Bradycardia and Cardiac Pacing overview

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The Key Is Understanding
Bradycardia

- Sinus node dysfunction
- AV node dysfunction (“block”)
- Neuro-cardiogenic reaction (VVS, CSH)
Sick Sinus Syndrome (SSS)

- Sinus bradycardia
- Sino-atrial block
- Sinus pauses
- Chronothropic incompetence
2\textsuperscript{nd} degree AV block

Second Degree AV Block • Mobitz 1 (Wenckebach)

<table>
<thead>
<tr>
<th>P Wave</th>
<th>PR Interval (in seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conduction intermittent</td>
<td>Increasingly Prolonged</td>
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</table>

Lead $V_1$
MOBITZ I
(AH block)

MOBITZ II
(HV block)
Atrial Pacing

His to V block
Prognostic implications

- **MOBITZ I**
  - Usually did not progress to Complete AVB
  - CAVB with nodal escape rhythm

- **MOBITZ II**
  - Progress to CAVB is a rule
  - CAVB with ventricular (very slow) escape: syncope and SCD can occur
Is It Mobitz I or Mobitz II?
• Differential diagnosis of 2:1 AV block

  • Rest ECG
    • QRS width
    • PR interval
  
  • Stress ECG
    • Exercise/atropine
    • Carotid sinus massage
  
  • EPS
    • HV interval
    • Atrial pacing
Third Degree (complete) AV Block

Or even worse...

Could be less good...
AHA/ACC Guidelines for PM implantation in patients with SA disease (2008)

Class I Indications

- Sinus node dysfunction with documented symptomatic sinus bradycardia & sinus pauses
- Symptomatic chronotropic incompetence

Class II Indications

- Class IIa: Symptomatic patients with SND and HR<40 but with no clear association between symptoms and bradycardia
- Class IIb: Chronic heart rate < 40 bpm while awake, in minimally symptomatic patients

Class III Indications

- Asymptomatic sinus node dysfunction
AHA/ACC Guidelines for PM implantation in patients with AV node disease

Class I Indications

- 3rd degree and advanced 2nd degree AV block associated with:
  - Symptomatic bradycardia
  - Documented periods of asystole ≥ 3 seconds in SR or ≥ 5 sec in AF
  - Escape rate < 40 bpm in SR in awake, symptom free patients
  - Escape rate >40 with LV dilatation/dysfunction or escape below his
  - Post AV junction ablation & Post-operative AV block

- Second degree AV block with associated symptomatic bradycardia

- Second degree AV block exercise induced

- Asymptomatic Type II 2nd degree AV block with wide QRS
AHA/ACC Guidelines for PM implantation in patients with AV node disease

Class II Indications

Class IIa:

- Asymptomatic CHB with a ventricular rate > 40 bpm and normal LV
- Asymptomatic Type II 2nd degree AV block with narrow QRS.
- Asymptomatic Type I 2nd degree AV block within the His-Purkinje system found incidentally at EP study
- First or second degree AV block with symptoms similar to those of pacemaker syndrome or hemodynamic compromise
Class I Indications

- Recurrent syncope caused by spontaneous carotid sinus stimulation and carotid sinus pressure induces a period of asystole > 3 seconds.
AHA/ACC Guidelines for PM implantation in patients with neuro-cardiogenic syncope

Class II Indications

❖ Class IIa:
  – Syncope without clear, provocative events and with a hypersensitive cardioinhibitory response (> 3 sec)

❖ Class IIb:
  – Significant symptomatic neurocardiogenic syncope associated with bradycardia documented spontaneously or at the time of tilt-table testing
Pacing Technology “Secret”

- Pacemakers do only 2 things:
  
  \[ \text{Pace} \quad \text{Sense} \]
Pacing Rate/Low Rate Limit

- The rate at which the pacemaker will pace if the patient does not have their own rhythm
Capture

- The depolarization of the Atria or Ventracles in response to a pacemaker stimulus
Sensing

- The ability of the pacemaker to sense an intrinsic electrical signal
Inhibition

- Suppression of the pacemaker stimulus by spontaneous (sensed) intrinsic event
Pacemaker malfunction

- Oversensing
- Undersensing
- Loss of capture
Oversensing

- **Definition**: The sensing of events other than P or R-waves by the pacemaker circuitry

- **Oversensing** leads to **Underpacing**
Ventricular Oversensing

Pacing interval

Pacing interval

Pacing interval

Pacing interval

Pacing interval
Oversensing Causes

- Normal signals oversensing
  - repolarization ("T wave")
  - opposite chamber activity or pacing stimulus (cross-talk)

- Lead failure
  - Insulation Break
  - Conductor Fracture

- External noise
  - Myopotentials
  - EMI
Undersensing

- **Definition:** Failure of the pacemaker to sense intrinsic P- or R-waves

- **Undersensing** leads to **Overpacing**
Ventricular Undersensing
Undersensing Causes

- Inadequate cardiac signal or programmed sensitivity
- Lead failure:
  - Insulation break
  - Conductor fracture
- Lead dislodgment
Loss of Capture

- **Definition**: The emitted pacemaker stimulus does not cause depolarization

- Loss of capture occurs when the pacemaker’s programmed energy is less than the stimulation threshold
Loss of Capture

No evidence of depolarization after pacing artifact
Loss of Capture Causes

- Increased pacing threshold
  - Hyperkalemia
  - Antiarrhythmic drugs
  - Exit block

- Decreased effective output
  - Dislodged lead (Perforation)
  - Lead failure (Insulation break, fracture)
  - PM end of life
ECG # 11
## PACING KOD

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<th>PACING MODE response to “sensed event”</th>
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<tr>
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Asynchronous Pacing – VOO/AOO/DOO

- Pacing without sensing
- Oldest mode of pacing
- Magnet mode for most pacemakers

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VOO

Non Sensed R-wave
Demand Pacing (VVI/AAI)

- Pacing with sensing
- Pacing pulse is inhibited by intrinsic “P” or “R-waves”
- Sensed events reset the pacing interval

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Ventricular Sensing / Inhibition

- Sensed R-waves re-start the pacing interval
Atrial Sensing / Inhibition

- Sensed P-waves re-start the pacing interval
Four States Of Dual Chamber Pacing (DDD)

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Atrial event **HAVE TO** followed by ventricular event
Maximum Tracking Rate
(Upper Rate Limit)

- The fastest rate the Ventricular channel can track intrinsic P-waves
- Goal:
  Prevent of tracking inappropriate fast atrial rhythms (AT/ AFL)
Upper Rate Behaviors

- Fixed-Ratio block (2:1, 3:1, etc)
- Wenckebach behavior
Rate Responsive Pacing (AAIR, VVIR, DDDR)

- The use of activity sensor to adjust the pacing rate (LRL) to patient’s metabolic needs
- Indication: Chronothopic Incompetence
Mode Selection Decision Tree

Sinus node disease

Atrial electrode

Rate responsive pacing
Mode Selection Decision Tree

AV node & Purkinje disease

Ventricular electrode

Chronic AF

Ventricular pacing

Sinus Rhythm

Atrio-ventricular pacing
Pacemaker Mediated Tachycardia

Tachycardia cycle time = VA conduction time + functional PV-Delay (usually PMT rate close to URL)
Advanced pacing features

- Mode Switch (DDD to VVI; DDD to AAI)
- PMT termination
- Autocapture
- Rate Drop Response
- Left ventricular pacing
Paced Tachycardia - DD

- PMT
- Tracking of atrial tachyarrhythmia
- Sensor mediated tachycardia
- Atrial lead oversensing
- Component failure/runaway tachycardia
A patient with severe CHF and a new DDD pacemaker developed bradycardia

1. Ventricular noncapture, atrium OK
2. Crosstalk
3. A+V lead dislodgment
4. Hyperkalemia
Be methodical – and you’ll succeed
Fixed-Ratio Block

- 2:1 Block
  (one v-paced event per two p-waves)

```
P  P  P  P  P  P  P  P  P  P  P
```
Post Ventricular Atrial Refractory Period (PVARP)

Atrial channel refractoriness after ventricular paced/sensed event
Automatic Mode Switching
DDD to VVI
Reversion to tracking mode
Uses of PVARP

- Prevent the Atrial channel from sensing:
  - Far-field Ventricular signals
  - Atrial Premature Contractions
  - Retrograde P-waves
Pacemaker Mediated Tachycardia

- Initiated by a loss of AV synchrony
  - PVC most common cause
  - Atrial loss of capture and undersensing, APC, magnet removal
- Pacemaker acts like a re-entrant pathway
Pacemaker Mediated Tachycardia

● Prevention
  • Extend PVARP
    (Program PVARP 50 ms longer than measured RVAC)
  • Fix atrial lead function

● Therapy
  • Magnet application
  • PVC option or PMT option
PMT Termination by pacemaker
ECG # 24
???
1. Ventricular noncapture
2. Normal pacemaker function
3. Ventricular undersensing
4. Multiple VPCS
1. Atrial undersensing
2. Normal upper rate response then 2:1 tracking
3. Tracking of short atrial tachycardia
4. PMT
1. Ventricular noncapture
2. Normal pacemaker function
3. Ventricular undersensing
4. Multiple VPCS
A DDD pacemaker was implanted in a 60-year-old male due to intermittent CHB. About four months later he returned complaining of palpitations interspersed with abrupt, short durations of fast heart rate associated with lightheadedness and shortness of breath. He also mentioned that he didn’t think the pacer was consistently increasing his pacing rate during exercise. As a result he felt more fatigued. The following ECG was recorded. What is your diagnosis?

1. Atrial undersensing
2. Ventricular noncapture
3. Atrial fibrillation
4. PMT
CASE STUDY 13

The tracing shown below is the Holter monitor of a 56-year-old plumber with complete AV block. He complained to his physician that sometimes when he was working he would feel lightheaded and faint.

Myopotential inhibition
Patient information:
- Pt has chronic atrial fibrillation with an irregular ventricular rate
- Pt’s heart rate does not reach 100 bpm in response to an exercise stress test
Determining the Optimal Pacing Mode 1

Patient information:

- Documented symptomatic sinus bradycardia
- When exercise tested, rate does not increase appropriately with increasing work loads
- At present, AV conduction is intact
Patient information:
- Pt has intermittent 2nd degree Type II AV block with symptoms
- Pt’s atrial rate responded appropriately (or not) to an exercise test