CARDIAC PACEMAKERS

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Lecture Outlines

- Indication of cardiac pacing
- The pacemaker system
- Temporary pacemakers
- Pacing modes
- Pacemaker malfunction
- Pacemaker complications
- Nursing management
Indication of Cardiac Pacing

- External electrical stimulation of the heart
- Used as treatment choice starting 1960s
- Indications:
  - Condition associated with failure of the heart to initiate its intrinsic electrical impulses
  - Bradydysrhythmias and Tachydysrhythmias
  - Atrioventricular block
  - Chronic Bifascicular or Trifascicular block
  - Sinus node dysfunction
  - Hypersensitive carotid sinus syndrome
Carotid sinus hypersensitivity (CSH):
- Is an exaggerated response to carotid sinus baroreceptor stimulation.
- It results in dizziness or syncope from transient diminished cerebral perfusion.
- Mechanical deformation of the carotid sinus leads to an exaggerated response with bradycardia or vasodilatation, resulting in hypotension, presyncope, or syncope.

Three types of CSH have been described.
- The cardioinhibitory (70-75% of cases)
  - Decreased heart rate, which results in sinus bradycardia, atrioventricular block, or asystole due to vagal action on sinus and atrioventricular nodes.
  - This response can be abolished with atropine.
- The vasodepressor (5-10% of cases).
  - Decreased vasomotor tone without a change in heart rate.
  - This response is not abolished with atropine.
- The mixed type comprises 20-25% of cases.
  - A decrease in heart rate and vasomotor tone occurs.
• Indication of Cardiac Pacing Classes
  – **Class I**: Necessary implemented pacemaker conditions.
    • Symptomatic 2\textsuperscript{nd} and 3\textsuperscript{rd} degree AV block (HR < 40 or asystole > 3second)
    • Bifascicular with intermittent 3\textsuperscript{rd} degree
    • SA node dysfunction with symptomatic bradycardia
    • CSHS with recurrent syncope
    • Symptomatic recurrent SVT
  – **Class II**: May be necessary but with some divergence opinion
    • Symptomatic 2\textsuperscript{nd} and 3\textsuperscript{rd} degree AV block (HR > 40)
    • SA node dysfunction with **NO** symptomatic bradycardia (HR < 30)
    • Recurrent syncope **without** clear S&S of CSH
    • An alternative to drug therapy or ablation
Indication of Cardiac Pacing

- **Class III**: Not effective may be harmful
  - Asymptomatic 1\textsuperscript{st}, 2\textsuperscript{nd} AV block or transient 3\textsuperscript{rd}
  - Asymptomatic Fasicular block
  - Asymptomatic SA node dysfunction
  - Recurrent syncope in the absence of cardioinhibitory responses
  - Tachycardia that are converted to fibrillation by pacing
The Pacemaker System

- **The pulse generator**
  - Lithium iodide battery
  - 20 – 30 g & about 5-7 mm thick
  - Life span about 6 – 12 years

- **The lead system**
  - Wire that communicate the generator and heart muscle
  - Bipolar lead (anode + & cathode -)
  - Leads are fixed to the myocardium by active fixation
Pulse generator

- **Pulse generator** is responsible for generating the pulse at the proper time based on events sensed

**Main elements:**
- Power source – provide the energy required for the operation of the pacemaker
- Memory (RAM/ROM) to store data for diagnostic purposes
- Antenna. Monitors relevant heart data and sends it, for example, to doctor
- Microprocessor – controls all operations
Pacing Lead

• The generator is connected to heart through the tiny wires called leads.

• Leads deliver the pulse to its destination in the heart, sense and carry back information to the pulse generator.

Each lead has an electrode on its tip. That tip actually burrows into heart wall.
Clinical Terminology Regarding Pacemakers

- Asynchronous pacing
- Capture
- Dual-chamber pacing
- Inhibited response
- Triggered
- Oversensing
- Undersensing
- Stimulation, capture or pacing threshold
- Sensing threshold
Temporary Pacing System

• **Indications:**
  - Asystole
  - Complete heart block
  - Sever bradycardia
  - Evaluate the need for temporary pacemakers (e.g. after cardiac surgeries)

• **Methods of Temporary Pacing**
  - *Transvenous pacemaker system*
    - External generator
    - Bipolar catheter
      - Negative: distal
      - Positive: proximal
Types of artificial cardiac pacemakers

**Unipolar system**
Single chamber - only one chamber is regulated

**Bipolar system**
Dual chamber - two leads are used.
Transvenous Leads Have Different “Fixation” Mechanisms

- Passive fixation
  - The tines become lodged in the trabeculae (fibrous meshwork) of the heart
Transvenous Leads

• **Active Fixation**
  - The helix (or screw) extends into the endocardial tissue
  - Allows for lead positioning anywhere in the heart’s chamber
Myocardial and Epicardial Leads

- Leads applied directly to the heart
  - Fixation mechanisms include:
    - Epicardial stab-in
    - Myocardial screw-in
    - Suture-on
Temporary Pacing System

• **Methods of Temporary Pacing**
  
  – *Epicardial pacemaker system*
    * Throacotomy: electrodes on the surface of the heart
    * Common after heart surgeries
    * External generator
    * Bipolar catheter

  – *External transcutaneous pacing*
    * Large gelled electrodes patches on the chest
    * Negative lead: interiorly and the positive lead posteriorly
Implantation Procedure

- The procedure is usually done under local anaesthesia

- The pulse generator is implanted under the skin

- The leads are inserted using x-ray control, via a vein found in this area, and positioned in the appropriate right sided heart chamber

- The leads are tested before the pulse generator is attached
Pacemaker Functioning

• Sensing function
  – Detection of heart’s intrinsic activity

• Inhibiting function
  – When intrinsic cardiac stimulus is adequate to generate the need HR
  – Pacing threshold: level of energy (voltage) that needed to establish successful pacing
  • Factors affecting threshold: hypoxia, hyperkalemia, digoxin toxicity, antidysrhythmic drugs
  – Sensitivity sensing: smallest signal the pacemaker will sense
  – Amplitude: largest atrial or ventricular intrinsic signal that sensed by the pacemaker
# Pacemaker Code

<table>
<thead>
<tr>
<th>Chambers paced</th>
<th>Chambers sensed</th>
<th>Modes of response</th>
<th>Programmable functions</th>
<th>Antitachycardia functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>V = Ventricle</td>
<td>R = Rate Modulated</td>
<td>O = None</td>
</tr>
<tr>
<td>V = Ventricle</td>
<td>V = Ventricle</td>
<td>T = Triggered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A = Atrium</td>
<td>A = Atrium</td>
<td>I = Inhibited</td>
<td>C = Communicating</td>
<td>P = Paced</td>
</tr>
<tr>
<td>D = Dual (A &amp; V)</td>
<td>D = Dual (A &amp; V)</td>
<td>D = Dual Triggered/Inhibited</td>
<td>M = Multiprogrammable</td>
<td>S = Shocks</td>
</tr>
<tr>
<td>O = None</td>
<td>O = None</td>
<td>O = None</td>
<td>P = Simple Programmable</td>
<td>D = Dual (P &amp; S)</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>O = None</td>
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</tr>
</tbody>
</table>
Pacing Modes

- **Single-Chamber Modes**
  - VVIRO mode
    - Ventricular demand pacing, ventricular sensing, inhibited ventricular response, rate modulation, and no multisite pacing
    - Adjust rate according to metabolic demand
  - AAIOO mode
    - Atrial demand, atrial sensing, inhibited atrial response, no rate modulation, no multisite pacing

- **Dual-Chamber Modes**
  - DDD for temporary pacing
  - DDDRO for permanent pacing
    - Dual-chamber, dual-chamber sensing, with both inhibited and triggered responses, rate modulation, or multisite pacing
Single Chamber Pacing
Dual Chamber Pacing
Pacemaker Malfunctions

- Failure to discharge
  - Absence of pacing spike
  - Replacement of generator must be done directly
  - Temporary pacemaker may be inserted in the emergencies

- Failure to capture
  - Implanted battery depletion or low battery
  - Drug therapy may be needed
Pacemaker Malfunctions

• **Undersensing**
  – Inappropriate placed pacemaker artifacts on the ECG
  – May be caused by lead dislodgement, lead insulation defect, or lead wire fracture
  – Increasing the sensitivity may improve this problem

• **Oversensing**
  – Pacemaker detects events other than those it was programmed to sense
  – For example tall T wave may interpreted by the pacemaker as QRS result in inhibiting the rate
  – May be caused by lead displacement or inappropriate sensitivity.
  – Electromagnetic interference
Pacemaker Complications

- Pneumothorax
  - Usually associated with transvenous lead through the subclavian vein
- Ventricular irritability
  - Caused by the endocardial catheter
  - PVCs is common sign of this complication
- Perforation of ventricular wall or septum
  - Not very common may be caused by the transvenous catheter
  - Positive QRS in lead V1 may suggested perforation
  - Low BP and high sinus rate
  - Conformation can be done by echocardiography
- Catheter or lead dislodgement
  - Confirmed by x-ray
  - May result in over or undersensing, or failure to capture
- Infection and phlebitis
  - Common with temporary pacing
Nursing Management

• Nursing Assessment
  – Assess the indication of the pacemaker
  – Assess present and past history
  – Assess patient’s physiological responses to pacemaker
  – Assess psychological responses

• Electrocardiogram Monitoring
  – ECG monitoring and analysis
  – Ability to detect pacemaker malfunction
  – Analysis of AV, VA, and pacing intervals
Nursing Management

• Nursing Diagnoses
  – Anxiety RT life-threatening condition
  – Knowledge deficit RT newly diagnosed condition
  – Risk of infection

• Patient Education and Family Education
  – The need for pacemaker
  – The insertion procedure
  – Visual and written guidelines should be provided
  – Care of pacemaker and possible complications
  – Sings and symptoms of pacemaker malfunctions

• Patient Safety
  – Electrical safety
  – Electrical safety with temporary pacemaker
Implantable Cardioverter Defibrillator (ICD)

- **Indications:**
  - Pt who survived an episode of sudden cardiac arrest
  - Pt who has documented life-threatening ventricular dysrhythmias
  - Pt with medication-refractory dysrhythmias
    - Like pacemaker powered by lithium battery with life expectancy of > 5 years
    - Placed subcutaneous
    - The ICD consists of tripolar lead tip
    - 2 of electrodes detect dysrhythmias and giving the shock and the 3\textsuperscript{rd} for sense the HR
Implantable Cardioverter Defibrillator (ICD)
Implantable Cardioverter Defibrillator (ICD)

• Functions
  • Anti tachycardia Pacing (ATP)
  • Cardioversion
  • Defibrillation
  • Anti bradycardia pacing (ABP)

• Perioperative Management
  • Patient and family education
  • Need general anesthesia
  • The thresholds is determined by inducing malignant dysrhythmias
  • Device usually left inactive 2-3 days post OP
Implantable Cardioverter Defibrillator (ICD)

- Discharge education
  - Patient and family education about the device
  - Importance of carrying device identification
  - CPR training for the family
  - External magnetic exposure
  - Activity guidelines

- Reference:
Questions and Answers