Puzzling Pacemakers

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Pacemaker:

- An electric device implanted in the body to regulate the heart beat.
- Delivers electrical stimuli over leads with electrodes in contact with the heart
- Consists of a generator and leads
    - Generator
        - Mini computer with power source
    - Leads
        - Electrical wires used to transmit electrical data back & forth from the heart to the pulse generator

The NASPE/BPEG generic (NBG) code					
Position	**I**	**II**	**III**	**IV**	**V**
Category	**Chamber(s) Paced**	**Chamber(s) sensed**	**Response to Sensing**	**Programmability, Rate Modulation**	**Antitachy-arrhythmia Functions**
Letters used	**O** = None **A** = Atrium **V** = **V**entricle **D** = Dual (A+V)	**O** = None **A** = Atrium **V** = Ventricle **D** = Dual (A+V)	**O** = None **T**= Triggered **I** = Inhibited **D** = Dual (T+I)	**O** = None **P** = Simple Programmable **M** = Multi-Programmable **C** = Communicating **R** = Rate modulation	**O** = None **P** = Pacing (antitachy-arrhythmia **S** = Shock **D** = Dual (P+S)

First Letter: Indicates what leads are available to pace
O = None
A = Atrium
V = **V**entricle
D = Dual (A+V)

Second Letter: Indicates which chamber that the pulse generator will monitor for spontaneous depolarization
O = None
A = Atrium
V = Ventricle
D = Dual (A+V)

Third Letter: Indicates what the pacemaker will do when it senses an event
O = None

- Asynchronous pacing
- Also called *fixed rate* or *magnet mode*
- Delivers a pacing stimulus at a fixed rate regardless of the heart's intrinsic activity
- It will cause competition with the heart's intrinsic activity , and the pacing stimulus may land during the descending limb of the T-wave

T = Triggered

- When the pacemaker activates a depolarization wave to a sensed event
- An example of a triggered response is when the pacemaker fires an impulse to the ventricles after it senses an atrial depolarization

I = Inhibited

- Demand or synchronous pacing
- Pacemaker responds to a sensed event by NOT firing a response for a certain amount of time.
- Paces only when patient's heart rate falls below set rate
- Avoids R on T phenomenon and ventricular dysrhythmias

D = Dual (T+I)

- Pacemaker can respond in a triggered manner for some pre-programmed cases and in an inhibitory manner for other pre-programmed events

Codes are combined to describe:

- The mode of pacing
- The mode of sensing
- How the pacemaker will respond to the presence or absence of intrinsic beats
    - AOO
    - AAI
    - VOO
    - VVI

Pacemaker Indications

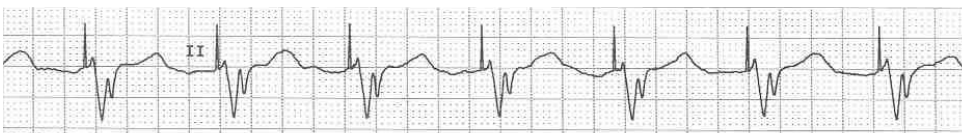
- Junctional Rhythms
- Second-degree AV block -- Mobitz type II
- Third-degree AV block
- SA node conduction problems
- Heart Failure with ventricular dysynchrony

Single-Chamber Systems

- The pacing lead is implanted in the atrium *or* ventricle, depending on the chamber to be paced and sensed

VVI

- Ventricular Demand Pacing
    - Pacer spike should be just before the QRS when no intrinsic event sensed
- Ventricular Sensing
    - Sensed intrinsic QRS inhibits ventricular pacing
- Used as backup pacing
- Does not provide AV synchrony -- may get pacemaker syndrome



AAI

- Atrial Demand Pacing
  - Pacer spike should be just before the p wave when no intrinsic event sensed
- Atrial Sensing
  - Sensed intrinsic p wave inhibits atrial pacing
- Used to provide atrial contraction with SA node conduction problems

AOO

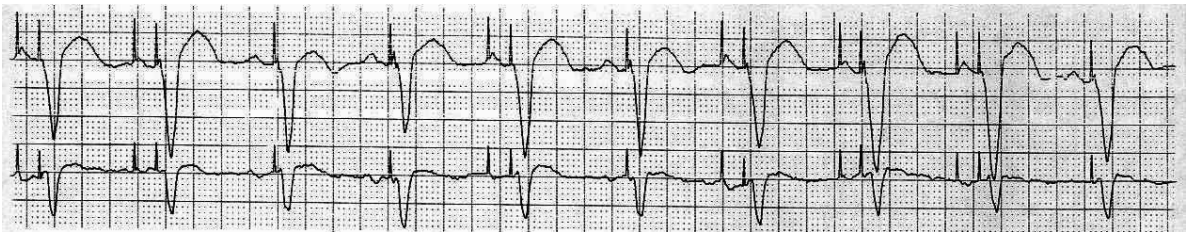
- Atrial asynchronous pacing at programmed pacing rate
- No Sensing
- Used to provide atrial contraction with SA node conduction problems

Dual-Chamber Systems

- The pacing leads are implanted in both the atrium and ventricle.

DDD

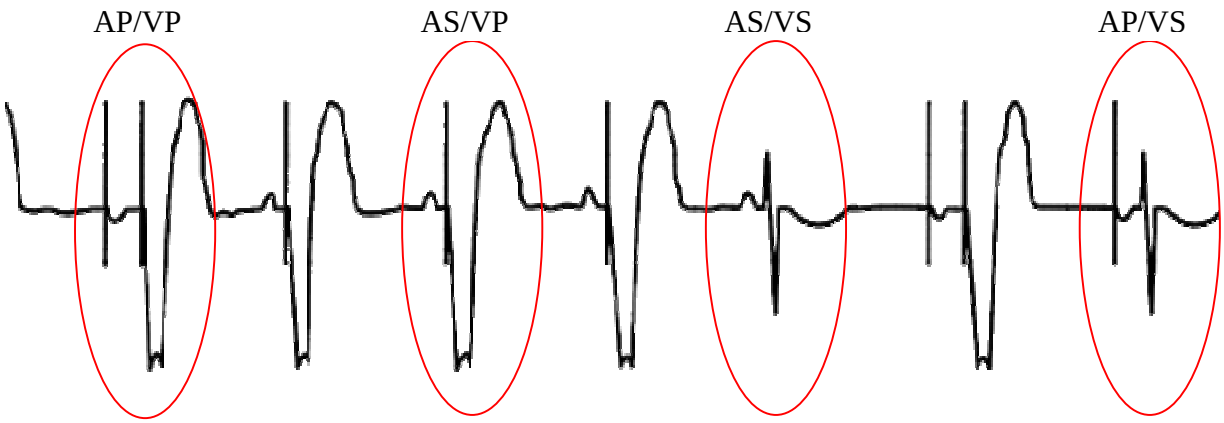
- Pacing in both the atrium and ventricle
  - Pacer spike should be just before the p wave when no intrinsic event sensed
  - Pacer spike should be just before the QRS when no intrinsic event sensed
- Sensing in both the atrium and ventricle
  - Intrinsic p wave and intrinsic QRS can inhibit pacing
  - Intrinsic p wave can "trigger" a paced QRS



Four Functions (faces) of DDD Pacing:

1. Atrial Sense, Ventricular Sense (AS/VS)
   - Native atrial and ventricular depolarization present. No pacing needed.
2. Atrial Pace, Ventricular Sense (AP/VS)
   - No atrial depolarization present. Atrial pacing occurs. Native ventricular depolarization present.
   - Good for junctional rhythms
3. Atrial Sense, Ventricular Pace (AS/ VP)
   - Native atrial depolarization present. No atrial pacing needed. No ventricular depolarization present. Ventricular pacing occurs.
   - Good for complete heart block or Mobitz II
4. Atrial Pace, Ventricular Pace (AP/VP)
   - No atrial or ventricular depolarization present. Atrial and ventricular pacing occurs.
   - Good for SA arrest, asystole

These four functions occur on a beat to beat basis depending on the conduction system of the individual's heart.



DDI or DDIR

- Paces both the atrium and ventricle
- Senses atrial and ventricle – however does not track the atrium.
- Good with for high atrial rates to prevent a high ventricular response (atrial tachyarrhythmias)

DVI:

- Paces both the atrium and ventricle
- No atrial sensing --- does not track the atrium.
- Senses ventricle
- Not commonly used. Good when atria silent.

DOO

- Atrial and ventricular asynchronous pacing at programmed pacing rate
- No Sensing of the atrium or ventricle
- Used when no attempt to synchronize paced events with intrinsic activity
- Contraindicated in the case of a competing intrinsic rhythm
- Good when individual is pacer dependent

Pacemaker Terminology & Troubleshooting

MA (Milliamps)

- The amount of energy needed to make the heart depolarize with the electrode (capture)
- Range from 0.1 - 20
- Usually set just above a patient's threshold to ensure a good capture
- Threshold is the minimal output required to capture the heart.
- On DDD pacemakers the MA is set for both the atrium and ventricle

Threshold Level

- The minimum stimulus required to cause stimulation of the myocardium (pacing) or minimum voltage for an intrinsic complex to be sensed.
- Also known as stimulation threshold

Fire

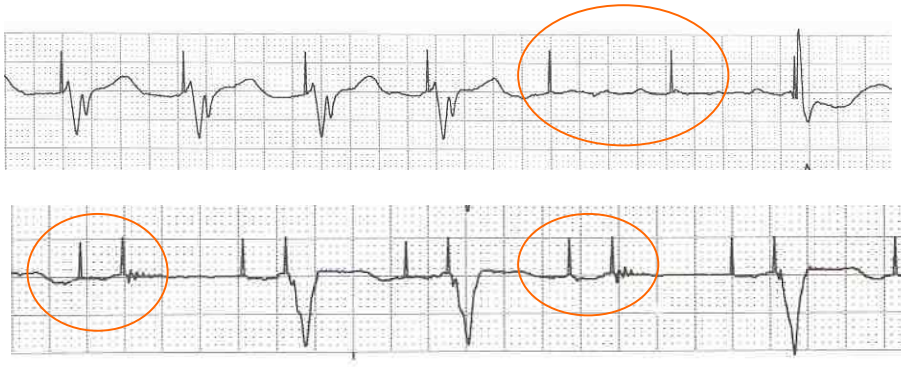
- The spike that is produced when the pacemaker elicits an electrical stimulus

Capture

- An effective, consistent cardiac depolarization of the heart caused by the pacemaker's electrical stimulus
- To assess capture it is necessary to see pacemaker spikes followed by depolarization
- For example an atrial spike followed by a "p wave" or a ventricular spike followed by a QRS.

Failure to Capture

- The presence of one or more pacer spikes that are not followed by an appropriately timed atrial and/or ventricular response



Treatment: failure to capture

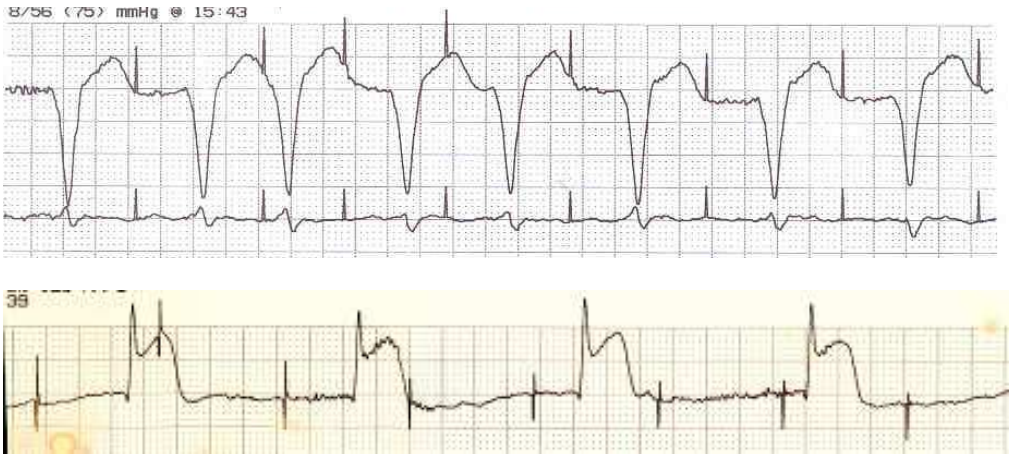
- Increase MA until capture present
  - Transvenous pacing typically requires MA 3 – 5 to capture
  - Epicardial pacing typically requires MA 10 – 20
  - Transcutaneous (external) pacing typically requires MA 60 – 100
  - Permanent pacing typically requires MA 3 - 5
- Transvenous Pacing
  - Have patient change positions to see if the lead will float back to make contact with the ventricular wall
- Epicardial Pacing
  - After increasing MA, try switching polarity of wires. The negative lead is the wire that paces and the positive lead is the wire that is providing the ground.
  - If only one epicardial wire is functional, place a skin lead. This lead should be in the positive pole.
- Permanent Pacing
  - May be a dislodged lead
- All Pacing – treat underlying conditions
  - Acidosis
  - Electrolyte imbalances especially hyperkalemia

Sensing/Sensitivity

- Sensing is the ability of the pacemaker to "see" when an intrinsic depolarization is occurring.
- The level at which intrinsic atrial or ventricular activity is recognized by the sensing electrodes; the lower the number, the greater the sensitivity
- With proper sensing, no pacer spike should occur during the escape interval

Undersensing (Failure to Sense)

- Undersensing leads to overpacing
- Pacemaker does not "see" or missed the intrinsic beat, and responds with a spike
- Pacemaker spikes where they should not be.

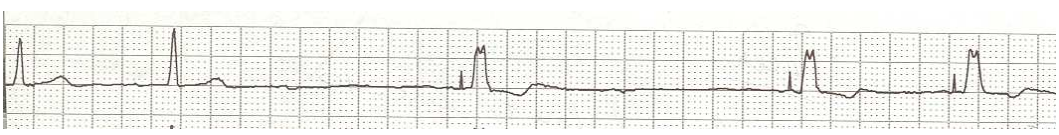


Treatment of Undersensing

- Decrease the sensitivity (millivolt setting) to make the pacemaker more sensitive
- The lower the number, the greater the sensitivity
- If the ventricular mV is set at 2 mV, the pacemaker will not see any QRS that is less than 2mV. If the QRS is small, the mV needs to be decreased to make the pacer more sensitive and see all the QRSs.
- Check all connections and batteries on temporary pacemakers.
- With epicardial pacing, try switching polarity.

Oversensing (Failure to Pace)

- Oversensing leads to underpacing
- Pacemaker "sees" complexes that are not p waves or QRSs and stops the pacer from firing or delivering a spike.
- An electrical signal other than the intended P or R wave is detected. For example a peaked T wave may be detected as an R wave.
- On EKG, an inappropriate long pause between pacing spikes

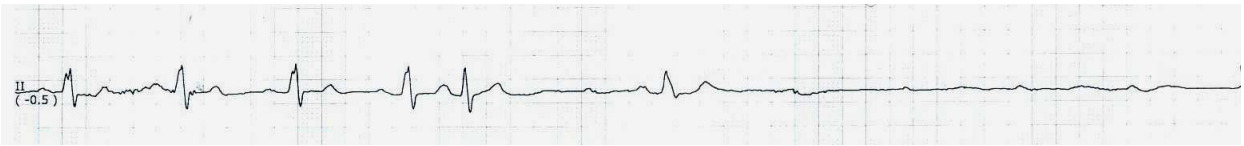


Treatment of Oversensing

- Increase the sensitivity (millivolt setting) to make the pacemaker less sensitive
- The higher the number, the less the sensitivity
- If the ventricular mV is set at 2 mV, the pacemaker will detect any complex that is greater than 2mV and stops the pacer from firing or delivering a spike. Typically this is a peaked T wave so the mV needs to be increased to number larger than the mV of the T wave.

Failure to Pace – not related to sensitivity settings

- The absence of packing artifacts when the intrinsic heart rate is slower than the pacemakers set rate.



Treatment: Failure to pace

Temporary Pacemakers

- Change the battery as many times it is a dead battery
- Check for loose or disconnected lead connections
- With epicardial pacing, if only one epicardial wire is functional, place a skin lead. This lead should be in the positive pole.

Permanent Pacemaker

- Battery may need to be changed or leads may be fractured

Timing Intervals

- When the pacemaker senses an atrial or ventricular complex, it starts the stopwatch of the generator.
- The stopwatch starts to measure a pre-designated amount of time during which the pacemaker will not fire

- Atrial and Ventricular Intervals
  - A - A interval
  - V- V Interval
  - V- A Interval
  - AV Interval
- Refractory Periods
  - In pacing, a programmable parameter that controls the length of time following a paced or sensed beat, during which the pacemaker's sensing circuit does not respond to sensed events.
  - PVARP=Post Ventricular Atrial Refractory Period=atrial refractory period
  - VRP=Ventricular Refractory Period
- Rate Intervals
  - Lower Rate
    - Defines the lowest rate the pacemaker will pace
  - Upper Rate
    - Defines the shortest interval (highest rate) the pacemaker can pace as dictated by the sensor

Atrial Tracking

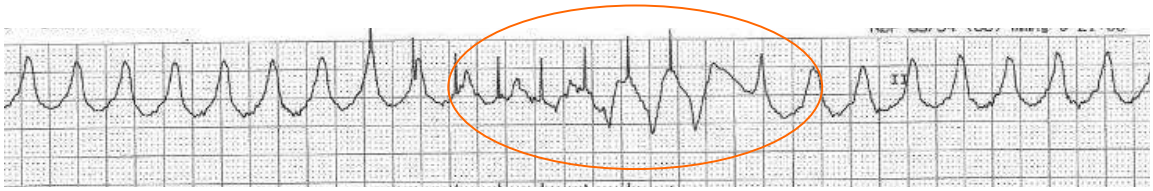
- Ventricular pacing rate follows or tracks the atrial activity
- Provides AV synchrony to get the benefit of the atrial kick (contraction) or 15 – 20% more of the cardiac output and thus prevents pacemaker syndrome
- If the atrial rate exceeds the upper rate limit, the pacer will postpone a ventricular output pulse until the upper rate limit interval times out. It does this by causing a paced Wenckebach or paced Mobitz II

Steps to interpret Pacemaker rhythms

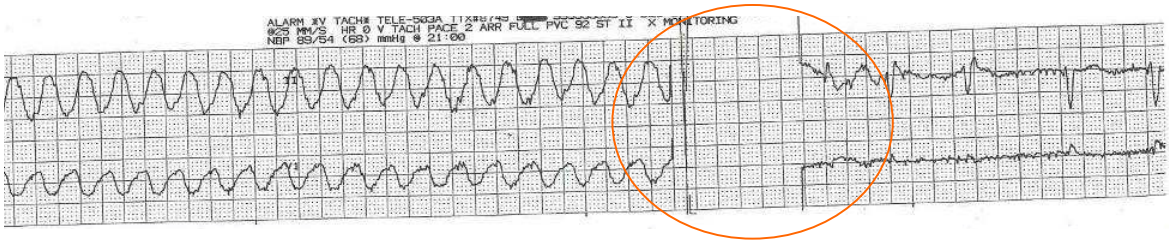
1. Select the lead in which the pacemaker spike(s) is seen the best
2. Identify the pacemaker spikes
    a. Atrial spikes should be noted immediately before the p wave
    b. Ventricular spikes should be noted immediately before the QRS
    c. Dual chamber pacing --- may or may not have two spikes depending on the intrinsic activity
3. After identifying the pacer spikes as atrial and/or ventricular, note where they are falling in relation to the p wave and to the QRS. Are they falling where they should be? If not, where are they falling and why.
4. When the pacer spikes are not falling where they should be then be prepared to treat immediately.
5. Is there capture?
6. What are the pacemaker settings including rate?

ICD: Internal Cardiac Defibrillator

- Treats tachydysthythmias by tiered functions
  - Antitachycardia Pacing
    - The device fires a preset number of rapid pulses in succession in an attempt to terminate the ventricular tachycardia



  - Cardioversion/Defibrillation at low voltage



  - Back up pacing for bradyarrhythmias post cardioversion or defibrillation

Pacemaker Magnet Mode

- When a magnet is applied the pacemaker paces **asynchronously** (no sensing)
- The pacemaker returns to previously programmed settings when the magnet is removed.
- The magnet mode is used to check the programming of the pacemaker and the battery life
- When a patient places the magnet over his device, it will go asynchronous to get a pacemaker strip to determine how well the device is functioning.
- A magnet **does not** turn off a pacemaker. A pacemaker is only turned off with a programming device.

ICD Magnet Mode

- Magnet application will NOT affect the Brady pacing function- it will continue as programmed.
- ICD magnet placement will disable the sensing function of the device and therefore- no therapy will be delivered
- **It will continue to pace but will not defibrillate**
- Once the magnet is removed, Tachy function will be enabled (restored)

When to use the magnet in ICDs:

- Inappropriate Shocks
  - Use until the company representative can interrogate the device and determine the cause for the inappropriate shocks
- Surgery: patient must be *on monitor* in the OR Suite and Turned back on in Recovery Area
- End stage disease states/hospice care (Physician ordered)