Temporary Pacemakers

Karim Rafaat, MD
Temporary pacemakers

Objectives

- Explain the situations when temporary pacemakers are indicated.
- Describe the principles of pacing.
- Illustrate normal and abnormal pacemaker behavior.
- Discuss the steps to be taken in troubleshooting a temporary pacemaker.
Indications for Temporary Pacing

- Bradyarrhythmias
- AV conduction block
  - Congenital complete heart block (CHB) - normal or abnormal heart structure
  - L-Transposition (corrected transposition)
    - Bundle of His long; AV node anterior
    - Prone to CHB
  - Trauma - surgical or other
- Slow sinus or junctional rhythm
- Suppression of ectopy
- Permanent pacer malfunction
- Drugs, electrolyte imbalances
- Sick Sinus Syndrome
  - Secondary to pronounced atrial stretch
  - Old TGA s/p Senning or Mustard procedure
Indications for Temporary Pacing

- Sick Sinus Syndrome
Principles of Pacing

**Electrical concepts**

- **Electrical circuit**
  - Pacemaker to patient, patient to pacemaker

- **Ampere** – a unit of electrical current delivered to stimulate a cardiac contraction
  - Milliamperes (mA)

- **Voltage** – a unit of electrical pressure causing the current of electrons to flow
  - Millivolts (mV)

- **Resistance** – the opposition to the flow of electrical current
Principles of Pacing

- Temporary pacing types
  - Transcutaneous
    - Emergency use with external pacing/defib unit
  - Transvenous
    - Emergency use with external pacemaker
  - Epicardial
    - Wires sutured to right atrium & right ventricle
    - Atrial wires exit on the right of the sternum
    - Ventricular wires exit on the left of the sternum
Principles of Pacing

Wiring systems

- Unipolar
  - One wire on the heart
  - Subcutaneous “ground wire”

- Bipolar
  - Two wires on the heart
  - One positive, one negative
Principles of Pacing

- **Modes of Pacing**
  - Atrial pacing
    - Intact AV conduction system required
  - Ventricular pacing
    - Loss of atrial kick
    - Discordant ventricular contractions
    - Sustains cardiac output
  - Atrial/Ventricular pacing
    - Natural pacing
    - Atrial-ventricular synchrony
Principles of Pacing

- 3-letter NBG Pacemaker Code
  - First letter: Chamber Paced
    - V- Ventricle
    - A- Atrium
    - D- Dual (A & V)
    - O- None
Principles of Pacing

- 3-letter NBG Pacemaker Code
  - Second letter: Chamber Sensed
    - V- Ventricle
    - A- Atrium
    - D- Dual (A & V)
    - O- None
Principles of Pacing

- 3-letter NBG Pacemaker Code
- Third letter: Sensed Response
  - T- Triggers Pacing
  - I- Inhibits Pacing
  - D- Dual
  - O- None
Principles of Pacing

Commonly used modes:

- **AAI** - atrial demand pacing
- **VVI** - ventricular demand pacing
- **DDD** - atrial/ventricular demand pacing, senses & paces both chambers
- **AOO** - atrial asynchronous pacing
- **DOO** - atrial/ventricular asynchronous pacing
Principles of Pacing

- **Atrial and ventricular output**
  - Milliamperes (mA)
    - Typical atrial mA 5
    - Typical ventricular mA 8-10

- **AV Interval**
  - Milliseconds (msec)
    - Time from atrial sense/pace to ventricular pace
    - Synonymous with “PR” interval

- **Atrial and ventricular sensitivity**
  - Millivolts (mV)
    - Typical atrial: 0.4 mV
    - Typical ventricular: 2.0 mV
Principles of Pacing (cont.)

- Atrial/ventricular rate
  - Set at physiologic rate for individual patient
  - AV Interval, upper rate, & PVARP automatically adjust with set rate changes

- Upper rate
  - Automatically adjusts to 30 bpm higher than set rate
  - Prevents pacemaker mediated tachycardia from unusually high atrial rates
  - Wenckebach-type rhythm results when atrial rates are sensed faster than the set rate

- Refractory period
  - PVARP: Post Ventricular Atrial Refractory Period
    - Time after ventricular sensing/pacing when atrial events are ignored
Principles of Pacing

- Electrical Safety
  - Microshock
  - Accidental de-wiring
    - Taping wires
    - Securing pacemaker

- Removal of pacing wires
  - Potential myocardial trauma
    - Bleeding
      - Pericardial effusion/tamponade
      - Hemothorax
  - Ventricular arrhythmias

- Pacemaker care & cleaning
  - Batteries
  - Bridging cables
  - Pacemakers
Pacemaker

Medtronic 5388 Dual Chamber (DDD)

1. Pace/Sense LEDs
2. Lock/Unlock Key
3. Lock Indicators
4. Rate Dial
5. Atrial Output Dial
6. Ventricular Output Dial
7. Menu Parameter Dial
8. Parameter Selection Key
9. Menu Selection Key
10. Pause Key
11. Power On Key
12. Power Off Key
13. Emergency/Asynchronous Pacing Key
14. Lower Screen
15. Ventricular Output Graphics
16. Atrial Output Graphics
17. Upper Screen
18. Rate Graphics
19. Setup Indicators
20. DDI Indicator
21. Low Battery Indicator
22. Setup Labels

Figure 3-1. Controls and Indicators of the Model 5388.
Pacemaker EKG Strips

- Assessing Paced EKG Strips
  - Identify intrinsic rhythm and clinical condition
  - Identify pacer spikes
  - Identify activity following pacer spikes
  - Failure to capture
  - Failure to sense

- EVERY PACER SPIKE SHOULD HAVE A P-WAVE OR QRS COMPLEX FOLLOWING IT.
Normal Pacing

- Atrial Pacing
  - Atrial pacing spikes followed by P waves
Normal Pacing

- Ventricular pacing
  - Ventricular pacing spikes followed by wide, bizarre QRS complexes
Normal Pacing

- A-V Pacing
  - Atrial & Ventricular pacing spikes followed by atrial & ventricular complexes
Normal Pacing

- DDD mode of pacing
  - Ventricle paced at atrial rate
Abnormal Pacing

- Atrial non-capture
  - Atrial pacing spikes are not followed by P waves
Abnormal Pacing

- Ventricular non-capture
  - Ventricular pacing spikes are not followed by QRS complexes
Failure to Capture

- **Causes**
  - Insufficient energy delivered by pacer
  - Low pacemaker battery
  - Dislodged, loose, fibrotic, or fractured electrode
  - Electrolyte abnormalities
    - Acidosis
    - Hypoxemia
    - Hypokalemia

- **Danger - poor cardiac output**
Failure to Capture

- Solutions
  - View rhythm in different leads
  - Change electrodes
  - Check connections
  - Increase pacer output ($\uparrow mA$)
  - Change battery, cables, pacer
  - Reverse polarity
Reversing polarity

- Changing polarity
  - Requires bipolar wiring system
  - Reverses current flow
  - Switch wires at pacing wire/bridging cable interface
Abnormal Pacing

- Atrial undersensing
  - Atrial pacing spikes occur irregardless of P waves
  - Pacemaker is not “seeing” intrinsic activity
Abnormal Pacing

- Ventricular undersensing
  - Ventricular pacing spikes occur regardless of QRS complexes
  - Pacemaker is not “seeing” intrinsic activity
Failure to Sense

- Causes
  - Pacemaker not sensitive enough to patient’s intrinsic electrical activity (mV)
  - Insufficient myocardial voltage
  - Dislodged, loose, fibrotic, or fractured electrode
  - Electrolyte abnormalities
  - Low battery
  - Malfunction of pacemaker or bridging cable
Failure to Sense

- Danger – potential (low) for paced ventricular beat to land on T wave
Failure to Sense

Solution

- View rhythm in different leads
- Change electrodes
- Check connections
- Increase pacemaker’s sensitivity (↓ mV)
- Change cables, battery, pacemaker
- Reverse polarity
- Check electrolytes
- Unipolar pacing with subcutaneous “ground wire”
Oversensing

- Pacing does not occur when intrinsic rhythm is inadequate
Oversensing

- **Causes**
  - Pacemaker inhibited due to sensing of “P” waves & “QRS” complexes that do not exist
  - Pacemaker too sensitive
  - Possible wire fracture, loose contact
  - Pacemaker failure

- **Danger** - heart block, asystole
Oversensing

Solution

- View rhythm in different leads
- Change electrodes
- Check connections
- Decrease pacemaker sensitivity (↑mV)
- Change cables, battery, pacemaker
- Reverse polarity
- Check electrolytes
- Unipolar pacing with subcutaneous “ground wire”
Competition

- **Assessment**
  - Pacemaker & patient’s intrinsic rate are similar
  - Unrelated pacer spikes to P wave, QRS complex
  - Fusion beats

![ECG Image](image-url)
Competition

- Causes
  - Asynchronous pacing
  - Failure to sense
  - Mechanical failure: wires, bridging cables, pacemaker
  - Loose connections

- Danger
  - Impaired cardiac output
  - Potential (low) for paced ventricular beat to land on T wave
Competition

Solution
- Assess underlying rhythm
  - Slowly turn pacer rate down
- Troubleshoot as for failure to sense
- Increase pacemaker sensitivity (↓mV)
- Increase pacemaker rate
Assessing Underlying Rhythm

- Carefully assess underlying rhythm
  - Right way: slowly decrease pacemaker rate
Assessing Underlying Rhythm

- Wrong way: pause pacer or unplug cables
Wenckebach

- **Assessment**
  - Appears similar to 2\textsuperscript{nd} degree heart block
  - Occurs with intrinsic tachycardia
Wenckebach

- **Causes**
  - DDD mode safety feature
  - Prevents rapid ventricular pacing impulse in response to rapid atrial rate
    - Sinus tachycardia
    - Atrial fibrillation, flutter
    - Prevents pacer-mediated tachycardia
    - Upper rate limit may be inappropriate
Wenckebach

- Solution
  - Treat cause of tachycardia
    - Fever: Cooling
    - Atrial tachycardia: Anti-arrhythmic
    - Pain: Analgesic
    - Hypovolemia: Fluid bolus
  - Adjust pacemaker upper rate limit as appropriate
Threshold testing

- **Stimulation threshold**
  - **Definition:** Minimum current necessary to capture & stimulate the heart
  - **Testing**
    - Set pacer rate 10 ppm faster than patient’s HR
    - Decrease mA until capture is lost
    - Increase output until capture is regained (threshold capture)
    - Output setting to be 2x’s threshold capture
      - Example: Set output at 10mA if capture was regained at 5mA
Performing an AEG

- **Purpose:** Determine existence & location of P waves
- **Direct EKG from atrial pacing wires**
  - Bedside EKG from monitor
  - Full EKG
- **Atrial pacing pins to RA & LA EKG lead-wires**
Interpreting an AEG
Sensitivity Threshold

Definition: Minimum level of intrinsic electric activity generated by the heart detectable by the pacemaker
Sensitivity Threshold Testing

- Testing
  - Set pacer rate 10 ppm slower than patient’s HR
  - Increase sensitivity to chamber being tested to minimum level (0.4mV)
  - Decrease sensitivity of the pacer (↑mV) to the chamber being tested until pacer stops sensing patient (orange light stops flashing)
  - Increase sensitivity of the pacer (↓mV) until the pacer senses the patient (orange light begins flashing). This is the *threshold* for sensitivity.
  - Set the sensitivity at $\frac{1}{2}$ the threshold value.
    - Example: Set sensitivity at 1mV if the threshold was 2mV.
Factors Affecting Stimulation Thresholds

<table>
<thead>
<tr>
<th>LOWER THRESHOLD</th>
<th>NO EFFECT</th>
<th>ELEVATE THRESHOLD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dexamethasone</td>
<td>Acetylcholine</td>
<td>Acidosis</td>
</tr>
<tr>
<td>Ephedrine</td>
<td>Atropine</td>
<td>Alkalosis</td>
</tr>
<tr>
<td>Exercise</td>
<td>Calcium (therapeutic level)</td>
<td>Amiodarone</td>
</tr>
<tr>
<td>Glucocorticoids</td>
<td>Digoxin</td>
<td>Disopyramide</td>
</tr>
<tr>
<td>Hyperoxia</td>
<td>Diphenyldantoin</td>
<td>Eating</td>
</tr>
<tr>
<td>Hypocapnia</td>
<td>KCL 40 mEq/1000cc</td>
<td>Flecanide</td>
</tr>
<tr>
<td>K⁺ in Ringers Solution</td>
<td>Lidocaine</td>
<td>Glucose</td>
</tr>
<tr>
<td>Prednisone</td>
<td>Morphine Sulfate</td>
<td>Insulin</td>
</tr>
<tr>
<td></td>
<td>Sodium Bicarbonate</td>
<td>Hypercapnia</td>
</tr>
<tr>
<td></td>
<td>Quinidine</td>
<td>Hypocalcemia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hypoxia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inderal</td>
</tr>
<tr>
<td></td>
<td></td>
<td>K⁺ with Insulin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mineral Corticoids</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pronestyl Toxicity</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sleeping</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verapamil</td>
</tr>
</tbody>
</table>
Practice Strip#1
Practice Strip #2
Practice Strip #3
Practice Strip #4
Practice Strip #5
Practice Strip #6
Practice Strip #7
Practice Strip #8
Practice Strip #9
Answers

Mode of pacing, rhythm/problem, solution

1. AAI: normal atrial pacing
2. Sinus rhythm: no pacing; possible back-up setting AAI, VVI, DDD
3. DDD: failure to sense ventricle; increase ventricular mA
4. VVI: ventricular pacing
5. DDD: failure to capture atria or ventricle; increase atrial & ventricular mA
6. DDD: normal atrial & ventricular pacing
7. DDD: normal atrial sensing, ventricular pacing
8. DDD: failure to capture atria; increase atrial mA
9. DDD: oversensing; decrease ventricular sensitivity
References

- Heger, J., Niemann, J., Criley, J. M. *Cardiology for the House Officer*, (2nd Ed.).
- Williams and Wilkins; 1987.