EMC 451

Advanced ECG Interpretation

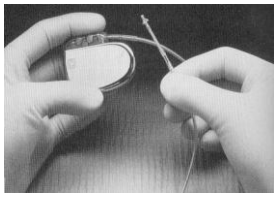
Unit 13: Pacemaker Therapies for Bradycardia

Unit Objectives

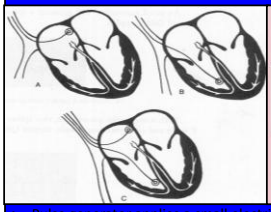
- Upon completion of this unit, you should be able to:
  - Describe the concept of pacing.
  - Discuss the mechanism of pacemaker sensing.
  - Describe the concepts of pacemaker stimulation.
  - List and describe the timing mechanisms of pacemakers.
  - List the main types of pacemakers.
  - Describe the 3 letter code used to describe the pacing modes.
  - Discuss the advantages of rate-responsive pacemakers.
  - Describe how pacemakers are "matched" to the patient.
  - Assess pacemaker function using the 12 lead EKG
  - Identify pacemaker failure.
  - Discuss the complications of diagnosing MI posed by pacemakers.
  - List the principles of treating patients with pacemakers.

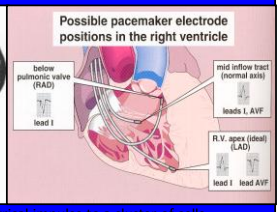
Pacemaker Concepts

- 100,000 new devices implanted annually
- Most commonly used in the management of symptomatic bradycardias caused by:
  - Abnormal cardiac impulse formation
  - Impaired impulse conduction
- May also contain defibrillator
- Unit consists of a pulse generator and pacing electrodes.



Pacemaker Concepts continued





- Pulse generator applies a small electrical impulse to a cluster of cells.
- The impulse is spread by cell-to-cell conduction.
- Electrode may be placed in several locations.
- Where the electrode rests determines the morphology of the QRS complex, axis deviation, and the leads in which the pacer spike may be observed.

Sensing

- Must coordinate pacing with the natural depolarizations so as to avoid stimulating a refractory muscle.
- Some pacemakers coordinate atrial and ventricular activity so as to mimic the natural AV synchrony.
- In addition to delivering stimuli, pacing leads also sense intrinsic beats and deliver them to the pulse generator where they are amplified and interpreted.
- Inappropriate sensing may lead to bradycardia, tachycardia, and R on T phenomenon.

Stimulation

- Not all beats (atrial or ventricular) will be paced; some may be native or intrinsic beats.
- Pulse generator applies a small electrical impulse to a cluster of cells.
- If the impulse is sufficiently strong, it will be propagated by cell-to-cell conduction, and is referred to as capture.
- Because the impulse forms and travels outside the conduction system, the QRS complex will be wide.
- Repolarization will also be altered resulting in changes in the ST segment and T wave.
- Because of these changes, infarction or ischemia cannot be diagnosed from the 12-lead using paced complexes.

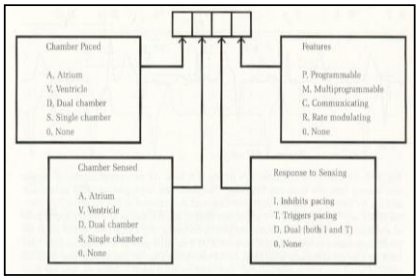
Pacemaker Timing

- Pacemakers continuously monitor the sequence and timing between depolarizations, both natural and paced.
- These depolarizations are checked against the desired sequences and time-limit intervals.
- If a natural depolarization fails to occur within the expected time frame, the pacemaker fires.
- There are several different timing mechanisms.

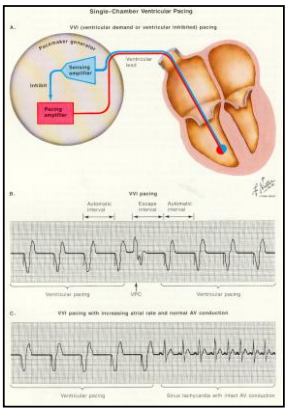
Pacemaker Timing

- The pacemaker uses an event from one cardiac cycle to set the time limit for the next event. If the next cycle occurs naturally before the time limit expires, the existing time limit is canceled and reset for the next cycle. If an event fails to occur naturally, the pacemaker fires and simultaneously resets the timing for the next cycle. This is called **intercycle** timing and is used in demand pacers.
- Pacing interval = (60,000 ms/min)/desired heart rate
  = 60,000/70 = 857 ms
- May be AA, VV, or VA
- Fixed rate pacemakers do not employ a timing mechanism and fire at a preset rate regardless of intrinsic activity.

Pacemaker Codes



Types of Pacemakers



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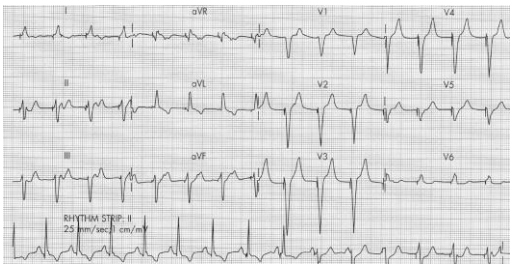

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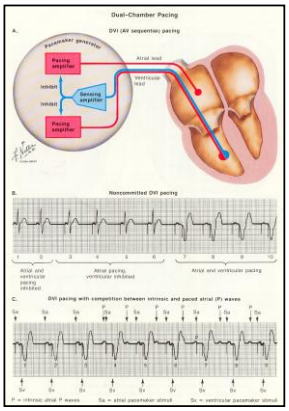

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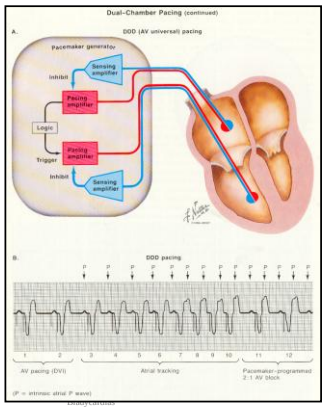

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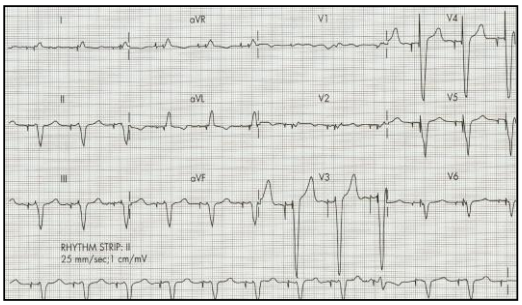
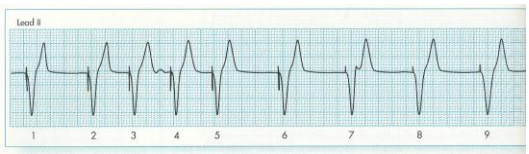


Rate Responsive Pacing

- Vary pacing rates to match the needs of the patient.
- Preset rate is used, unless physiologic demands require faster heart rate.
- If atria are capable of normal firing, the P wave is used to alter firing rate of the ventricles (atrial tracking).
- If atria cannot be used as triggering stimulus for ventricular pacing, other physiologic monitors are used:
  - Vibration may be used as a surrogate measure of activity.
  - Respiration
  - Blood temperature

Rate Responsive Pacing

- VVI rate responsive pacer



Matching the Pacemaker to the Patient

- Pacemaker type depends upon the reliability of the patient's conduction system and ability of the atria to initiate impulses.
- Reliable conduction/atrial bradycardia
  - Need only to pace the atria
  - Atrial sensing used to inhibit pacing if there is intrinsic atrial activity (AAI)
  - Must periodically verify reliability of conduction system because ventricles are not directly paced.
- Unreliable conduction/normal atrial rate
  - Senses atria and ventricles, paces ventricles as needed, and inhibits ventricular firing as needed.
  - Provides AV synchrony
  - Provides backup ventricular pacing if atrial bradycardia develops.
- Unreliable conduction and atrial bradycardia
  - Ventricles must be paced and sensed.
  - Atria must be paced and used to trigger ventricular pacing (AV synchrony)
  - No atrial sensing (DVI mode)

Assessing Pacemaker Function

- Find all pacemaker spikes (atrial and ventricular)
  - Are the all capturing?
- Determine the rate at which the pacemaker is set.
  - Measure the interval between two successive spikes
  - Do all of the intervals match?
- Look for spontaneous beats
  - Determine the underlying rhythm
- Determine if spontaneous beats are sensed
  - Is the pacemaker inhibited by a faster rhythm?
  - Does the pacemaker take over when the spontaneous rhythm slows below the preset rate?

Pacemaker Failure

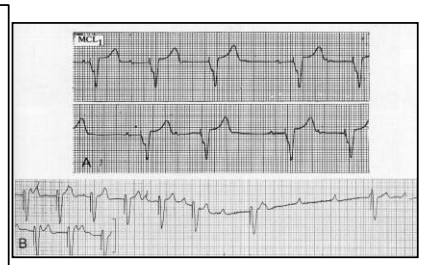
- Failure to sense
  - Most commonly caused by either alteration of the position of an endocardial electrode or scar formation between the electrode and myocardium.

Pacemaker Failure

- Failure to pace
  - Pacing spike that is not followed immediately be the appropriate cardiac waveform.
  - May be atrial, ventricular, or both, depending on the type of pacemaker and the failure mechanism.
  - May result from migration of pacing electrode or increase in the pacing threshold.
  - Can be life-threatening.

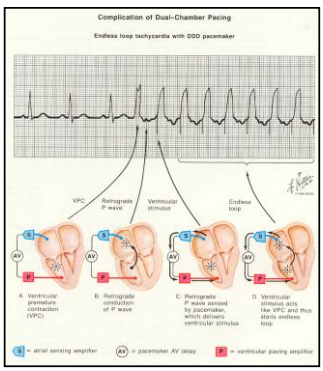
Pacemaker Failure

- Oversensing
  - Pacing is inhibited because it senses some electrical activity other than the appropriate cardiac waveform
  - May sense T wave or skeletal muscle potential.



Pacemaker Failure

- **Pacemaker-mediated tachycardia**
  - May occur in DDD pacemakers where all of the electrical components to simulate an accessory bypass tract around the AV node exist (artificial version of WPW).
  - A PVC initiates the sequence. The PVC is conducted retrograde to the atria (inverted P wave). This is sensed by the pacemaker which delivers a ventricular pace impulse. The ventricular stimulus is conducted in a retrograde fashion and the endless loop repeats.



Pacemaker Failure

- Complications
  - Infection
  - Electrode perforation of muscle wall
  - Pacemaker mediated tachycardias
  - Reduced cardiac output with pacemakers that lack AV synchrony
  - Pacing of muscles of the chest wall or the diaphragm

Diagnosing MI in Patients with Pacemakers

- Virtually impossible to diagnose ischemia/infarction changes when all QRS complexes are paced.
- With a right ventricular electrode, the EKG shows an LBBB configuration. As discussed in previous section, the LBBB pattern masks QRS and ST-T changes of MI.
- Can only use non-paced beats to identify signs of infarction/ischemia.

Principles for Field Management of Pacemaker Patients

- If your patient has a pacemaker, is bradycardic or hypoperfusing, and you don't see any pacemaker spikes on the EKG, or they are infrequent, the pacemaker is probably not working. Treat the patient as if he/she didn't have a pacemaker. If you have an external pacemaker, use it.
- If your patient has a wide complex tachycardia that is not pacemaker mediated, treat the wide complex tachycardia regardless of what the pacemaker is doing.
- If the patient's heart rate is within normal range, yet he/she is hypoperfusing, the pacemaker is not to blame. Look for another cause.
- If the patient has a pacemaker, has a reasonable heart rate, and is perfusing adequately, don't worry about the pacemaker.