Update on Cardiac Risk

Managing a Patient with a Cardiac Device

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Medical College of Wisconsin
Disclosure

- Nothing to disclose
1993 to 2006 nationwide:
- 2.4 million patients with primary PM
- 0.80 million patients with primary ICD
- 369,000 PM replacement
- 74,000 ICD revision

Broadening indications for PM
- Resynchronization
- Heartfailure

PM/ICD

- History and Classification
- ICD Therapy
- Perioperative Management
- Electromagnetic Interference (EMI)
History

- First battery operated PM developed 1958 and first implanted PM 1960
- First ICD placed 1980

Medtronic’s history of miniaturizing pacemakers. Source: Medtronic.
<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chamber(s)</td>
<td>Chamber(s)</td>
<td>Response to sensing</td>
<td>Programmability rate modulation</td>
<td>Multisite Pacing</td>
</tr>
<tr>
<td>paced</td>
<td>sensed</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>O = None</td>
<td>O = None</td>
<td>O = None</td>
<td>O = None</td>
<td>O = None</td>
</tr>
<tr>
<td>A = Atrium</td>
<td>A = Atrium</td>
<td>T = Triggered</td>
<td>R = Rate Response</td>
<td>A = Atrium</td>
</tr>
<tr>
<td>V = Ventricle</td>
<td>V = Ventricle</td>
<td>I = Inhibited</td>
<td></td>
<td>V = Ventricle</td>
</tr>
<tr>
<td>D = Dual (A+V)</td>
<td>D = Dual (A+V)</td>
<td>D = Dual (T+I)</td>
<td></td>
<td>D = Dual (A+V)</td>
</tr>
</tbody>
</table>

**NASPE** - North American Society of Pacing and Electrophasiology  
**BPEG** – British Pacing and Electrophysiology Group
# ICD - NASPE/BPEG Generic Code

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<th>IV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shock Chamber(s)</strong></td>
<td><strong>Antitachycardia Pacing</strong></td>
<td><strong>Tachycardia Detection</strong></td>
<td><strong>Antibradycardia Pacing</strong></td>
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<td>O = None</td>
<td>O = None</td>
<td>E = Electrogram</td>
<td>O = None</td>
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<td>A = Atrium</td>
<td>H = Hemodynamic</td>
<td>A = Atrium</td>
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<tr>
<td>V = Ventricle</td>
<td>V = Ventricle</td>
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**BPEG** – British Pacing and Electrophysiology Group
ICD/PM

- History and Classification
- ICD Therapy
- Perioperative Management
- Electromagnetic Interference (EMI)
How does an ICD work?

Early ICD’s - shock only

Now

- Low energy shock for VT, high energy shock for VF
- Antitachycardic Pacing (ATP) - saves shocks and battery
- Backup pacing (post shock)
## ICD- Detection Algorithm

<table>
<thead>
<tr>
<th></th>
<th>VT-1 Zone</th>
<th>VT-Zone</th>
<th>VF-Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rate</strong></td>
<td>90-200 bpm</td>
<td>110-220 bpm</td>
<td>130-250 bpm</td>
</tr>
<tr>
<td><strong>Duration</strong></td>
<td>1-60 sec</td>
<td>1-30 sec</td>
<td>1-15 sec</td>
</tr>
<tr>
<td><strong>Redetection</strong></td>
<td>1-15 sec</td>
<td>1-15 sec</td>
<td>1 sec</td>
</tr>
<tr>
<td><strong>Post-Shock</strong></td>
<td>1-60 sec</td>
<td>1-30 sec</td>
<td>1 sec</td>
</tr>
</tbody>
</table>
ICD - ATP

- **Burst**
  - Attempt 1 with 3 pulses
  - Attempt 2 with 4 pulses

- **Scan**
  - Redetection
  - Scan burst

- **Ramp**
  - Ramp Burst

- **Ramp/Scan**
  - Ramp burst
  - Ramp/Scan burst

Adapted from www.guidant.com
PM/ICD

- History and Classification
- ICD Therapy
- Perioperative Management
- Electromagnetic Interference (EMI)

This document was developed as a joint project with the American Society of Anesthesiologists (ASA), and in collaboration with the American Heart Association (AHA), and the Society of Thoracic Surgeons (STS)

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Perioperative Management

Preop
- Past medical history
- Interrogation, reprogramming

Intraop
- Monitoring
- Magnet

Postop
- Interrogation
Preoperative Evaluation

- Patients History
- EKG
- CXR
- Electrolytes
- Interrogation
Patients History

- Indication, time and symptoms before implantation
- Manufacturer, model and program
- Last evaluation
  - underlying rhythm
  - battery status
  - recent shocks (if ICD)
- New symptoms (syncope, dizziness, fatigue, CP, SOB, palpitations, confusion)
EKG

- Underlying rhythm vs. paced rhythm (vagal maneuver discouraged)
- PM dependency?
  - higher risk if CHB or severe bradycardia
  - lower risk if SSS or carotid sinus hypersensitivity
- Signs of malfunction?
PM in the EKG

- DDD
PM in the EKG

- VVI
- VDD
PM in the EKG

- AAI

- VOO
PM in the EKG

- DDDR rate response

Various sensors:
- muscle activity
- transthoracic electrical impedance
- temperature
- minute ventilation
- QT-Interval
- pH
CXR

- Pacemaker vs. ICD
- Location of device and leads (transvenous vs. epicardial, ventricular and/or atrial)
- Manufacturer
- Lead integrity (insertion into generator, entry into subclavian vein, passage between clavicle and first rib)
- Signs of CHF
CXR
CXR

RV lead

RV lead
CXR

RV lead
CXR

Right atrial lead
LV - coronary sinus lead
Right ventricular lead

Right atrial lead
Coronary sinus lead
Right ventricular lead
CXR RV lead
Interrogation

- Need to know manufacturer to bring correct programmer
- Underlying rhythm
- Programmed settings
- Battery status
- Check threshold if PM dependency
- Call manufacturer
### Manufacturers

<table>
<thead>
<tr>
<th>Company</th>
<th>Phone Number</th>
<th>Company</th>
<th>Phone Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM Pacemaker Corp. (Guidant Medical)</td>
<td>800-227-3422</td>
<td>Diag/Medcor (St. Jude Medical)</td>
<td>800-722-3774</td>
</tr>
<tr>
<td>Angelon (Sorin)</td>
<td><strong>800-352-6466</strong></td>
<td>Edwards Pacemaker Systems (Medtronic)</td>
<td>800-325-2518</td>
</tr>
<tr>
<td>Arco Medical (Boston Scientific)</td>
<td>800-227-3422</td>
<td>ELA Medical (Sorin)</td>
<td>800-352-6466</td>
</tr>
<tr>
<td>Biotronik</td>
<td><strong>800-547-0394</strong></td>
<td>Intermedics (Boston Scientific)</td>
<td><strong>800-227-3422</strong></td>
</tr>
<tr>
<td>Boston Scientific</td>
<td><strong>800-227-3422</strong></td>
<td>Medtronic</td>
<td>800-505-4636</td>
</tr>
<tr>
<td>Cardiac Control Systems</td>
<td>Unavailable</td>
<td>Pacesetter (St. Jude Medical)</td>
<td><strong>800-722-3774</strong></td>
</tr>
<tr>
<td>Cardio Pace Medical, Inc. (Novacon)</td>
<td>Unavailable</td>
<td>Siemans-Elema (St. Jude Medical)</td>
<td>800-722-3774</td>
</tr>
<tr>
<td>Cardiac Pacemakers, Inc.: CPI (Boston Scientific)</td>
<td><strong>800-227-3422</strong></td>
<td>Sorin</td>
<td>800-352-6466</td>
</tr>
<tr>
<td>Coratonic (Biocontrol Technology)</td>
<td>Unavailable</td>
<td>Teletronics Pacing (St. Jude Medical)</td>
<td><strong>800-722-3774</strong></td>
</tr>
<tr>
<td>Cordis Corporation (St. Jude Medical)</td>
<td>800-722-3774</td>
<td>Ventrifex (St. Jude Medical)</td>
<td><strong>800-722-3774</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vitatron (Medtronic)</td>
<td>800-328-2518</td>
</tr>
</tbody>
</table>

*Companies in bold market both pacemakers and implantable cardioverter-defibrillators.*
Reprogramming options

ICD

- Turn off anti-tachycardic pacing/shock
- Change pacemaker program
Reprogramming options

PM

- Asynchronous
- Turn off rate response
- Consider increase in pacing rate to optimize oxygen-delivery to tissues for major surgery
- Some manufacturers recommend increase of amplitude and duration based on threshold test. Changes in threshold by surgery are described

Rate Response

- 63yo after laser stomach surgery under sedation developed HR 130/Min with Hypotension in PACU when connected to Monitor - disappeared when respiratory rate monitor disabled
  

- 59yo for TURP under spinal developed gradually increase in HR to 130/Min every time the electrocautery (unipolar) was used
  
  Wong DT: Anesthesiology 2001, 94:710-1
Rate Response

- 70yo for craniotomy under GA developed periodically increase in HR to 120/Min during drilling - disappeared after reprogramming to DDD instead of DDDR
  
  Schwartzenburg CF: Anesthesiology V87, 5, Nov 1997

- Similar incidents described in helicopter transport, elevators, coughing, sneezing
  
Intraoperative Precautions

- Alternate pacing modality available
- Have external defibrillator available (ICD)
- Magnet
- Chronotropes (Atropine, Isoproterenol, Ephedrine)
- Electrosurgery cautery precautions
- Anesthetic specials
## Alternate pacing modality

<table>
<thead>
<tr>
<th>Mode</th>
<th>Time to initiate</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transcutaneous</td>
<td>1-2 Min</td>
<td>Variable capture, patient discomfort</td>
</tr>
<tr>
<td>Transesophageal</td>
<td>Minutes</td>
<td>Unreliable ventricular capture, requires special generator (if rhythm responsive to atrial pacing)</td>
</tr>
<tr>
<td>Transvenous</td>
<td>3-20 Minutes</td>
<td>Invasive, question of stability</td>
</tr>
<tr>
<td>Pacing PA catheter</td>
<td>Minutes (if PA catheter in place)</td>
<td>Requires specific PA catheter</td>
</tr>
<tr>
<td>Epicardial</td>
<td>&lt;1 Min</td>
<td>Postoperative only, early lead failure</td>
</tr>
</tbody>
</table>

Trankina MF, In Faust RS 2002
Magnet
PM - Magnet

Generally *asynchronous* pacing, but
- Magnet response manufacturer depended
- Possibly increases risk for reprogramming in presence of EMI)
Placement of Magnet over Pacemaker pulse generator

IN GENERAL ALL PACEMAKERS PACE ASYNCHRONOUSLY (see individual special functions below)

- **Boston Scientific**
  - Magnet Response Modes:
    - EGM
    - Battery Test
    - OFF
  - ECG Response:
    - Yes
      - Depleted Battery
      - OFF
    - No
      - Depleted Battery
      - EOL?
  - AV Delay: 100ms and 3rd beat @ 50% programmed PW
  - Battery Status:
    - BOL: 100
    - ERN: 90
    - ERT: 85

- **Medtronic**
  - Magnet Response Modes:
    - TMT Mode† (*except Enrythm)
    - Magnet Mode
  - ECG Response:
    - Yes
      - Depleted Battery
    - No
      - EOL?
  - 3 beats @ 100 bpm (TMT*)

- **St. Jude Medical**
  - Magnet Response Modes:
    - EGM
    - Battery Test
    - OFF
  - ECG Response:
    - Yes
      - Depleted Battery
    - No
      - EOL?

- **Biotronik**
  - Magnet Response Modes:
    - Asynchronous
    - Synchronous
    - Auto
  - ECG Response:
    - Yes
      - Depleted Battery
      - Synchronous Mode
    - No

- **Sorin (ELA Medical)**
  - Magnet Response Modes:
    - ON
  - ECG Response:
    - Yes
      - Depleted Battery
    - No

**Across all manufacturers, the pacing response is unpredictable at or below EOL**
ICD - Magnet

Generally

- ‘Monitor only’ (suspend anti-tachycardia therapy) and
- no effect on pacing

but response unpredictable
In general SUSPENDS TACHYTHERAPY, but PACING UNAFFECTED (see specific features below)

**Boston Scientific (Guidant)**
- Magnet Response Mode: ON
- ICD Responds to Magnet: Yes
- Audio/Vibrate Response to Magnet: Change tachy mode with magnet feature (some models)
  - Present: ON (Tachy Tx suspended w/magnet)
  - Absent: OFF (Tachy Tx active)

**Medtronic**
- Magnet Response Mode: ON
- ICD Responds to Magnet: Yes
- Audio/Vibrate Response to Magnet: Yes
  - (All Clear Tone)
  - (Low Urgency Tone)
  - (High Urgency Tone)

**St. Jude Medical**
- Magnet Response Mode: ON
- ICD Responds to Magnet: Yes
- Audio/Vibrate Response to Magnet: No Audio/Vibration

**Biotronik**
- Magnet Response Mode: ON
- ICD Responds to Magnet: Yes
- Audio/Vibrate Response to Magnet: No Audio

**Sorin (ELA Medical)**
- Magnet Response Mode: ON
- ICD Responds to Magnet: Yes
- Audio/Vibrate Response to Magnet: No Audio

**Effect of Magnet on Tachytherapy**
- 1. No Tone Heard
- 2. No Tone
- 3. Depowered Battery
- 4. Different manufacturer
- 5. Position of magnet

**Effect of Magnet on Pacing**
- No effect

**UPON REMOVAL OF MAGNET (2 FEET AWAY FROM THE DEVICE)**
- Tachy Tx OFF
- Magnet removal
- Back to baseline

**ON MAGNET REAPPLICATION After 10 sec.**
- 1. Beeping sound: Tachy Tx enabled
- 2. Continuous tone: Tachy Tx programmed to OFF (call Biotronik)

**IFF ICD MALFUNCTION SUSPECTED REINTERROGATE THE DEVICE**
- (eg: cautery application close to the device situations where ICD reset may occur)
Reprogramming

Preferred over Magnet if

- **PM dependent** patients
- Disabling of *rate response*
- Non supine surgery
Intraoperative Monitoring

Electrical and mechanical evidence of heart function

- EKG, disable Filter
- Blood pressure related tracing: pulse oximeter, arterial line (consider in Biventricular PM, HOCM)
- Avoid unipolar electrocautery

Rozner MA, Anesthesiology 2002, 96, 773-4
Electrocautery

- Direct current interference
- Possible inhibition of pacing, asynchronous pacing, increase in pacing rate (rate response)
- Possible device reset or permanent device damage
- Risk of inappropriate shock
- Possible myocardial tissue damage at lead tip

Adapted from www.guidant.com
Electrocautery

If surgical site is close to the device
- Consider asynchronous pacing mode
- Short, intermittent, irregular bursts
- Confirm normal device function and programmed parameters postop
- Bipolar electrocautery recommended, if unipolar necessary, current path should be as far from device/leads as possible (eg. place ‘bovie pad’ on forearm)
Anesthetic specials

Concerns

- Strain on device and cables (patient movement, position)
- **Shivering** or fasciculations (Succhynylcholine)
- **Ischemia** and electrolyte disturbances (treat loss of capture as ischemia until proven otherwise)
- Toxic doses of Local Anesthetics can potentially lead to loss of capture

Summary

It is not the device, but the patients disease!

- Get as much information as possible
- Vigilance if patient is PM dependent
- Have backup pacing/defibrillating device available
- Magnet can be useful