PACEMAKER EMERGENCIES

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Disclosures: None

PACEMAKER EMERGENCIES
- Failure to capture
- Failure to sense
- Oversensing
  - Pauses in paced rhythm
  - Rapid triggered ventricular paced rates
- Rapid paced rates
- No output

PACEMAKER GENERATOR RATES (INTERVALS)
- Low rate limit (standby rate, base rate, automatic rate)*
- Magnet
- Upper rate limit*
  - Maximum tracking
- Interference
- Fallback
- AV interval (fixed, variable, rate-adaptive)
- PVARP (fixed, variable)
- PVAB
  *Atrial based, sensor based

CHEST X-RAY IN PACEMAKER PATIENTS
- Lead(s) position
- Lead configuration (bipolar, unipolar)
- Generator position
- Generator identification
- Connector block integrity
  - Faulty connection
  - Loose set screw
- Lead fracture
- Lead insulation defect
CAUSES OF PACEMAKER NONCAPTURE

- Tissue is refractory (e.g., prior depolarization)
- Lead dislodgement
- Increase in myocardial stimulation threshold
- Lead insulation break
- Inappropriately low programmed output
- Generator end of life
### INCREASE IN MYOCARDIAL STIMULATION THRESHOLD

<table>
<thead>
<tr>
<th>Physiologic</th>
<th>Metabolic</th>
<th>Electrolytes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low sympathetic tone</td>
<td>Hyperglycemia</td>
<td>Hyperkalemia</td>
</tr>
<tr>
<td>Sleeping</td>
<td>Hypoxemia</td>
<td></td>
</tr>
<tr>
<td>Eating</td>
<td>Hypercarbia</td>
<td></td>
</tr>
<tr>
<td>Pathologic</td>
<td>Acidosis</td>
<td>Alkalosis</td>
</tr>
<tr>
<td>Myocardial infarct</td>
<td>Hypothyroidism</td>
<td></td>
</tr>
<tr>
<td>Myocarditis</td>
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</tbody>
</table>

### EFFECT OF DRUGS ON PACING THRESHOLD

- **Increase**
  - Bretylium
  - Flecaïnide
  - Propafenone
  - Sotalol

- **Possibly increase**
  - β-blockers
  - Bretylium
  - Lidocaine
  - Procainamide
  - Quinidine

- **Decrease**
  - Atropine
  - Epinephrine
  - Isoproterenol
  - Steroids
PSEUDOLATENCY IN HYPERKALEMIA: VALUE OF SIMULTANEOUS ECG LEADS

TYPE II PACEMAKER EXIT BLOCK IN HYPERKALEMIA

PSEUDO ATRIAL PACING IN HYPERKALEMIA
CAUSES OF UNDERSENSING

- Poor intracardiac signal
- Intracardiac signal occurs in pacemaker refractory period
- Lead dislodgement
- Insulation failure
- Conductor wire fracture
CAUSES OF ABSENT PACING STIMULUS ARTIFACT

- Normal inhibition
- Electromagnetic inhibition
- Conductor wire fracture
- Loose lead-generator connections
- Lead insulation break
- Component failure
- Battery end of life

CAUSES OF PACEMAKER OVERSENSING

Physiologic intracardiac signals
- T waves (VVI systems)
- R waves (AAI systems, DDD(R) systems with mode switch)

Physiologic extracardiac signals
- Muscle potentials (diaphragm, pectoral, seizure, shiver)
- EMI
CLINICAL/HOSPITAL SOURCES OF EMI

Endogenous
Myopotentials

Medical equipment
Electrocautery
MRI
Cardioversion, defibrillation
Transcutaneous pacing
Electrotherapy
- Transcutaneous nerve stimulation
- Implanted neuromuscular stimulators
Ionizing radiation
Lithotripsy

EFFECTS OF DEFIBRILLATION AND/OR CARDIOVERSION ON PERMANENT PACEMAKERS

- Undersensing due to intracardiac signal alteration
- Failure to capture due to stimulation threshold increase
- Reprogramming (e.g., lead configuration)
- Backup pacing (usually VOO at the backup rate)
- Myocardial burns with creatine kinase release
Dx OF CONDUCTOR WIRE FRACTURE

**ECG**
- Absence of stimulus artifacts
- Attenuation of stimulus artifacts
- Reversal of stimulus artifact polarity
  (analog machines)
- Stimuli delivered at multiples of programmed rate
- Voltage transients

**Interrogation**
- High lead impedance

**IEGM**
- Voltage transients sensed at “P” or “R” events

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**RAPID PACED VENTRICULAR RATES**

<table>
<thead>
<tr>
<th>DDD systems</th>
<th>PMT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal tracking</td>
<td>Sinus tachycardia</td>
</tr>
<tr>
<td>of rapid atrial rates</td>
<td>Atrial fibrillation</td>
</tr>
<tr>
<td>Myopotential triggering</td>
<td>Atrial flutter</td>
</tr>
<tr>
<td>Electromagnetic triggering</td>
<td>Automatic atrial tachycardia</td>
</tr>
</tbody>
</table>

- With subsequent PMT
- Without subsequent PMT
- Cautery
- Chest wall stimulation
- Environmental

Rate-adaptive systems: Rapid pacing should occur only if and when sensor is activated
USES OF MAGNET

- Assess capture
- Determine elective replacement time/end of life
- Break pacemaker-mediated tachycardia and other causes of rapid paced V rates
- Treat crosstalk inhibition
- Treat oversensing

RESPONSES OF PULSE GENERATORS TO MAGNET APPLICATION

**Single chamber pacemakers**
- AOO, VOO at rate other than programmed
- AOO, VOO at programmed rate

**Dual chamber pacemakers**
- DOO at fast rate
- DOO at fast rate, short AV interval
- Cyclic function (e.g., 3 @ 100/min, then 85/min @ programmed AVI)

THINGS YOU THOUGHT YOU KNEW BUT DON’T

- Lead configuration (unipolar, bipolar)
- Mode of function in pts with A and V leads
- Whether sensor is programmed on or off
- Response to rapid atrial rates
- Most intervals (e.g., URI, sensor-based LRI, URI)
- Response to “noise”
- Backup rate / mode / lead configuration
- ERI / EOL rates
CAUSES OF PACING IN BACKUP MODE
- Cold (e.g., transport by air)
- EOL (battery voltage low)
- EMI (battery voltage normal)
  - Cardiovascular
  - Lithotripsy
  - Diathermy
  - Transcutaneous pacing
  - Tasers
  - Bug zappers

DIAGNOSIS OF PACING IN BACKUP (RESET) MODE
- VOO, VVI pacing
- May shift to unipolar
- May not respond to magnet

PROBLEMS IN ECG Dx OF MI IN PACED PTS
- Programming equipment to lower rate may not be available
- Low rate programming may be hemodynamically detrimental
- “Memory T wave” abnormalities preclude accurate Dx

ECG Dx OF MI IN PACED PTS: RELIABLE CRITERIA

<table>
<thead>
<tr>
<th>Relation to QRS polarity</th>
<th>Sens (%)</th>
<th>Spec (%)</th>
<th>Likelihood</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥ 5mm ST ↑ when discordant</td>
<td>53</td>
<td>88</td>
<td>4.4</td>
</tr>
<tr>
<td>≥ 1mm ST ↑ when concordant</td>
<td>18</td>
<td>94</td>
<td>3.1</td>
</tr>
<tr>
<td>≥ 1mm ST ↓ V1-3</td>
<td></td>
<td></td>
<td>1.8</td>
</tr>
</tbody>
</table>

Sgarbossa et al, Gusto-1, Xth World
Total N = 42,021; V paced = 17