Review of Pacemakers and ICD Therapy: Overview and Patient Management

Charles J. Love, MD FACC FAHA FHRS CCDS
Professor of Medicine
Director, Cardiac Rhythm Device Services
OSU Division of Cardiovascular Disease
President, International Board of Heart Rhythm Examiners
Ohio State University Medical Center

Disclosures

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

The Pacemaker System

- Patient
- Lead
- Pacemaker
- Programmer
Lithium Battery

Leads

- Endocardial
- Epicardial
Unipolar

Bipolar
Bipolar Configuration

Fixation Mechanisms
Leads; The Weak Link

Indications for Pacing
Indications for Pacing
Indications for Pacing

- Coronary Artery Disease
- Idiopathic Degeneration
- Coronary Artery Disease
- Idiopathic Degeneration

Bundle of His

Causes of Conduction Defects

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

Symptomatology + Documented Events = Reliable Indications for Pacing

• Sick Sinus Syndrome
• Heart Block
• Carotid Sinus Hypersensitivity
• Post RF Ablation
## Sick Sinus Syndrome

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

## Sinus Bradycardia

![Electrocardiogram](image)
Sinus Arrest and Sinoatrial Exit Block

- Sinus Arrest
- SA Exit Block

Atrial Fibrillation with Slow Ventricular Response
Tachycardia-Bradycardia Syndrome

Indications for Pacing
# Second Degree A-V Block

- Mobitz Type I (Wenckebach)
- Mobitz Type II

---

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

![ECG Image]
Mobitz Type II

Third Degree A-V Block
Congenital Third Degree A-V Block

NASPE / BPEG (NBG) PACEMAKER CODE

CODE
### 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 A-Atrium V-Ventricle D-Dual (A+V)</td>
<td>O-None A-Atrium V-Ventricle D-Dual (A+V)</td>
<td>O-None T-Triggered I-Inhibited D-Dual (T+I)</td>
<td></td>
<td></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>
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 A-Atrium V-Ventricle D-Dual (A+V)</td>
<td>O-None A-Atrium V-Ventricle D-Dual (A+V)</td>
<td>O-None T-Triggered I-Inhibited D-Dual (T+I)</td>
<td></td>
<td></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>

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>Rate Modulation</td>
<td>Multi Chamber Pacing</td>
</tr>
<tr>
<td>Letters Used</td>
<td>O-None A-Atrium V-Ventricle D-Dual (A+V)</td>
<td>O-None A-Atrium V-Ventricle D-Dual (A+V)</td>
<td>O-None T-Triggered I-Inhibited D-Dual (T+I)</td>
<td>O-None R-Rate modulation</td>
<td>O-None A-Atrium V-Ventricle D-Dual</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>
Ventricular Capture

- Paced Ventricular events re-start the pacing interval
Ventricular Sensing / Inhibition

Ventricular Loss of Capture

Loss of Capture
Ventricular Fusion

Ventricular Pseudofusion
VVIR

Activity Sensor

<table>
<thead>
<tr>
<th>Sensor Output</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>---------------</td>
<td>---------------</td>
</tr>
<tr>
<td>~~~~~~~~~~~~~</td>
<td>Sedentary</td>
</tr>
<tr>
<td>~~~~~~~~~~~~~</td>
<td>Walk</td>
</tr>
<tr>
<td>~~~~~~~~~~~~~</td>
<td>Run</td>
</tr>
</tbody>
</table>

Piezo sensor glued to inside of pacemaker case
AV Delay

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

Base Rate 60 ppm
MTR 120 ppm
AVD 200 ms
PVARP 250 ms
ECG # 3

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

ECG # 16

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

Magnet Application

1) Pacemaker
2) ICD

Normal Ventricle

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

Coronary Sinus and Vein Anatomy

Courtesy of A. Auricchio, University of Magdeburg, Germany.
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
QRS Width Reduction ECG

Therapy OFF

Therapy ON

Lead V3

QRS=160 ms

QRS=120 ms
# 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 is 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

---

**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 know 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)
### MAGNETIC RESONANCE IMAGING (MRI)

- Generally contraindicated
- Asynchronous pacing
- Rapid pacing
- If absolutely necessary in the non-pacemaker dependent patient ONE should:
  - decrease output to non-capture
  - program OFF

### LITHOTRIPSY

**Guidelines for Lithotripsy in Paced Patients**

- Program the pacemaker to the VVI or VOO mode
- Keep the focal point of the lithotriptor no closer than six inches from the pacemaker
- Cardiac monitoring throughout the procedure
# Therapeutic Radiation

- Diagnostic / Therapeutic
- CMOS circuitry
- Cumulative effect
- Recommendations
  - shielding / repositioning device

## CMOS Circuits

- Damage may result with doses as low as 500 RADS
- In a typical pacemaker 5000 - 10,000 transistors are simultaneously under attack and potentially subject to failure
ADDITIONAL EMI SOURCES

Other Electromagnetic Sources

- Microwaves
- Arc welding
- Automobile alternators
- Cellular phones
- Phantom Reprogramming

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
**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

**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 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:

- 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:

- 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.