Pacemakers and Implantable Defibrillator
CARDIAC PACEMAKER

- Introduction
- Definition
- Types
- Indication
- Pacing modes
- Pacing modalities
- Settings
- Malfunction and troubleshooting
- ICD
- Patient’s Management
GOALS

- Identify the pacemakers types and indication.
- Identify the pacemakers modes and modalities.
- How to assess the output and sensitivity.
- Basic temporary pacemaker concept.
- What to do in malfunction and troubleshoot.
- To know about the implanted defibrillators.
- To know the nursing care post procedure.
A pacemaker system is a device capable of generating artificial pacing impulses and delivering them to the heart. It consists of a pulse generator and appropriate electrodes. In the past few years electronic pacemaker systems have become extremely important in saving and sustaining the lives of cardiac patients whose normal pacing function of the heart have been impaired.
WHAT IS THE PACEMAKER?

Electronic device that provides electrical stimuli to the heart muscle.

WHAT ARE THE TYPES OF PACEMAKERS?

- Temporary pacemaker
- Permanent pacemaker
WHAT IS THE INDICATION FOR EACH TYPE?

- **TPM:**
  - Post surgical patient (open heart surgery)
  - Heart block post myocardial infarction
  - Symptomatically Bradycardic
  - Patient who require overdrive dysrhythmia control
  - Patient whose native rate may be depressed by medication
PPM:
- Symptomatic sinus bradycardiac or atroventricular AV block
- Sinus bradycardia as a result of necessary drug therapy
- Advanced AV block with:
  i. asystole >3 sec
  ii. escape rate < 40 bpm
  iii. catheter ablation of AV node
  iv. neuromuscular disease
  v. postoperative AV block that is not expected to recover
  vi. Recurrent syncope attack due to heart disease
PACEMAKER MODES

- **Fixed-rate (asynchronous) pacing**
  - Delivers pacing stimulus at a fixed rate regardless of spontaneous cardiac depolarization (nonsensing)

- **Demand (synchronous) pacing**
  - Delivers pacing stimulus when the heart’s intrinsic pacing fails below a predetermined rate.
  - Pacing is either inhibited or triggered by the sensing of intrinsic beats

- **Atrioventricular (AV sequential) pacing**
  - Delivers pacing stimulus to atrium and ventricle in physiological sequence with sufficient AV delay.
PACING MODALITIES:

- **VVI:**
  - (v) the paced chamber is the ventricle
  - (v) the sensed chamber is the ventricle
  - (I) the pacemaker response is inhibited
  - The inhibited response means that the pacemaker will be inhibited from pacing if the ventricle is depolarizing unaided

- **AAI:**
  - (A) the paced chamber is the atrium
  - (A) the sensed chamber is the atrium
  - (I) the pacemaker response is inhibited
  - If the pacemaker sensed native P wave it is inhibited from pacing
DDD:

the Ds stand for “dual” either the atrium or the ventricle or both may be paced; either native P wave or native R wave may be sensed, and the pacemaker may be inhibited or triggered to pace, depending on the combination of events it detects.
Example of DDD pacing

Atrial Spike

Ventricular Spike

26-JAN-1918 (77 yr)
Male Caucasian

© 1997 Frank G. Yanowitz, M.D.
**AOO, VOO, DOO:**

The first letters of these modes indicate the place of pacing: A=atrium=ventricle, A=dual. In OO modes, the pace maker does not detect native events (as indicated by O in second position) and because the pacer is not sensing, it naturally can have no response to sensed events (as indicated by the O in the third position).

- **MODE SWITCH:**
  
  It is the pacer detection protocol that allows automatic switching of pacing modes to prevent rapid ventricular pacing in response to rapid atrial rates.
- AOO
- VOO
- D00
Pacemakers codes

1st letter
Chamber(s) paced
A = atrium
V = ventricle
D = dual

2nd letter
Chamber(s) sensed
A = atrium
V = ventricle
T = triggered
D = dual
O = none

3rd letter
respond to sensing
I = inhibit (demand)
T = triggered
D = dual
O = none (asynch)

Chamber paced
Chamber sensed
Action or response to a sensed event
V V I
APPLICATION OF MAGNET TO A PACEMAKER TURNS OFF THE SENSING MODALITY MAKING THE PACMAKER ASYNCHRONOUS
WHAT IS THE PACING OR CAPTURE THRESHOLD (output)?

Is the smallest amount of energy from the pacemaker that consistently provokes contraction of the target chamber the energy output measured in milliamperes (mA).
HOW IS THE CAPTURE THRESHOLD ASSESSED?

1- Gradually slow the pacing rate, observing carefully for patient tolerance, until the patient is in his own native rhythm.

2- Set the output to a low value (1 mA) then rise the pacing rate to a level slightly higher than the patient own rate.

3- If you see only pacing artifacts (spikes) with no corresponding depolarization at the same rate or with only intermittent response of the heart, you have not yet reached the capture threshold, increase the output by another mA and test again.

4- Repeat until every spike is followed immediately by depolarization of the target chamber, then dial in at least twice as much output for the chamber you are evaluating.

5- Document the threshold,
WHAT IS THE SENSING THRESHOLD?

Is the ability of the pacer to detect native cardiac signals P and R waves, the sensing threshold measured in millivolts (mV).

HOW IS THE SENSING THRESHOLD ASSESSED?

1. Reduce the pacing rate until the patient underlying rhythm is fully emerged.
2. Make the pacer as insensitive to the ventricle as you can by setting ventricular sensitivity to the higher value.
3. Set the pacing rate a bit higher than the patient rate.
4. Continue decreasing the sensitivity value until at least no more pacing occurs, at this point the pacer is sensitive to detect cardiac signals.
5. Document the sensitivity threshold and set the sensitivity at least twice as high by decreasing the value to half its numeric size, example if the ventricular sensing threshold is 6mV you may choose a final setting of 3mV for the ventricle.
Rate

i. Fixed: stimulus provided at a preset rate (greater than patient’s rate)

1. Demand: stimulus provided when the patient’s heart falls below a predetermined rate (proper sensing is required)
MALFUNCTION AND TROUBLESHOOTING

- Failure to Capture
- Failure to Fire (Failure to pace)
- Undersensing
- Oversensing
FAILURE TO FIRE

Spikes are not noted during period of asystole or bradycardia

- Causes
  - i. Loose connection on the system
  - ii. Failure of battery or pulse generator
  - iii. Broken lead wires
  - iv. Lead wire dislodgment

- Interventions
  - i. Assure pacing connections
  - ii. Replace battery or generator as appropriate
  - iii. Reposition leading wire
  - iv. Attempt pacing with another pacing system
Failure to fire. The ventricular demand pacemaker should have paced as the last 6 complexes of the strip are atrial P waves, followed by no QRS complex.
FAILURE TO CAPTURE

Spike is not followed by a P or QRS complex as appropriate

- **Causes**
  1. Loose connections on the system
  2. Failure of battery or pulse generator
  3. Broken lead wires
  4. Lead wire dislodgment or fibrous at site of electrodes
  5. Low pacing threshold (output)

- **Interventions**
  1. Assure pacing connections
  2. Check threshold and increase output mA
  3. Repositioning the patient may also resolve the problem
FAILURE TO CAPTURE
UNDERSENSING

- Inability of the pacemaker to sense spontaneous myocardial depolarization
- Pacemaker loses its ability for self-inhibition
- Competition between the paced complexes and intrinsic heart’s rhythm occur
- Demonstrated on the ECG by a pacing spike occurring after or unrelated to intrinsic QRS_
- It is a serious malfunction that could lead to dangerous ventricular dysrhythmia as VT & VF
UNDERSENSING

Causes

i. Inadequate QRS signal (QRS signal not detected by pacemaker, low sensitivity)

ii. Myocardial ischemia, fibrosis, electrolytes disturbances

iii. Inappropriate mode selection (asynchronous)

Intervention

- Increase sensitivity (moving the sensitivity dial toward its lowest setting)
**UNDERSENSING**

**Undersensing.** This transcutaneous temporary pacemaker set in the ventricular demand mode fires and paces appropriately in the beginning of the strip. The 9th complex is the patient’s inherent QRS complex which should have been sensed by the pacemaker. Instead the pacemaker fired.
OVERSENSING

- Inappropriate sensing of patients QRS
- The pacemaker thinks it detects a QRS complex so it inhibit itself and does not fire
- Result in unexplained pauses in the ECG traces

Causes
  i. Tall P or T waves
  ii. Electrical signals produced by skeletal muscle contractions (during shivering or seizures)

Intervention
  i. Decrease sensitivity (moving the sensitivity dial toward its highest setting, 20 mV)
  ii. Try to eliminate possible sources of electromagnetic interference in the patient’s environment
Oversensing. This ventricular demand pacemaker was set at a rate of 70 ppm. The interval between complexes 1 and 2 is correct for the set rate of 70 ppm. The spike-to-spike intervals between complexes 2 and 3 and between complexes 3 and 4 are prolonged. The large T wave probably is inhibiting the pacemaker inappropriately.
What are implantable cardiac defibrillators?

Pacemaker Complications

- Failure to pace (oversensing)
- Failure to sense
- Loss of capture

From Millar, et al., 1985

Copyright © 2001 by W.B. Saunders Company. All rights reserved.
An implantable cardiac defibrillator (ICD) is a small electronic device installed inside the chest to prevent sudden death from cardiac arrest due to life threatening abnormally fast heart rhythms (tachycardias). The ICD is capable of monitoring the heart rhythm. When the heart is beating normally, the device remains inactive. If the heart develops a life-threatening tachycardia, the ICD delivers an electrical "shock(s)" to the heart to terminate the abnormal rhythm and return the heart rhythm to normal.
INDICATION FOR ICD:
Patients at risk of developing sudden cardiac arrests due to ventricular tachycardias and fibrillations are candidates for ICDs. ICDs do not prevent the occurrence of life-threatening rhythms, but can quickly terminate them when they occur. Recent clinical trials have identified several groups of patients who should receive ICDs. They are:

- VT/VF arrest not due to reversible causes.
- Spontaneous VT with structural heart disease
- Syncope of unknown etiology with relevant VT/VF
- VT in asymptomatic patient with nonsustained VT, CAD, LVF that is not suppressible by antiarrhythmic drugs
A magnet applied over the ICD turn off detection, and therefore without detection of arrhythmias no therapies can be delivered, but a magnet over the ICD does not turn the pacemaker function of the ICD into asynchronous pacing mode.
INSERTION OF PACEMAKER

- EQUIPMENT REQUIRED
  - one sterile insertion kit which includes:
    - one gauge angiographic needle
    - one vessel dilator
    - guide wires
    - one introducer sheath with homeostasis valve
    - one introducer dilator
    - pressure tubing
  - one basin filled with sterile saline
  - local anesthetic with syringe and needle
  - one sterile scalpel and blade
  - sterile 20 cc syringe
  - sterile long drape and sterile gloves
WHENEVER POSSIBLE USE FLUROSCOPY DURING THE WIRE INSERTION, IF NOT AVAILABLE URGENT CXR SHOULD BE DONE TO DETERMAINE THE WIRE PLACEMENT
NURSING CARE POST PACEMAKER INSERTION

- ECG monitoring
- Hemodynamic monitoring
- Frequent assessment of pacemaker
- Electrical safety
- Pacing insertion site care
  - Cleaning, dressing, signs of infection
- Protect pacemaker from accidental adjustment
- Patient & family education
ANY QUESTION ?
REFERENCES

- Critical Care Secrets
  Hilda M. Schell / Kathleen A. Puntillo 2001

- Clinical Cardiology 23, 315-326 (2009)

- MKSAP14, American College of Physicians 2009

- Making Sense Of the ECG
  Andrew R Houghton / David Gray 2008