1

2 **Pacemaker Rhythms**

- Objectives

3 **Pacemaker Systems**

- Pacemaker
  - An artificial pulse generator that delivers an electrical current to the heart to stimulate depolarization
  - Pacemaker systems are usually named according to where the electrodes are located and the route the electrical current takes to the heart

4 **Pacemaker System**

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

5 **Permanent Pacemaker - Indications**

- Permanent or intermittent complete AV block
- Permanent or intermittent second-degree AV block type II
- Sinus node dysfunction
  - Sick sinus syndrome manifested as:
    - Severe sinus bradycardia
    - Bradycardia-tachycardia syndrome
    - Sinus arrest
    - Sinus block

6 **Temporary Pacemakers**

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

7 **Temporary Pacing – Indications**

- Hemodynamically significant bradycardia
- Bradycardia with escape rhythms unresponsive to drug therapy
- Overdrive pacing of tachycardia refractory to pharmacologic therapy or electrical countershock
- Bradyasystolic cardiac arrest

8 **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

9

10 **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

11 **Pacemaker Modes**

12 **Fixed-Rate (Asynchronous) Pacemakers**

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

13 **Demand (Synchronous, Noncompetitive) Pacemakers**

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

14 **Pacemaker Identification Codes**

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

15 **Pacemaker Identification Codes**

16 **Single-Chamber Pacemakers**

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

17 **Atrial Pacing**

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

18 **Ventricular Pacing**

- A pacing electrode is placed in the right ventricle
- Produces a pacemaker spike followed by a wide QRS, resembling a ventricular ectopic beat

19 **Ventricular Pacing**

- Cannot coordinate pacing with the patient's intrinsic atrial rate
  - Results in asynchronous contraction of the atrium and ventricle (AV asynchrony)
  - Ventricular demand pacemaker rarely used in a patient with an intact SA node
    - But may be used for chronic atrial fibrillation

20 **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

21 **AV Sequential Pacemaker**

- An AV sequential pacemaker is an example of a dual-chamber pacemaker
- Stimulates the right atrium and right ventricle sequentially
  - Mimics normal cardiac physiology
  - Preserves atrial kick

22 **AV Sequential Pacemaker**

23 **Dual-Chamber Pacemakers**

- Dual-chamber pacemakers may also be 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)

24 **Dual-Chamber Pacemakers**

- If spontaneous atrial depolarization does not occur within a preset interval:
  - Atrial pulse generator fires
  - Stimulates atrial depolarization at a preset rate
  - Pacemaker waits

- Simulates normal delay in conduction through AV node (the PR interval)
- "Artificial" or "electronic" PR interval = AV interval

25 **Dual-Chamber Pacemakers**

- If spontaneous ventricular depolarization does not occur within a preset interval:
  - Pacemaker fires
  - Stimulates ventricular depolarization at a preset rate

26 **Transcutaneous Pacing (TCP)**

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

27 **Transcutaneous Pacing – Indications**

- Significant bradycardias unresponsive to atropine therapy or when atropine is not immediately available
- "Bridge" until transvenous pacing can be accomplished or cause of bradydysrhythmia is reversed
  - Drug overdose
  - Hyperkalemia
- May be considered in asystolic cardiac arrest (less than 10 minutes in duration) and witnessed asystolic arrest

28 **Transcutaneous Pacing – Technique**

29 **Transcutaneous Pacing – Technique**

30 **Transcutaneous Pacing – Technique**

- Connect the patient to the ECG monitor
- Obtain a rhythm strip
- Verify the presence of a paceable rhythm
- Connect the pacing cable to adhesive electrodes on the patient
- Turn on the pacemaker generator
- Set the pacing rate
  - In a patient with a pulse, set the rate at 60 to 80
  - In a pulseless patient, set the rate at 80 to 100

31 **Transcutaneous Pacing – Technique**

- Set the output (milliAmps) setting
  - Asystole
    - Maximum output
  - In a responsive patient
    - Increase the current slowly
    - Sedation or analgesia may be needed

32 **TCP - Electrical Capture**

- Observe for electrical capture
  - Usually indicated by wide QRS and broad T wave
    - In some patients, electrical capture is less obvious - indicated only as a change in the shape of the QRS

33 **TCP - Mechanical Capture**

- Assess the right upper extremity or right femoral pulse
  - Avoid assessment of pulses on the patient's left side (due to the location of pacer pads)
    - TCP produces jerking muscle contractions of chest and shoulder girdle muscles that can be confused with a palpable pulse

34 **TCP - Technique**

- Once mechanical capture has been confirmed, note the milliampere setting
- Continue pacing at an output level slightly higher than the threshold of initial electrical capture

- About 2 milliamps above the noted capture setting

35 **TCP – Technique**

- Monitor the patient closely
- Record the ECG rhythm
- Chest compressions can be performed during pacing without risk of injury to the rescuer

36 **TCP – Contraindications**

- Children weighing less than 15 kg (33 lbs) unless pediatric pacing electrodes are used
- Flail chest
- Bradycardia in setting of severe hypothermia
- Bradyasystolic arrest > 20 minutes duration (relative contraindication)

37 **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

38 **Pacemaker Malfunction**

39 **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

40 **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
- Patient signs and symptoms may include:
  - Syncope
  - Chest pain
  - Bradycardia
  - Hypotension

41 **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

42 **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

43 **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

44 **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)

45 **Failure to Capture**

- Patient signs and symptoms may include:
  - Fatigue
  - Bradycardia
  - Hypotension

46 **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

47 **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

48 **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

49 **Failure to Sense (Undersensing)**

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

50 **Failure to Sense – 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

51 **Failure to Sense – Possible Interventions**

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

52 **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

53 **Oversensing**

- The patient with a pacemaker should avoid strong electromagnetic fields such as arc welding equipment and magnetic resonance imaging (MRI)

54 **Oversensing – Possible Interventions**

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

55 **Complications of Transcutaneous Pacing**

- Pain from electrical stimulation of the skin and muscles
- Failure to recognize that the pacemaker is not capturing
- Failure to recognize the presence of underlying treatable VF
- Tissue damage, including third-degree burns, has been reported in pediatric patients with improper or prolonged transcutaneous pacing

56 **Complications of Temporary Transvenous Pacing**

- Bleeding
- Infection
- Pneumothorax
- Cardiac dysrhythmias
- Myocardial infarction
- Lead displacement
- Fracture of the pacing lead
- Hematoma at the insertion site
- Perforation of the right ventricle with or without pericardial tamponade
- Perforation of the inferior vena cava, pulmonary artery, or coronary arteries due to improper placement of pacing lead

57 **Complications of Permanent Pacing**

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

58 **Complications of Permanent Pacing**

- Long-term complications of permanent pacing may include:
  - Infection
  - Electrode displacement
  - Congestive heart failure
  - Fracture of the pacing lead
  - Pacemaker-induced dysrhythmias
  - Externalization of the pacemaker generator
  - Perforation of the right ventricle with or without pericardial tamponade

59 **Analyzing Pacemaker Function on the ECG**

60 **Identify the Intrinsic Rate and Rhythm**

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

61 **Is There Evidence of Paced Activity?**

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

62 **Is There Evidence of Paced Activity?**

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

63 **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

64 **Analyze the Rhythm Strip**

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

65 **Questions?**