Pacemakers and ICDs

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Pacers

1952 Zoll

1958
Leads
Unipolar vs. Bipolar

- **Unipolar**
  - Larger pacing spikes on EKG
  - Small diameter lead body
  - Less rigid lead body
  - More susceptible to oversensing
  - May produce muscle and nerve stimulation

- **Bipolar**
  - Larger diameter lead body
  - Tend to be stiffer
  - Less susceptible to oversensing
  - Unipolar programmable
  - Less likely to produce muscle and nerve stimulation
Basics

• Pulse generator:
  – Provides energy, and has an advanced timer with circuitry and memory chips

• Leads:
  – Pace and sense
Procedure

- Left or right infraclavicular incision
- Pocket
- Access (axillary, cephalic, subclavian)
- Lead insertion
- Pacer placement
- Closing
Pacemakers

- 92 y/o lady with history of recurrent syncope
- ECG and echo OK

Loop recorder:

Dx???

7 sec. pause
Indications

• SSS

• The short story:
  – NO SYMPTOMS: NO PACEMAKER
  – Symptomatic brady – not iatrogenic
  – Chronotropic incompetence
  – Syncope with evidence of SSS
  – Pauses (3 sec) or very slow HR (<40) while awake and symptoms
Indications

- AV Block
  - 3rd degree AVB, or 2nd degree AV block Mobitz II
  - Any 2nd degree AV block with symptoms
  - Mobitz I, proven to be intra or infra hisian with EPS
  - Some neuromuscular diseases (even without symptoms)

- 2nd degree AV Mobitz I, no symptoms → No pacer
55 y/o with nl EF, SR with LBBB, asymptomatic 2\textsuperscript{nd} degree AV block, looked like Mobitz I......
His
Indications

• Syncope with HV >70
• Asymptomatic with HV>100
• Infrahisian block, not physiologic

• Long QT
  – Same as others, plus pts with pause dependant VT
Bifascicular Block
Indications

• Bifascicular or “trifascicular” block
  – Same as regular AV block
  – No symptoms or AV block → no pacer
• Vasovagal/Neurocardiogenic
  – Not indicated for most patients
• Carotid hypersensitivity syndrome
  – Syncope plus + CSM=Pacer
  – No symptoms, even with + CSM=no pacer
• HCM
  – Same as SSS
  – Medically refractory with high LVOT gradient
  – Not indicated in the absence of gradient even with symptoms
Temporary Pacer

- Refractory symptomatic sinus node dysfunction (Temp if reversible or post MI)
- Complete heart block
- Alternating bundle-branch block
- New bifascicular block in AMI
- Bradycardia-dependent ventricular tachycardia
<table>
<thead>
<tr>
<th>I: Chamber Paced</th>
<th>II: Chamber Sensed</th>
<th>III: Response to Sensing</th>
<th>IV: Programmable Functions/Rate Modulation</th>
<th>V: Multisite Pacing</th>
</tr>
</thead>
<tbody>
<tr>
<td>V: Ventricle</td>
<td>V: Ventricle</td>
<td>T: Triggered</td>
<td>P: Simple programmable</td>
<td>P: Pace</td>
</tr>
<tr>
<td>D: Dual (A+V)</td>
<td>D: Dual (A+V)</td>
<td>D: Dual (T+I)</td>
<td>C: Communicating</td>
<td>D: Dual (P+S)</td>
</tr>
<tr>
<td>O: None</td>
<td>O: None</td>
<td>O: None</td>
<td>R: Rate modulating</td>
<td>O: None</td>
</tr>
<tr>
<td>S: Single (A or V)</td>
<td>S: Single (A or V)</td>
<td></td>
<td>O: None</td>
<td></td>
</tr>
</tbody>
</table>
Mode Selection Decision Tree

1. Symptomatic bradycardia
   - Are atrial tachyarrhythmias present?
     - N
     - Y
       - Is AV conduction intact?
         - N
           - (SSS)
           - AAIR
           - DDDR
         - Y
           - Is SA node function presently adequate?
             - N
               - (CSS, VVS)
               - DDD, DDI with RDR
             - Y
               - DDD, VDD DDDR
               - VVI
               - VVIR

2. Is AV conduction intact?
   - Y
     - Are they chronic?
       - N
         - DDDR
         - AAIR
       - Y
         - DDD, VDD DDDR
         - VVI
         - VVIR
Troubleshooting
Sensing or Capture problems
Too much, or too little

crosstalk
myopotentials
No capture
Diagnostics

VT

AFIB
Pacemaker syndrome

• Symptoms:
  – syncope or near-syncope, orthostatic dizziness, fatigue, exercise intolerance, weakness, lethargy, chest fullness or pain, cough, uncomfortable pulsations in the neck or abdomen, right upper quadrant pain, and other nonspecific symptoms.

• Cause:
  – Loss of AV synchrony, most common in VVI or DDI mode.
Pacemaker syndrome
ICDs
History of ICD Therapy

• 1966: Device conception

• 1980: First human implant at Johns Hopkins Hospital. To meet criteria, the patients had to have survived two episodes of cardiac arrest not associated with an infarction and VF had to be documented at least once.
First Clinical Model

- 250 g
- Short-lived
- Shock only
- Nonprogrammable
- No data storage
- Committed
- Required thoracotomy and abdominal implant
Implantable Defibrillators (1989-2001)

- 209 cc
- 113 cc
- 80 cc
- 80 cc
- 72 cc
- 54 cc
- 62 cc
- 49 cc
- 39.5 cc
- 39 cc
- 39.5 cc
- 39 cc
- 39.5 cc
- 36 cc
Device Evolution

1985  1991  1995
Device Features

- Programmable therapy options
  - Energy selection
  - Multiple zones
  - Antitachycardia pacing
- Data storage
- Discrimination of SVT and VT
- Single, dual-chamber or bi-ventricular pacing
- Audible patient alerts
- Longevity up to 8 years:

Antitachycardia Pacing

![Image](Antitachycardia_Pacing.png)

How it works

- Reentry Circuit
- Excitable Gap
- Depolarizing Wavefront from ATP Stimulus
Shock Pathway

Vectors

Example of Dual Coil: $AX > B$

(Active Can + SVC HV Coil > RV HV Coil)
## Implantable Cardioverter Defibrillator Trials for Secondary Prevention of SCD

<table>
<thead>
<tr>
<th>STUDY GROUP</th>
<th>Mortality</th>
<th>Rel RR</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control</td>
<td>ICDs</td>
<td></td>
</tr>
<tr>
<td>AVID VF, sustained VT; EF ≤ 40% ICD vs amiodarone Mean EF 35% F/U: 18 mo</td>
<td>24%</td>
<td>15.8%</td>
<td>30%</td>
</tr>
<tr>
<td>CIDS VF, symptomatic VT; EF ≤ 35%, CL &lt; 400ms Mean EF 34% F/U: 36 mo</td>
<td>29.6%</td>
<td>25.3%</td>
<td>-30%</td>
</tr>
<tr>
<td>CASH Survivors of SCD (VF/VT) propafenone/metoprolol/amiodarone/ICD Mean EF 45%, F/U: 57 mo</td>
<td>44.4%</td>
<td>36.4%</td>
<td>23%</td>
</tr>
<tr>
<td>Meta-analysis</td>
<td>28%</td>
<td></td>
<td>0.006</td>
</tr>
</tbody>
</table>

AVID = Antiarrhythmics vs Implantable Defibrillators. NEJM 1997; 337:1576 (terminated early)  
CIDS = Canadian ICD study. Circulation 2000;101:1297  
CASH = Cardiac Arrest Study of Hamburg. Circulation 2000;102:748
ICD for Primary Prevention Study Criteria Comparison

<table>
<thead>
<tr>
<th>Inclusion Criteria</th>
<th>MADIT¹ 1996 (n = 196)</th>
<th>MUSTT² 1999 (n = 704)</th>
<th>MADIT II³ 2002 (n = 1232)</th>
<th>SCD-HeFT (n = 2521)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAD/Post-MI</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>LV Dysfunction</td>
<td>✓ (≤35%)</td>
<td>✓ (≤40%)</td>
<td>✓ (≤30%)</td>
<td>✓ (≤35%)</td>
</tr>
<tr>
<td>NSVT</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inducible VT on EPS</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inducible, non-suppressible VT on EPS</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

28 y/o man with recurrent syncope

- NI ECG, some PVCs
- NI Echo
- NI MRI heart
- Recurrent syncope
Time for an ICD??????
Indications for ICD

- Spontaneous or inducible VT/VF
- Sustained VT with structural heart disease
- Unexplained syncope with inducible VT/VF or in very high risk patients
- High risk inherited conditions (Long QT, Brugada)
- LVEF < 35% ischemic or non-ischemic
Contraindications

- Incessant VT or VF
- VT or VF due to a completely reversible cause
- Psychiatric illness potentially aggravated by ICD therapy
- Terminal illness
- Class IV CHF without option of cardiac transplantation (except bi-V)
VT vs. SVT
Sometimes, it’s just bad: Lead fracture, noise, oversensing (diaphragmatic myopotentials in this case)
Anti Tachycardia Pacing

Examples of Success (A) and Failure (B)

A. VT onset \(\rightarrow\) ATP onset

Episode duration = 5.3 s

B. VT onset \(\rightarrow\) 1\(^{st}\) ATP onset

2nd ATP onset \(\rightarrow\) Accelerated VT \(\rightarrow\) 4.8 J shock

Episode duration = 16.8 s


Anti Tachycardia Pacing
Bi-V ICD
• Dyssynchrony is an anatomical-mechanical event involving:
  – Abnormal ventricular activation (EF)
  – Decreased ventricular filling
  – Abnormal ventricular wall motion
• Up to 50%-70% of patients with HF have ventricular dyssynchrony
Who Needs CRT?

Classic indication:

- NYHA = III-IV
- QRS duration ≥120 ms
- EF ≤ 35%

New Indication:

- NYHA = I-II
- EF <30%
- LBBB
Bi-V Trials

• These trials show:
  – Better exercise tolerance
  – Better QOL
  – Better NHYA class
  – Improved mortality
Pacer/ICD Complications

• Acute: Bleeding, pneumothorax, lead dislodgement, hematoma, lead malposition, perforation, PE, SCV DVT

• Infection or erosion in 1-2% of cases and requires system removal

• Malfunction of device; lead is the weakest link can fracture or fail

• Inappropriate shocks

• Ventricular pacing might be detrimental
  – MADIT II demonstrated increased incidence of CHF in defibrillator patients
  – DAVID trial demonstrated 3.6% mortality increment with DDD versus backup VVI
Lead fracture

Middle cardiac vein

LV through ASD
Pt with pain under rib cage post implant

Lack of capture post implant
Rare Complications

Twiddler Syndrome

Erosion
Follow up

• Wireless devices
• Routine ICD checks at home
• Interrogator to device without a cable
• Internet/satellite, GSM based interrogation
• No more: “go to the ER for a shock”
Questions?