Chapter 8

Pacemaker Rhythms

Objectives

- Define the following terms: sensitivity, capture, asynchronous, synchronous, threshold.
- Identify the components of a pacemaker system.
- Describe a unipolar and bipolar pacing electrode.
- Explain the differences between fixed-rate and demand pacemakers.

Objectives

- Describe the primary pacing modes.
- Identify the cardiac chamber(s) stimulated by different pacing methods.
- Describe the appearance of a typical pacemaker spike on the ECG.
- Describe the appearance of the waveform on the ECG as a result of atrial pacing and ventricular pacing.
- Describe the benefits of AV sequential pacing.

Objectives

- Identify the primary indications for transcutaneous pacing.
- Describe the procedure for transcutaneous pacing.
- List three types of pacemaker malfunctions.
- Identify possible complications of transcutaneous pacing.
- Describe how to analyze pacemaker function on the ECG.

Key Terms

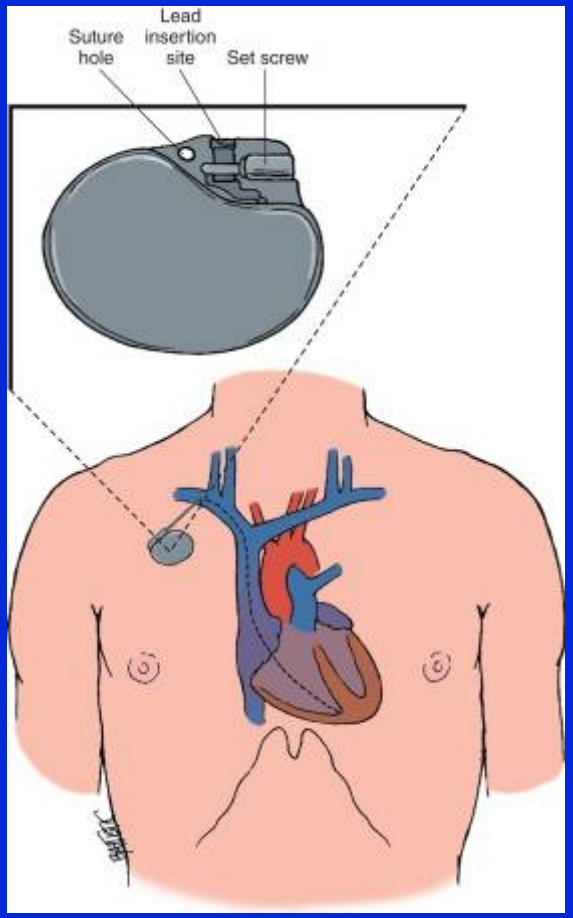
- Sensing
- Capture
- Asynchronous
- Synchronous
- Threshold

Pacemaker Systems

- Pacemaker
  - An artificial pulse generator that delivers an electrical current to the heart to stimulate depolarization

Pacemaker Systems

- Consist of a pulse generator (power source) and pacing lead(s)



Permanent Pacemaker

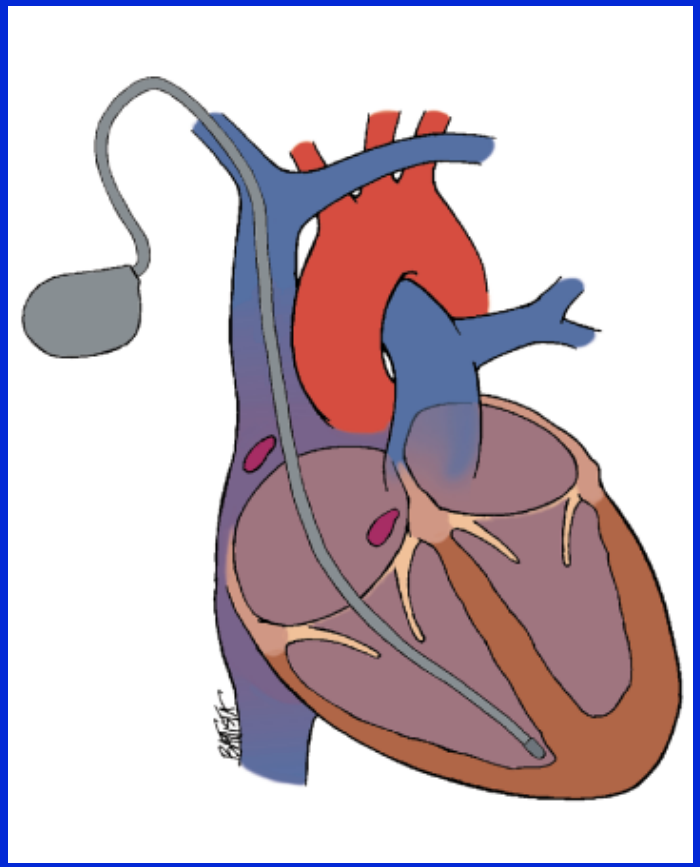
- Implanted in the body, usually under local anesthesia
- Pacemaker wires are surrounded by plastic catheters
- The pacemaker's circuitry is housed in a hermetically sealed case made of titanium that is airtight and impermeable to fluid

Temporary Pacemakers

- Transvenous pacemaker
- Epicardial pacing
- Transcutaneous pacing (TCP)

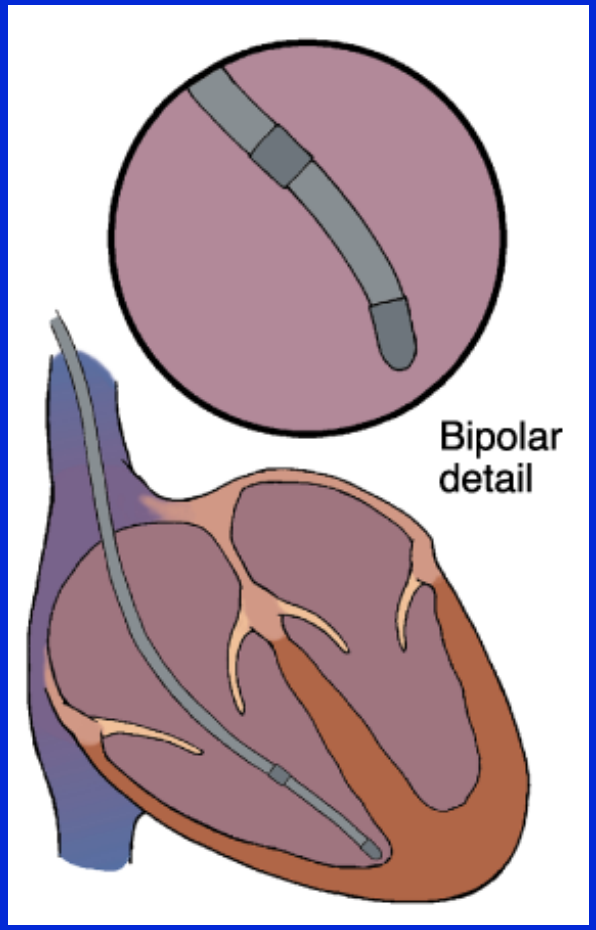
Pacemaker Electrodes—Unipolar

- One pacing electrode located at distal tip
- Negative electrode in contact with heart
  - Pulse generator (located outside the heart) functions as positive electrode
  - Pacemaker spikes are often large due to distance between positive/negative electrodes



Pacemaker Electrodes—Bipolar

- Contains a positive and negative electrode at the distal tip of pacing lead wire
- Pacer spike is often small and difficult to see



Pacemaker Modes

Fixed-Rate (Asynchronous) Pacemakers

- Continuously discharge at a preset rate (usually 70-80/min) regardless of patient's heart rate
- Does not sense patient's own cardiac rhythm
  - May result in competition between the patient's cardiac rhythm and that of the pacemaker
- Not often used today

Demand (Synchronous, Noncompetitive) Pacemakers

- Discharge only when patient's heart rate drops below pacemaker's preset (base) rate
- Can be programmable or nonprogrammable
  - Voltage level and impulse rate are preset at time of manufacture in nonprogrammable pacemakers

Pacemaker Identification Codes

- Five-letter coding system used to assist in identifying a pacemaker's preprogrammed pacing, sensing, and response functions

Pacemaker Identification Codes

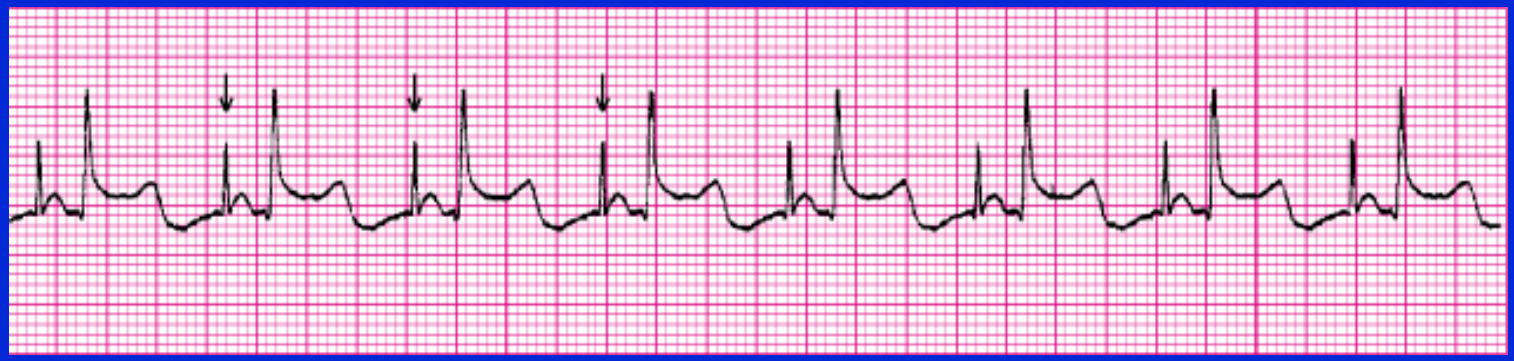
Chamber Paced	Chamber Sensed	Response to Sensing	Programmable Functions	Antitachycardia Functions
O = None	O = None (fixed-rate pacemaker)	O = None (fixed-rate pacemaker)	O = None	O = None
A = Atrium	A = Atrium	T = Triggers pacing	P = Simple programmability (rate and/or output)	P = Pacing (antitachycardia)
V = Ventricle	V = Ventricle	I = Inhibits pacing	M = Multi-programmable	S = Shock
D = Dual chamber (atrium & ventricle)	D = Dual chamber (atrium & ventricle)	D = Dual (triggers & inhibits pacing)	C = Communication R = Rate responsive	D = Dual (pacing & shock)

Single-Chamber Pacemakers

- A single chamber (either the atrium or ventricle) pacemaker has one lead placed in the heart

Atrial Pacing

- Pacing electrode placed in the right atrium
  - Produces pacemaker spike followed by a P wave
- May be used when SA node is diseased or damaged but conduction through AV junction and ventricles is normal



Ventricular Pacing

- Pacing electrode placed in right ventricle
- Produces pacemaker spike followed by a wide QRS, resembling a ventricular ectopic beat

Dual-Chamber Pacemakers

- A dual-chamber pacemaker paces both the atrium and ventricle
- Two-lead system placed in the heart
  - One lead is placed in the right atrium
  - A second lead is placed in the right ventricle

AV Sequential Pacemaker

- Type of dual-chamber pacemaker
- Stimulates right atrium and right ventricle sequentially
  - Mimics normal cardiac physiology
  - Preserves atrial kick

Dual-Chamber Pacemakers

- Also called DDD pacemakers
  - Both atrium and ventricle are paced (D)
  - Both chambers are sensed (D)
  - Has both a triggered and inhibited mode of response (D)

Transcutaneous Pacing (TCP)

- Recommended as the initial pacing method of choice in emergency cardiac care
  - Effective
  - Quick
  - Safe
  - Least invasive pacing technique currently available

TCP—Indications

- Significant bradycardia unresponsive to atropine therapy or when atropine is not immediately available or indicated

- "Bridge" until transvenous pacing can be accomplished or cause of the bradycardia is reversed
  - Drug overdose
  - Hyperkalemia

TCP—Procedure

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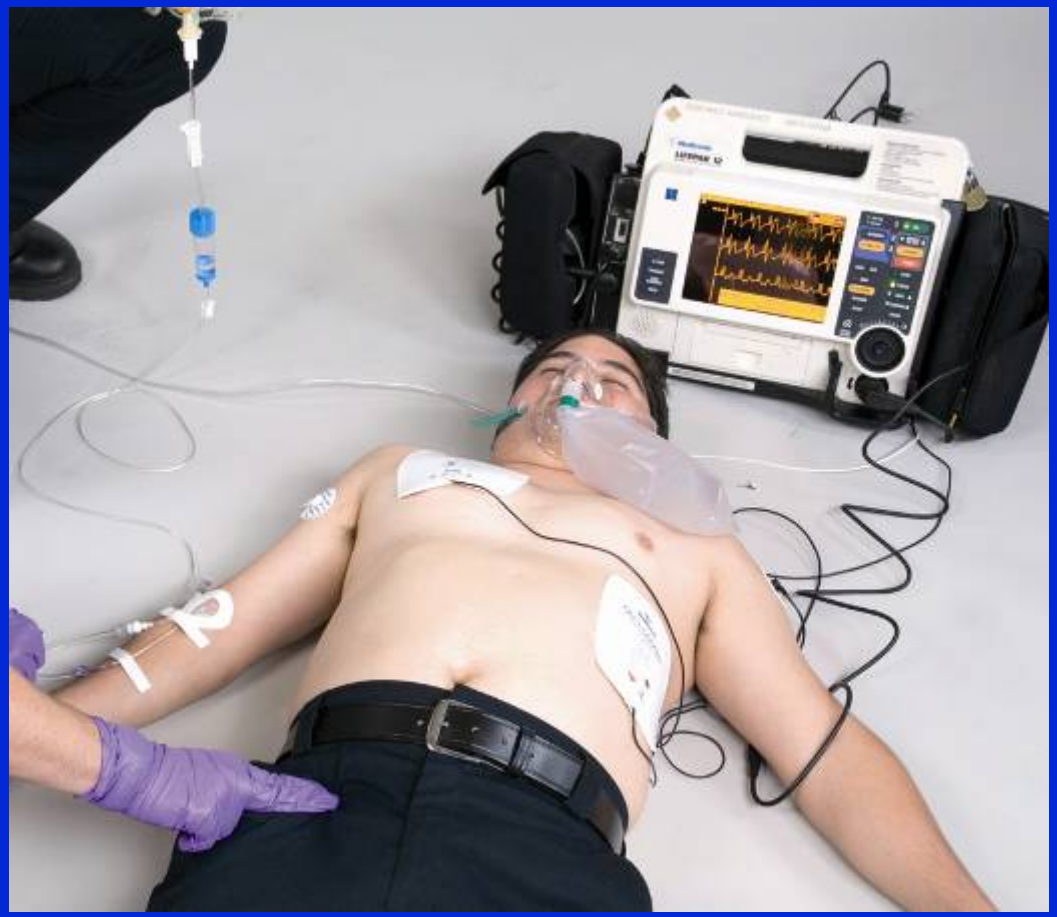
TCP—Electrical Capture

- Observe for electrical capture
  - Usually indicated by wide QRS and broad T wave

TCP—Procedure



TCP—Procedure

TCP—Limitations

- Patient discomfort
  - Proportional to intensity of skeletal muscle contraction and direct stimulation of cutaneous nerves
  - Degree of discomfort varies with:
    - Device used
    - Stimulating current required to achieve capture

Pacemaker Malfunction

Failure to Pace

- Also called “failure to fire”
- Pacemaker malfunction that occurs when:
  - Pacemaker fails to deliver an electrical stimulus
  - Pacemaker fails to deliver the correct number of electrical stimulations per minute

Failure to Pace

- Recognized on the ECG as an absence of pacemaker spikes and a return of the underlying rhythm for which the pacemaker was implanted

- Signs and symptoms may include:
  - Syncope
  - Chest pain
  - Bradycardia
  - Hypotension

Failure to Pace—Causes

- Battery failure
- Fracture of the pacing lead wire
- Displacement of the electrode tip
- Pulse generator failure
- Broken or loose connection between the pacing lead and the pulse generator
- Electromagnetic interference
- Sensitivity setting set too high

Failure to Pace—Possible Interventions

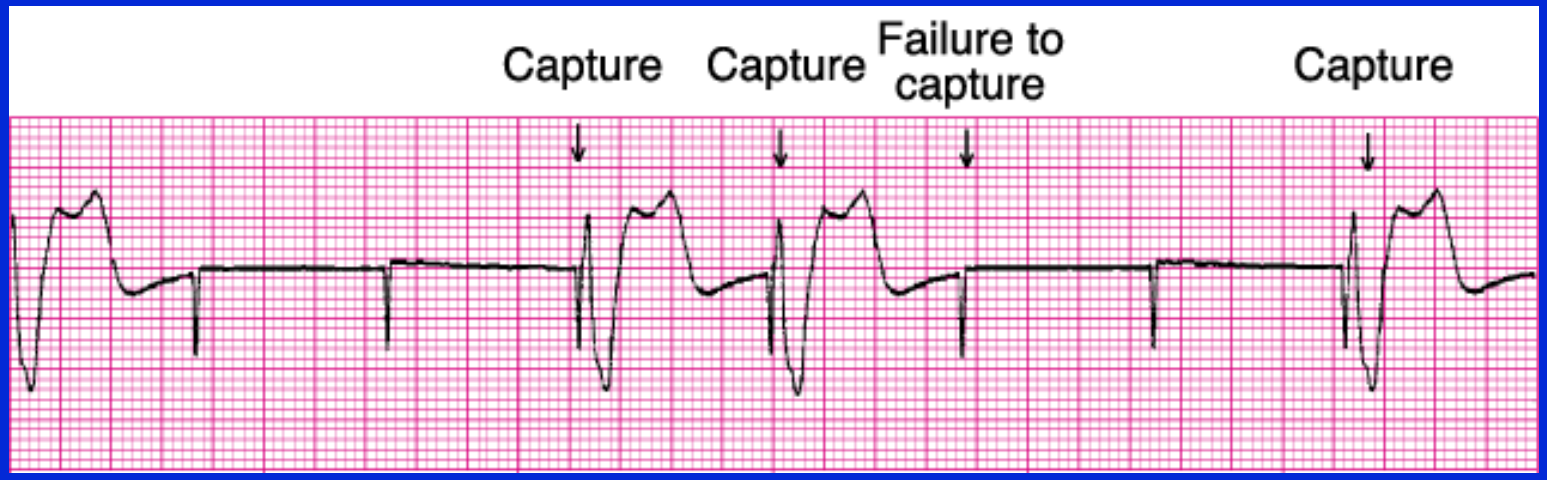
- Adjusting sensitivity setting
- Replacing pulse generator battery
- Replacing pacing lead
- Replacing pulse generator unit
- Tightening connections between pacing lead and pulse generator
- Performing an electrical check
- Removing source of electromagnetic interference

Failure to Capture

- Capture
  - Successful depolarization of atria and/or ventricles by an artificial pacemaker
- Failure to capture
  - Inability of pacemaker stimulus to depolarize myocardium

Failure to Capture

- Recognized on the ECG by visible pacemaker spikes not followed by P waves (if electrode in atrium) or QRS complexes (if electrode in right ventricle)



Failure to Capture—Causes

- Battery failure
- Fracture of pacing lead wire
- Displacement of pacing lead wire (common cause)
- Perforation of myocardium by a lead wire
- Edema or scar tissue formation at electrode tip
- Output energy (mA) set too low (common cause)
- Increased stimulation threshold because of:
  - Medications
  - Electrolyte imbalance
  - Increased fibrin formation on catheter tip

Failure to Capture—Possible Interventions

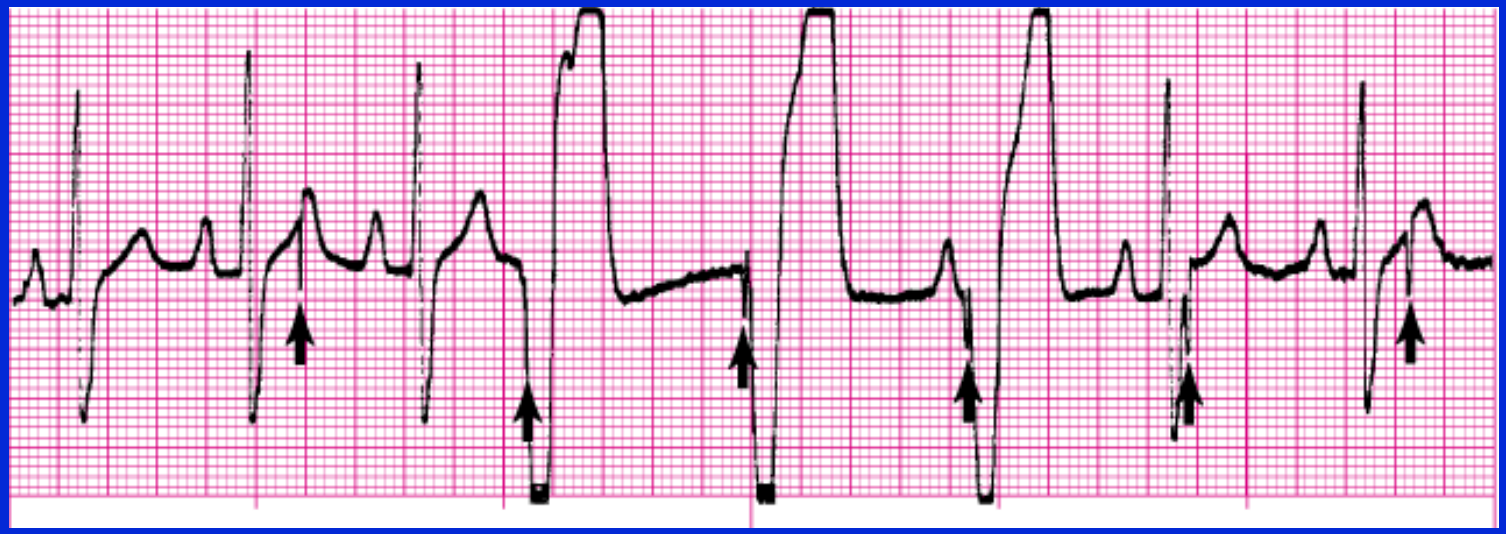
- Repositioning the patient
- Slowly increasing the output setting (mA) until capture occurs or maximum setting is reached
- Replacing pulse generator battery
- Replacing or repositioning the pacing lead
- Surgery

Failure to Sense (Undersensing)

- Sensitivity
  - Extent to which a pacemaker recognizes intrinsic electrical activity
- Failure to sense
  - Occurs when the pacemaker fails to recognize spontaneous myocardial depolarization

Failure to Sense (Undersensing)

- Recognized on the ECG by pacemaker spikes that follow too closely behind the patient's QRS complexes



Failure to Sense (Undersensing) —Causes

- Battery failure
- Fracture of pacing lead wire
- Displacement of the electrode tip
  - Most common cause
- Decreased P wave or QRS voltage
- Circuitry dysfunction
  - Generator unable to process QRS signal
- Increased sensing threshold from edema or fibrosis at the electrode tip, antiarrhythmic medications
- Severe electrolyte disturbances
- Myocardial perforation

Failure to Sense—Possible Interventions

- Increasing sensitivity setting
- Replacing pulse generator battery
- Replacing or repositioning pacing lead

Oversensing

- Pacemaker malfunction that results from inappropriate sensing of extraneous electrical signals
  - Atrial sensing pacemakers may inappropriately sense ventricular activity
  - Ventricular sensing pacemakers may misidentify a tall, peaked intrinsic T wave as a QRS complex

Oversensing

- The patient with a pacemaker should avoid strong electromagnetic fields
  - Arc welding equipment
  - Magnetic resonance imaging (MRI)

Oversensing—
Possible Interventions

- Adjustment of pacemaker's sensitivity setting
- Possible insertion of a bipolar lead if oversensing is due to unipolar lead dysfunction

Pacing – Possible Complications

Complications of Transcutaneous Pacing

- Coughing
- Skin burns
- Interference with sensing
- Pain from electrical stimulation of the skin and muscles
- Failure to recognize that the pacemaker is not capturing
- Tissue damage, including third-degree burns
- Pacing threshold changes

Complications of Temporary Transvenous Pacing

- Bleeding
- Infection
- Pneumothorax
- Cardiac dysrhythmias
- Myocardial infarction
- Lead displacement
- Fracture of pacing lead
- Hematoma at insertion site
- Perforation of right ventricle
- Perforation of major vessel

Complications of Permanent Pacing

- Complications associated with implantation procedure:
  - Bleeding
  - Local tissue reaction
  - Pneumothorax
  - Cardiac dysrhythmias
  - Air embolism
  - Thrombosis

Complications of Permanent Pacing

- Long-term complications of permanent pacing
  - Infection
  - Electrode displacement
  - Congestive heart failure
  - Fracture of the pacing lead
  - Pacemaker-induced dysrhythmias
  - Externalization of the pacemaker generator
  - Perforation of the right ventricle

Analyzing Pacemaker Function on the ECG

Identify Intrinsic Rate and Rhythm

- Are P waves present? At what rate?
- Are QRS complexes present? At what rate?

Is There Evidence of Paced Activity?

- If paced atrial activity is present, evaluate the paced interval
  - Paced interval: time measured between two paced beats
- Using calipers or paper, measure distance between two consecutive paced atrial beats
  - Determine rate and regularity of the paced interval

Is There Evidence of Paced Activity?

- If paced ventricular activity is present, evaluate the paced interval
  - Using calipers or paper, measure distance between two consecutive paced ventricular beats
  - Determine rate and regularity of the paced interval

Evaluate the Escape Interval

- Escape interval
  - Time measured between the last beat of the patient's own rhythm and the first paced beat
- Compare the escape interval to the paced interval measured earlier
  - The paced interval and the escape interval should measure the same

Analyze the Rhythm Strip

- Analyze the rhythm strip for:
  - Failure to capture
  - Failure to sense
  - Oversensing
  - Failure to pace

Questions?