Pacemakers And ICDs

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Disclosures

• No conflicts of interest
Pacemakers/ICDs

• Electrical therapy used to treat:
  – Bradyarrhythmias
  – Tachyarrhythmias

• USA implantations from 1990 to 2002
  – 2.25 million pacemakers
  – 416000 ICDs

• USA
  – 255,000/year pacemakers
  – 133,000/year ICDs
# Pacer Codes

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
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<tbody>
<tr>
<td>Chamber paced</td>
<td>Chamber sensed</td>
<td>Mode of response</td>
</tr>
<tr>
<td>V - ventricle</td>
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<td>I - inhibited</td>
</tr>
<tr>
<td>A - atrium</td>
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<td>T - triggered</td>
</tr>
<tr>
<td>D - dual</td>
<td>D - dual</td>
<td>D - dual</td>
</tr>
<tr>
<td>0 - none</td>
<td>0 - none</td>
<td>0 - none</td>
</tr>
</tbody>
</table>
Pacemaker - Patient competition

- Interpolated beats could compromise cardiac output
- Ventricular fibrillation from R-on-T
R-on-T
## Pacer Codes

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Atrial tracking

- Requires dual chamber leads
- If the atria speed up, ventricles are paced at the faster rate
- Maintains AV synchrony
- Higher cardiac output when needed

- VAT
- DDD
Pacemaker Function Codes

- What does each mode do?
- Will it keep you alive if there is sinus node block?
- Will it treat A-V node block?
- Does competition occur?
- Does it track the atrial rate?
<table>
<thead>
<tr>
<th>Mode</th>
<th>Treats sinus node disease?</th>
<th>Treats AV node disease?</th>
<th>? No compn</th>
<th>Atrial kick?</th>
<th>Tracks the atrial rate?</th>
<th>Pacemaker math</th>
<th>Use?</th>
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</thead>
<tbody>
<tr>
<td>VOO</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
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</tr>
<tr>
<td>VVI</td>
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<td>✓</td>
<td>✓</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
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<tr>
<td>DOO</td>
<td>✓</td>
<td>✓</td>
<td>x</td>
<td>✓</td>
<td>x</td>
<td></td>
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</tr>
<tr>
<td>VAT</td>
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<td>✓</td>
<td>x</td>
<td>✓/x</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DDD</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</table>
DDD - Universal Mode

- Dual chamber pacing
- Atrial kick adds to ventricular filling
- Only paces as needed: A and V
- Allows atrial tracking
- Not indicated in AF
Demand Modes

- Inhibited modes
- Back up modes
- Pace when needed
- Inhibit when not needed
- Avoid competition

- VVI
- AAI
- DDD
Asynchronous Modes

- Never inhibited by artifact or electrocautery
- Emergency pacing mode
- Cause competition

- A00
- V00
- D00
Rate

• Lower rate
  – Back up rate

• Upper rate
  – Highest rate ventricles will be paced in response to an atrial rhythm
  – Maximum atrial tracking
  – Wenkebach
Rate Adaptive Pacing

- Changes the rate of the pacer in response to the metabolic demand
- Physiological variables
  - Body motion or activity
  - Body chemistry changes
    - Minute ventilation
    - Respiratory rate
    - Central venous SO2
    - Central venous pH
  - Central venous temperature
  - Electrical changes in the heart
Rate Adaptive Methods

• Vibration sensor
  – Piezo-electric crystal
  – Deforms with movement
  – High sensitivity, low specificity

• Trans-thoracic bio-impedence
  – Measures depth and rate of respiration
  – Lower sensitivity, high specificity

• Vibration and minute ventilation
  – High sensitivity and specificity
Temporary Perioperative Pacing

- Any indication for permanent pacing
- Cardiac surgery
- Bifascicular block with 1st degree block?
Temporary Pacing Techniques

• Transvenous
  – Ordinary pacing catheter
  – Pace-port pulmonary artery catheter
  – Balloon directed catheter

• Epicardial

• Trans-cutaneous

• Trans-oesophageal
Balloon Directed Pacing Wire
Floating a Pacing Wire
1: SVC
Floating a Pacing Wire
2: Right Atrium
Floating a Pacing Wire
3: Right Ventricle
Trans-esophageal Atrial Pacing
Trans-cutaneous Pacing
Transcutaneous Pacing Control
Transcutaneous Pacing Control
Temporary
External
Pacer
A Sensitivity: 0.5 mV

V Sensitivity: 2.0 mV

A-V Interval: 170 ms

Upper Rate: 110 ppm

PVARP: 300 ms

A. Tracking: On

Settings: Automatic

Rapid Atrial Pacing

Mode Selection
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
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<tr>
<td>A Sensitivity</td>
<td>0.5 mV</td>
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<tr>
<td>V Sensitivity</td>
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<tr>
<td>A-V Interval</td>
<td>170 ms</td>
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<tr>
<td>Upper Rate</td>
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<td>PVARP</td>
<td>300 ms</td>
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<td>A. Tracking</td>
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<tr>
<td>Settings</td>
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<td>Rapid Atrial Pacing</td>
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<tr>
<td>Mode Selection</td>
<td></td>
</tr>
</tbody>
</table>
ASYNCHRONOUS PACING

To Resume Synchronous Pacing Press
Perioperative Concerns

• History
  – Indication for pacemaker
  – Return of symptoms?

• Evaluation
  – ECG
  – Listen with AM radio - tuned to 550Hz
  – Slow the heart by vagal manoeuvres
    • Could be dangerous
  – Pacing system analyser
Pacemaker Interrogation

- Required if the pacer has not been interrogated in the past year
- Checks the mode of the pacer
- Assesses battery level
- Test for pacemaker malfunction
- ERI
  - Elective Replacement Indicator
  - Triggered at regular follow up interrogation
  - Indicates need to replace the battery or device
Make and Type of Pacer?

• Pacemaker Passport
• Medical documentation
• X-ray signs
Single Lead Pacer
Single Lead Pacer

Biotronik - Triplos LV-T
Dual Chamber Pacer
Dual Chamber Pacer
Dual Chamber Pacer

Guidant - Discovery II SR
Single Lead ICD
Single Lead ICD

Guidant - Ventak Prizm
Dual Lead ICD
Dual Lead ICD

Medtronik - Insync Marquis
Bi-Ventricular Pacer ICD
Bi-Ventricular Pacer ICD
<table>
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<tr>
<th>Model Number/Name</th>
<th>NBD Code</th>
<th>X-Ray ID</th>
<th>Connectors</th>
<th>RV</th>
<th>LV</th>
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<tr>
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<td>PLY</td>
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<tr>
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<tr>
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<tr>
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<td>PJM</td>
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<td>GEM II DR</td>
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Electromagnetic Interference

- EMI converts pacers to asynchronous mode
- *Intermittent* interference, eg electrocautery, does not convert to asynchronous mode
- Cautery can inhibit the pacers
Reprogramming Pacemakers for Surgery

• Usually not required
• Consider in pacer dependent pt with cautery close to the device
• Consider turning off rate adaptive pacing to avoid tachycardia
• Programmer or magnet should be available
Magnet

- Converts to asynchronous mode
- Avoids inhibition from electro-cautery
- May cause competition
- Rate may indicate battery depletion
- Random phantom reprogramming
  - magnet and electrocautery combination
Random Phantom Reprogramming

- May occur when a magnet is used in the presence of EMI
- Electro-cautery is a form of EMI
- May occur with cautery alone close to the device
- Rate, mode, output may all be changed to bizarre values
- Less likely with modern pacemakers
  - digital programming signal rather than an analogue
Management of Random Phantom Reprogramming

- Leave the magnet in place
- Interrogate ASAP post-op
- Reprogram if required
Recommendations for Cautery

• Grounding plate away from the unit
• Keep output low
• Use short bursts
• Monitor the pulse
• Have atropine and isoproterenol available
• Convert to asynchronous mode
  – Magnet
  – Pacing system analyser / Reprogramming head for multiprogrammable units
Anaesthetic/ICU Management with Pacemakers

- Avoid electrolyte imbalances
- Aim for PaCO2 close to normal
- Inhibition may occur due to fasciculations with sux
- Most anaesthetic techniques do not affect pacing
- Deep ventilation may cause loss of contact of the electrode with the myocardium
Microshock

- Pacing leads provide a direct electrical pathway to the heart
- Ventricular fibrillation may be induced by a small electrical shock from static
- The leads should be electrically isolated when not in use
- External electrodes should be handled wearing insulating gloves
Implantable Cardiac Defibrillators

- eg. AICD
- Have pacing capability
- Defibrillation *must* be turned off before surgery above the umbilicus
  - Magnet *may* work
- The pacer can not be set to asynchronous mode
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Protocol</td>
<td>ICD vs. conventional therapy (mainly amiodarone)</td>
<td>Electrophysiologically guided therapy (ICD or drug therapy) vs. no electrophysiologically guided therapy</td>
</tr>
<tr>
<td>Sample size, n</td>
<td>ICD: 95 Conventional therapy: 101</td>
<td>Guided ICD: 161 Guided drug therapy: 190 No guided therapy: 353</td>
</tr>
<tr>
<td>Inclusion criteria</td>
<td>Previous Q-wave myocardial infarction, EF ≤ 0.35, asymptomatic nonsustained VT, and inducible VT not suppressible with procainamide therapy</td>
<td>Coronary artery disease, EF ≤ 0.40, asymptomatic nonsustained VT, and inducible VT</td>
</tr>
<tr>
<td>Reduction in mortality with ICD therapy</td>
<td>54% at 27 months</td>
<td>74% at 60 months</td>
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*EF = ejection fraction; ICD = implantable cardioverter-defibrillator; MADIT = Multicenter Automatic Defibrillator Implantation Trial; MUSTT = Multicenter Unsustained Tachycardia Trial; VT = ventricular tachycardia.
† Preliminary results as of March 1999.

**Multicenter Automatic Defibrillator Implantation Trial (MADIT)**
**Multicenter Unsustained Tachycardia Trial (MUSTT)**
ICD Response to Magnet

- **Medtronic**
  - The magnet does not alter pacing for bradycardia
  - The magnet temporarily suspends monitoring and therapy for as long as the magnet is on

- **St. Jude Medical**
  - The magnet does not alter pacing for bradycardia
  - The ICD must be programmed to be receptive to the magnet (default)
ICD Response to Magnet

• **Ventricelx**
  – The magnet temporarily suspends monitoring and therapy for as long as the magnet is on

• **Sulzer Intermedics**
  – The magnet does not alter pacing for bradycardia
  – Pacing and shock therapy are terminated for as long as the magnet is in position

• **Biotronik**
  – The magnet will initiate a test of the pulse width of the impulse used for bradycardia related pacing
ICD Response to Magnet

• Guidant/CPI
  – The ICD must be programmed to be receptive to the magnet
  – If the ICD is programmed to “off”, then the magnet will switch the ICD between “off” and “monitor + therapy”
  – If the ICD is programmed to “monitor only”, then the magnet will switch the ICD to “monitor + therapy”
  – Continuously holding the magnet over the ICD will keep the ICD in the “monitor only” mode
ICD Response to Magnet

• **Boston Scientific**
  – If the ICD is programmed “off” and takes a catastrophic hit, eg cautery over the device it goes to “Safety mode” (VVI 72 bpm with 165bpm VF zone with shock therapy) Patient and/or surgeon may be shocked
  – If programmed to “Electro-cautery mode” the safety architecture will prevent reversion to “Safety mode”
    • Recommended mode for surgery
    • Provides asynchronous pacing
    • Pacing can be disabled before programming Electro-cautery mode
    • VVI, AAI or DDD cannot be used
Does your patient have an ICD or Pacemaker?

Yes a **pacemaker**

OR

Yes an **ICD** and the procedure is **below** the **umbilicus** as determined by the Surgeon, Proceduralist or Designee

---

No **Intervention Required**

*If the CIED is close to the surgical field or there are clinical concerns or questions, the Anesthesia Provider, Surgeon, Proceduralist or Designee may place an order for ICD / Pacemaker procedural management and page the CVC/UH Device Nurse **#2263**
Does your patient have an ICD or Pacemaker?

Yes an **ICD** and the procedure is **at or above** the **umbilicus** as determined by the Surgeon, Proceduralist or Designee.

- Anesthesia Provider, Surgeon, Proceduralist or Designee may place an order for ICD / Pacemaker procedural management and page the CVC / UH Device Nurse **#2263**

CIED (Device) Nurse assesses patient and makes decision about Intervention needed (Magnet or Non-Magnet)

**Magnet**

- Intervention Needed: Magnet compatible Device and patient position amenable to magnet placement

- CIED (Device) Nurse and Anesthesia Provider or Procedure Nurse discuss magnet placement

- CIED (Device) Nurse writes note with recommendation including discharge instructions and completes order in the electronic medical record

- Anesthesia Provider places magnet at case start and removes at case end
Does your patient have an ICD or Pacemaker?

Yes an **ICD** and the procedure is **at or above** the **umbilicus** as determined by the Surgeon, Proceduralist or Designee.

Anesthesia Provider, Surgeon, Proceduralist or Designee may place an order for ICD / Pacemaker procedural management and page the CVC / UH Device Nurse **#2263**

CIED (Device) Nurse assesses patient and makes decision about Intervention needed (Magnet or Non-Magnet)

**Non-Magnet**

Intervention Needed:
Not magnet compatible or patient position not amenable to magnet placement necessitating tachycardia therapies to be disabled

CIED (Device) Nurse places pink armband, disables tachycardia therapies and ensure external defibrillator patches are in place.

Patient transported to OR / Procedure with **defibrillator patches in place**

Patient transported to PACU with **defibrillator patches in place**.

PACU Nurse or Recovery Nurse or PACU Anesthesia Provider pages CIED (Device) Nurse **#2263** for post-op evaluation

CIED (Device) Nurse enables tachycardia therapies and interrogates to assure proper device function and programming. Patches may safely be removed by recovery staff.

CIED (Device) Nurse removes pink armband, completes order and writes note in electronic medical record

**Yes an ICD and the procedure is at or above the umbilicus as determined by the Surgeon, Proceduralist or Designee.**

Anesthesia Provider, Surgeon, Proceduralist or Designee may place an order for ICD / Pacemaker procedural management and page the CVC / UH Device Nurse **#2263**

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CIED (Device) Nurse removes pink armband, completes order and writes note in electronic medical record
Intra-operative Management of an ICD

• Have a magnet available

• Defibrillation function of the ICD must be turned OFF (or temporarily suspended)
  – If the operation is above the umbilicus

• If time, contact EP prior to the operation to be advised if a magnet will work or if reprogramming is needed
Intra-operative Management of an ICD

• If no time to consult EP preop, then tape a magnet over the device and leave it in place
• Tachy therapy will be temporarily suspended while the magnet is in place
• Brady therapy will not be affected
• Therapy mode may NOT resume after removing the magnet from Guidant devices
Intra and Post-operative Management of an ICD

- Monitor ECG continuously while the ICD is turned off
- Alternative means for cardioversion/defibrillation needed
- Apply patches for external defibrillation during surgery
- Ensure that the external patches are as far away as possible from the device
Pacemakers

• Understand the modes
• Know when and how to use temporary pacing
• Know what to do with permanent pacers / ICDs in the OR/ICU