td>
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</table>

<table>
<thead>
<tr>
<th>Fixation Mechanisms</th>
<th>Indications for Pacing</th>
</tr>
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<tbody>
<tr>
<td><img src="image3.png" alt="Fixation Mechanisms" /></td>
<td><img src="image4.png" alt="Indications for Pacing" /></td>
</tr>
</tbody>
</table>
Indications for Pacing

- Coronary Artery Disease
- Idiopathic Degeneration
- Calcification
- Endocarditis
- Heart Surgery
- RF Ablation

Causes of Conduction Defects
**Indications for Pacing**

<table>
<thead>
<tr>
<th>Symptomatology + Documented Events = Reliable Indications for Pacing</th>
</tr>
</thead>
</table>

**Sick Sinus Syndrome**

- Sinus Bradycardia
- Sinus Arrest
- SA Exit Block
- Atrial Fibrillation with a Slow Ventricular Response
- Tachy-brady Syndrome

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**Indications for Pacing**

- Sick Sinus Syndrome
- Heart Block
- Carotid Sinus Hypersensitivity
- Post RF Ablation

**Sinus Bradycardia**
<table>
<thead>
<tr>
<th>Sinus Arrest and Sinoatrial Exit Block</th>
<th>Tachycardia-Bradycardia Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Sinus Arrest ECG" /></td>
<td><img src="image" alt="Tachycardia-Bradycardia ECG" /></td>
</tr>
<tr>
<td><img src="image" alt="SA Exit Block ECG" /></td>
<td></td>
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<tr>
<th>Atrial Fibrillation with Slow Ventricular Response</th>
<th>Indications for Pacing</th>
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<tr>
<td><img src="image" alt="Atrial Fibrillation ECG" /></td>
<td><img src="image" alt="Pacing Indications" /></td>
</tr>
</tbody>
</table>
### Second Degree A-V Block

- Mobitz Type I (Wenckebach)
- Mobitz Type II

### Mobitz Type II

![Mobitz Type II Image]

### Second Degree A-V Block (Mobitz or Wenckebach)

![Second Degree A-V Block Image]

### Third Degree A-V Block

![Third Degree A-V Block Image]
### Congenital Third Degree A-V Block

![ECG waveform](image)

### The NASPE/BPEG Generic (NBG) Code

<table>
<thead>
<tr>
<th>Position</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Chamber(s) Paced</td>
<td>Chamber(s) Sensed</td>
<td>Response to Sensing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Letters Used</td>
<td>O-None</td>
<td>A-Atrium</td>
<td>V-Ventricle</td>
<td>D-Dual (A+V)</td>
<td>O-None</td>
</tr>
<tr>
<td>Manufacturer's Designation Only</td>
<td>S-Single (A or V)</td>
<td>S-Single (A or V)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### NASPE / BPEG (NBG) PACEMAKER CODE

![Pacemaker image](image)
### The NASPE/BPEG Generic (NBG) Code

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<tr>
<th>Position</th>
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</thead>
<tbody>
<tr>
<td>Category</td>
<td>Chamber(s) Paced</td>
<td>Chamber(s)ensed</td>
<td>Response to Sensing</td>
<td>Rate Modulation</td>
<td>Multi Chamber Pacing</td>
</tr>
<tr>
<td>Letters Used</td>
<td>O-None</td>
<td>A-Atrium</td>
<td>V-Ventricle</td>
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#### Diagrams

- **AOO**
- **AAI**
- **VVI**
- **VVT**
- **VOO**
VVI

Ventricular Sensing / Inhibition

Ventricular Capture

- Paced Ventricular events re-start the pacing interval

Ventricular Loss of Capture

Loss of Capture
Ventricular Fusion

Ventricular Pseudofusion

VVIR

Activity Sensor

Sensor Output

Activity

Sedentary

Walk

Run

Piezo sensor glued to inside of pacemaker case
Minute Ventilation

AV Delay

An intrinsic R-wave came from the patient so the AV Delay was terminated.

AVI  AV Interval terminated

Base Rate 60 ppm
MTR 120 ppm
AVD 200 ms
PVARP 250 ms

ECG # 2
Magnet Application

1) Pacemaker
2) ICD

ECG # 3

Base Rate 60 ppm
MTR 120 ppm
AVD 200 ms
PVARP 250 ms

Normal Ventricle

ECG # 16

Base Rate 60 ppm
MTR 120 ppm
AVD 200 ms
PVARP 250 ms

Courtesy of A. Auricchio, University of Magdeburg, Germany.
Dilated Cardiomyopathy with LBBB

Coronary Sinus and Vein Anatomy

Placement of Leads for BiV Pacing

• Chest x-ray, lateral view showing LV lead (Medtronic Attain LV model 2187) placed into a mid-lateral vein.

Left Ventricular Lead Placement
Resynchronization Therapy

<table>
<thead>
<tr>
<th>Off</th>
<th>On</th>
</tr>
</thead>
</table>

Courtesy of A. Auricchio, University of Magdeburg, Germany.

ICDs

- Implantable Cardioverter Defibrillator
  - NOT AICD (this is a Trademarked brand name)
  - Full pacemaker functionality
  - Detects rapid ventricular rates
  - Capable of delivering 800V at 20 amps
    - Peak output of 29-40 Joules
      - Can be lower output as skin in not in the way
ICD Function

- Identifies fast ventricular rates
- May terminate the rhythm
  - Pacing pulses
  - Cardioversion
  - Defibrillation

CARDIOVERSION / DEFIBRILLATION

- Prior to any electrical procedure, device interaction must be analyzed
- Pacemaker interference is possible with cardioversion / defibrillation
- Paddles for cardioversion / defibrillation or electrocautery should be 4-6 inches away
- Paddles should be placed anterior / posterior if possible

ICD Function

EFFECTS OF ELECTROCAUTERY

- Reprogramming
- Permanent damage to the pulse generator
- Inhibition of the pulse generator
- Reversion to a fall-back*, noise reversion mode, or electrical reset. (*The characteristics of the fall-back mode should be known so that its presence is not confused with malfunction or end-of-service)
- Myocardial thermal damage secondary to transmission of electrical discharge to the heart via the lead (resulting in myocardial infarction or ventricular fibrillation or both)
<table>
<thead>
<tr>
<th>MAGNETIC RESONANCE IMAGING (MRI)</th>
<th>THERAPEUTIC RADIATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Generally contraindicated</td>
<td>• Diagnostic / Therapeutic</td>
</tr>
<tr>
<td>• Asynchronous pacing</td>
<td>• CMOS circuitry</td>
</tr>
<tr>
<td>• Rapid pacing</td>
<td>• Cumulative effect</td>
</tr>
<tr>
<td>• If absolutely necessary in the non-pacemaker dependent patient ONE should:</td>
<td>• Recommendations</td>
</tr>
<tr>
<td>• decrease output to non-capture</td>
<td>• shielding / repositioning device</td>
</tr>
<tr>
<td>• program OFF</td>
<td></td>
</tr>
</tbody>
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<thead>
<tr>
<th>LITHOTRIPSY</th>
<th>CMOS CIRCUITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guidelines for Lithotripsy in Paced Patients</td>
<td>• Damage may result with doses as low as 500 RADS</td>
</tr>
<tr>
<td>• Program the pacemaker to the VVI or VOO mode</td>
<td>• In a typical pacemaker 5000 - 10,000 transistors are simultaneously under attack and potentially subject to failure</td>
</tr>
<tr>
<td>• Keep the focal point of the lithotriptor no closer than six inches from the pacemaker</td>
<td></td>
</tr>
<tr>
<td>• Cardiac monitoring throughout the procedure</td>
<td></td>
</tr>
</tbody>
</table>

THERAPEUTIC RADIATION

- Diagnostic / Therapeutic
- CMOS circuitry
- Cumulative effect
- Recommendations
  - shielding / repositioning device
### ADDITIONAL EMI SOURCES

Other Electromagnetic Sources
- Microwaves
- Arc welding
- Automobile alternators
- Cellular phones
- Phantom Reprogramming

### CELLULAR PHONES

**Recommendations**
- Patients should avoid carrying their activated phone in a breast or shirt pocket that is overlaying the pacemaker
- Avoid placing the antenna in close proximity to the pulse generator
- Pacemaker dependent patients should discuss usage with their physician

### CELLULAR PHONES

- Analog vs. digital
- Potential interference can be minimized by avoiding direct contact of the antenna and the pulse generator
- May cause inappropriate inhibition, asynchronous pacing, safety pacing, inappropriate rate adaptation, and mode switching

### General Device Questions:

- Can a patient use a microwave oven?
  - As long as the device is not placed in the oven, it is OK
  - We recommend starting the oven and taking a step or two away from it
General Device Questions:

- Can a patient go through airport security?
  - Procedures for this vary from airport to airport. We suggest that the patient identify themselves as a pacemaker or defibrillator patient, and present their device ID card. They are usually walked around the security gate and given a hand search.

General Device Questions:

- Can a patient with an ICD drive a car?
  - Assuming they have a license, yes. This assumes that the patient has not had syncope or significant pre-syncope in the past 6 months. If an event compromising consciousness has occurred, the 6 month clock starts over.

General Device Questions:

- Can a patient walk through electronic article surveillance gates at the store?
  - Yes, but the rule is “Walk, don’t linger”.
  - Leaning on the gate, or staying in the scanning area may result in interference with proper device function until the patient moves out of the gate.

General Device Questions:

- A patient with an ICD is going to have an operation. What needs to be done with the device?
  - The risk to the patient should be assessed by the physician who follows the device. The major risk is that the use of unipolar electrocautery will be oversensed by the ICD, interpreted as VF, and result in a shock being delivered.