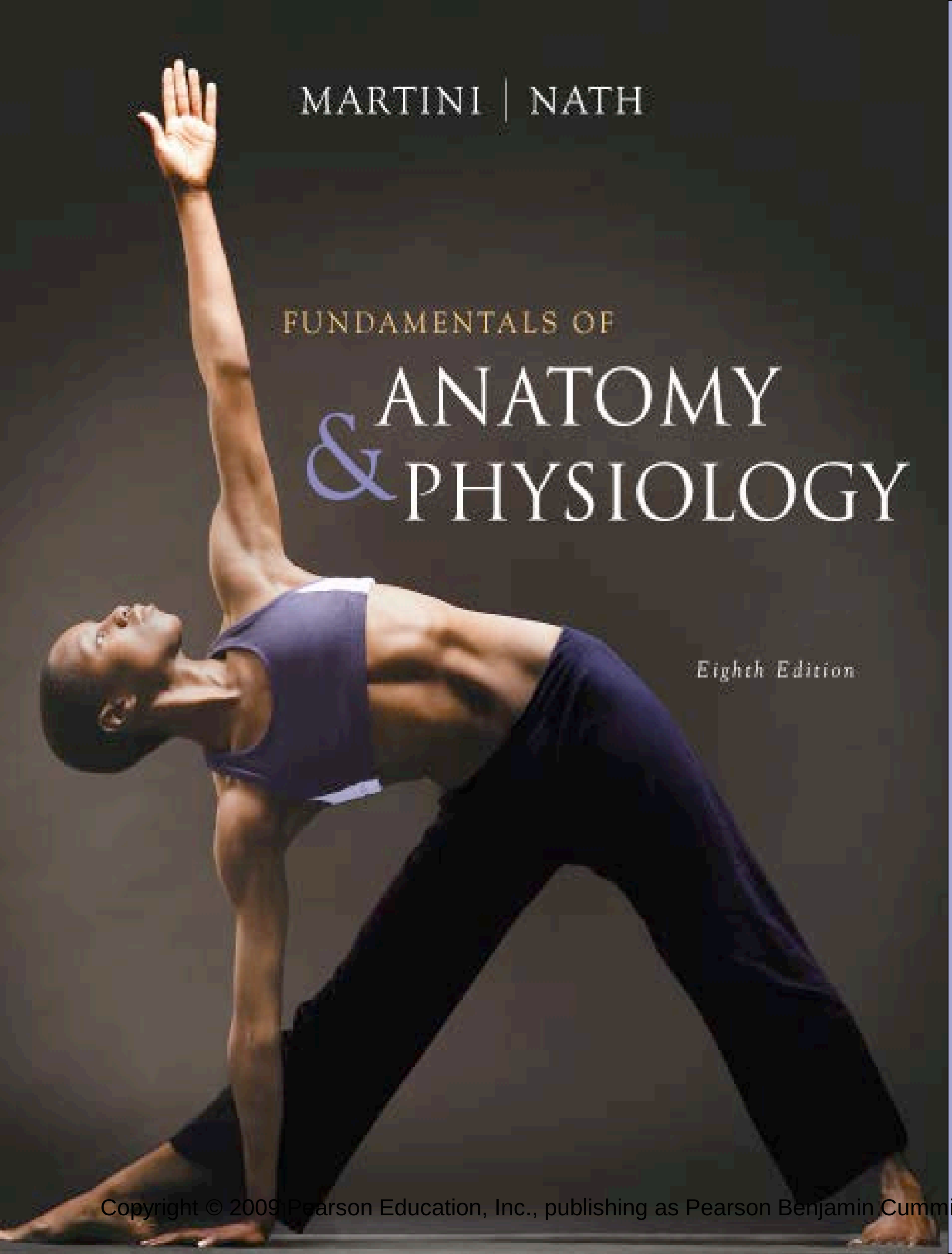

Chapter

20

The Heart

PowerPoint® Lecture Slides prepared by Jason LaPres
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Introduction to Cardiovascular System

- The Pulmonary Circuit
  - Carries blood to and from gas exchange surfaces of lungs
- The Systemic Circuit
  - Carries blood to and from the body
- Blood alternates between pulmonary circuit and systemic circuit

The Conducting System

- Heartbeat
  - A single contraction of the heart
  - The entire heart contracts in series
    - First the atria
    - Then the ventricles

The Conducting System

- A system of specialized cardiac muscle cells
  - Initiates and distributes electrical impulses that stimulate contraction
- **Automaticity**
  - Cardiac muscle tissue contracts automatically

The Conducting System

- Structures of the Conducting System
  - Sinoatrial (SA) node - wall of right atrium
  - Atrioventricular (AV) node - junction between atria and ventricles
  - Conducting cells - throughout myocardium

The Conducting System

- Conducting Cells
  - Interconnect SA and AV nodes
  - Distribute stimulus through myocardium
  - In the atrium
    - **Internodal pathways**
  - In the ventricles
    - AV bundle and the bundle branches

The Conducting System

- Heart Rate
  - SA node generates 80–100 action potentials per minute
  - Parasympathetic stimulation slows heart rate
  - AV node generates 40–60 action potentials per minute

The Conducting System

- The Sinoatrial (SA) Node
  - In posterior wall of right atrium
  - Contains pacemaker cells
  - Connected to AV node by internodal pathways
  - Begins atrial activation (Step 1)

The Conducting System

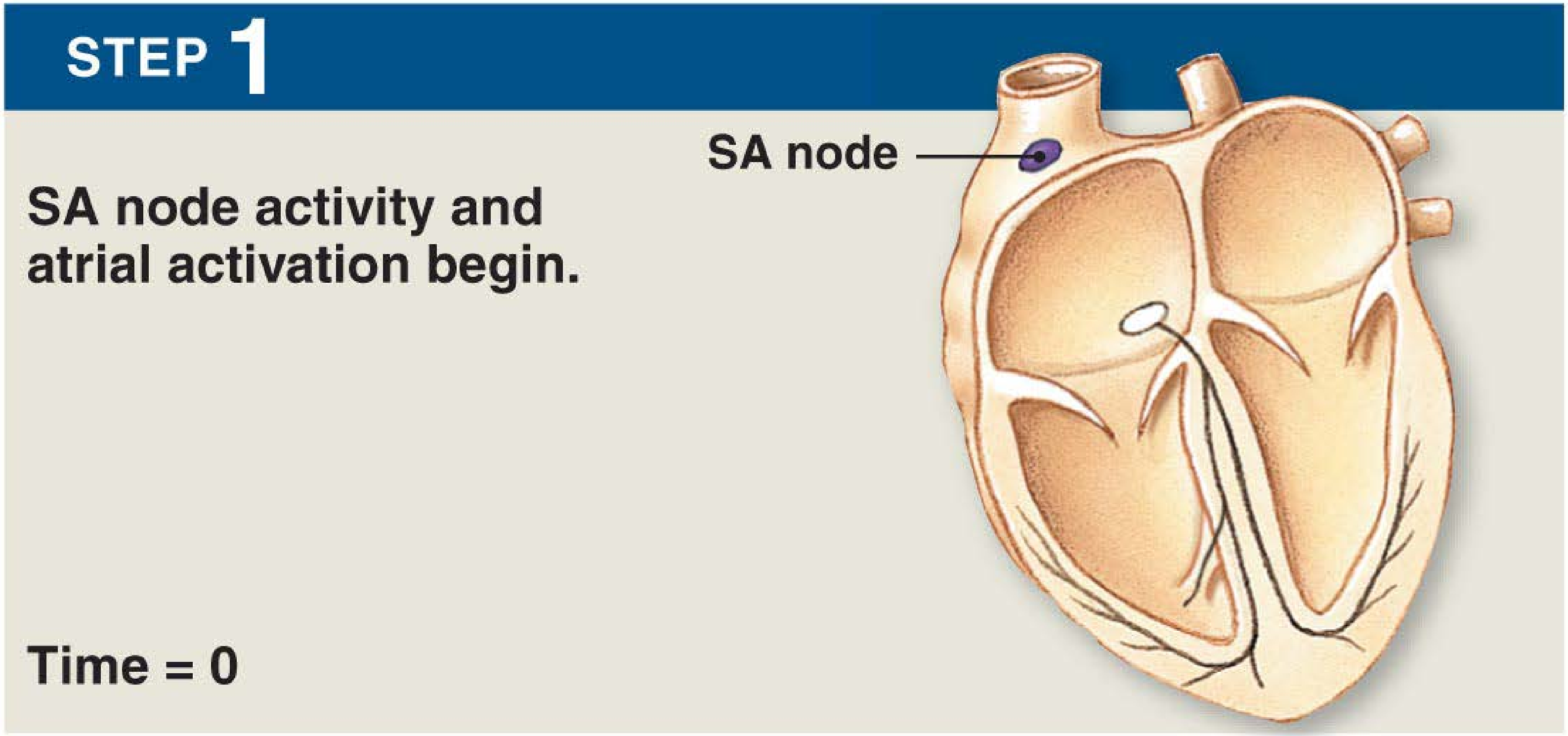


Figure 20–13 Impulse Conduction through the Heart

The Conducting System

- The Atrioventricular (AV) Node
  - In floor of right atrium
  - Receives impulse from SA node (Step 2)
  - Delays impulse (Step 3)
  - Atrial contraction begins

The Conducting System

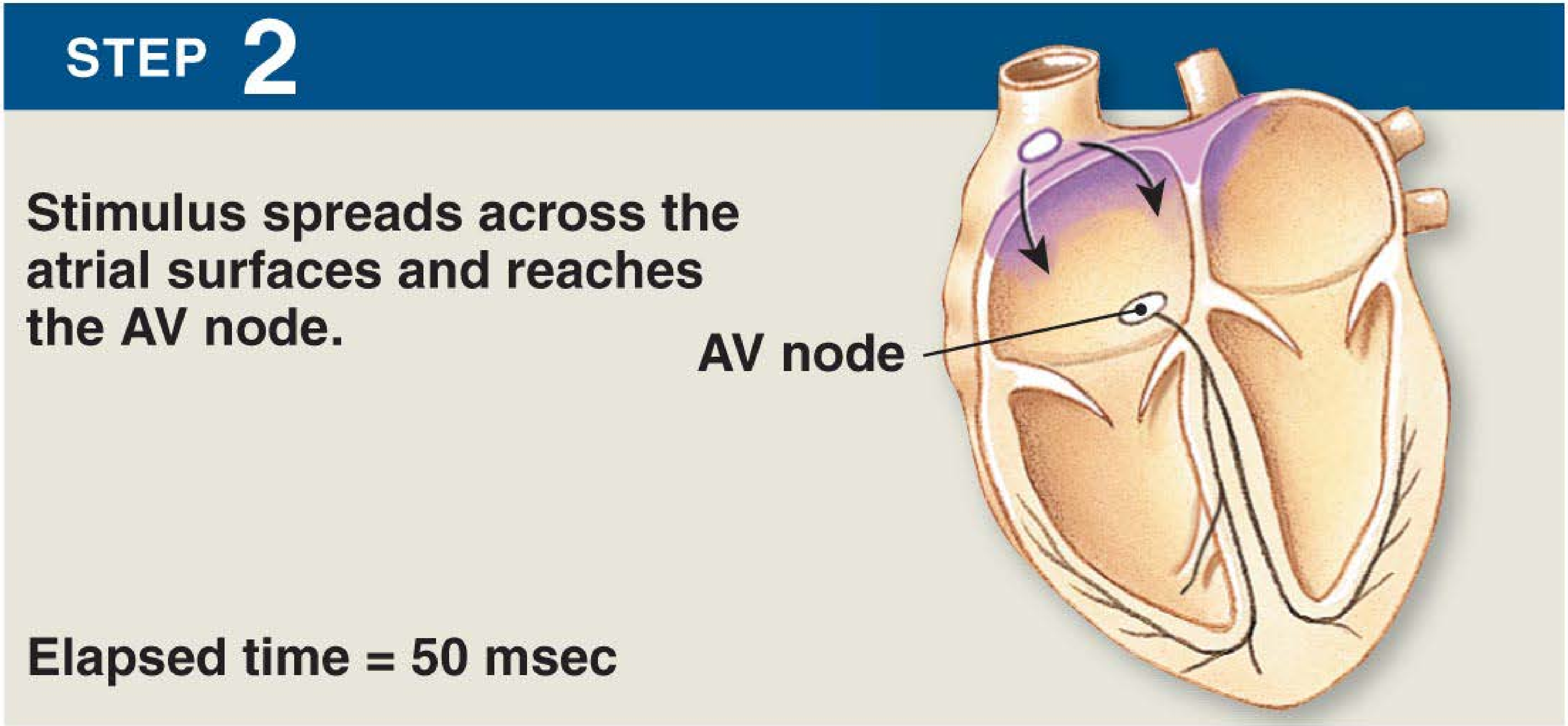


Figure 20–13 Impulse Conduction through the Heart

The Conducting System

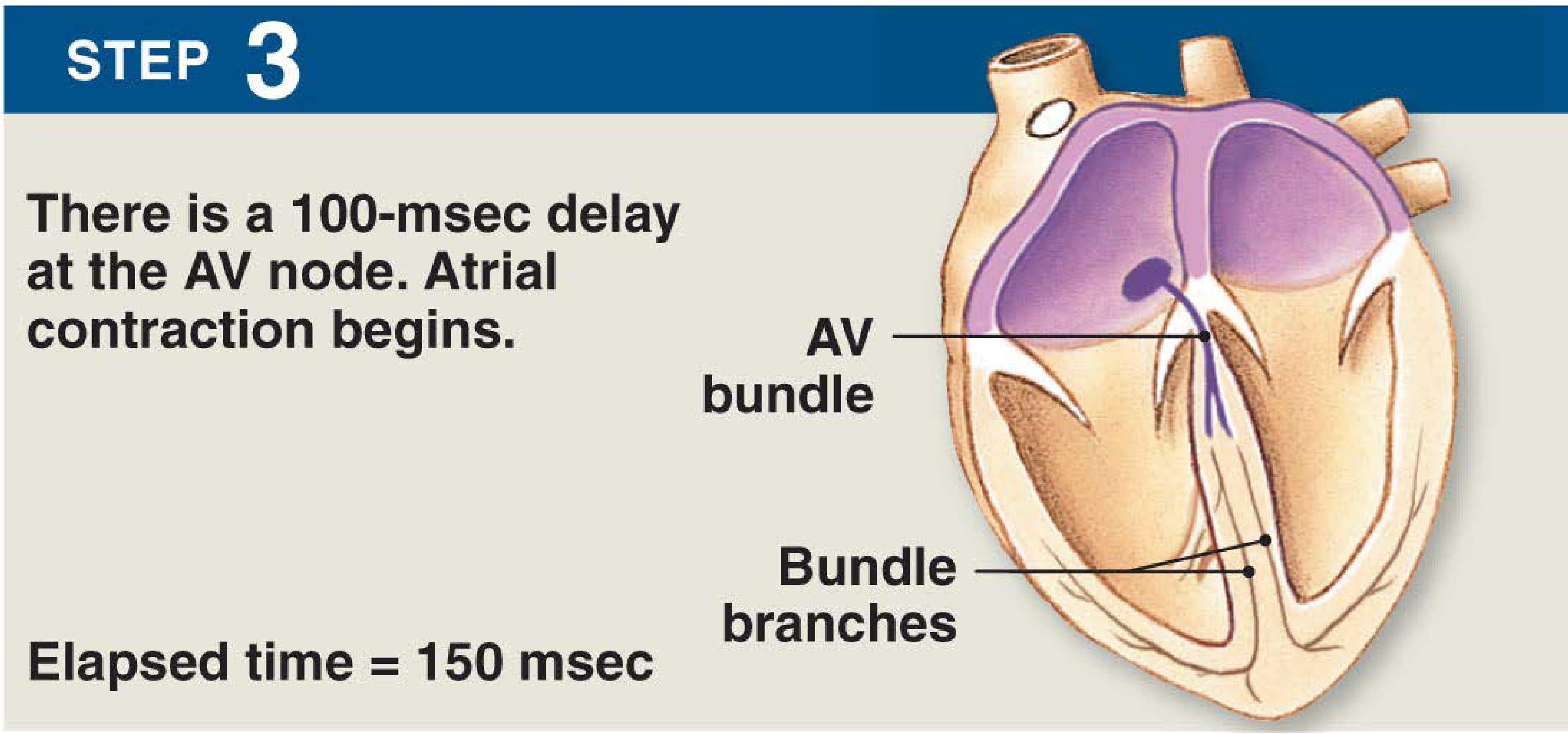


Figure 20–13 Impulse Conduction through the Heart

The Conducting System

- The AV Bundle
  - In the septum
  - Carries impulse to left and right bundle branches
    - Which conduct to Purkinje fibers (Step 4)
  - And to the moderator band
    - Which conducts to papillary muscles

The Conducting System

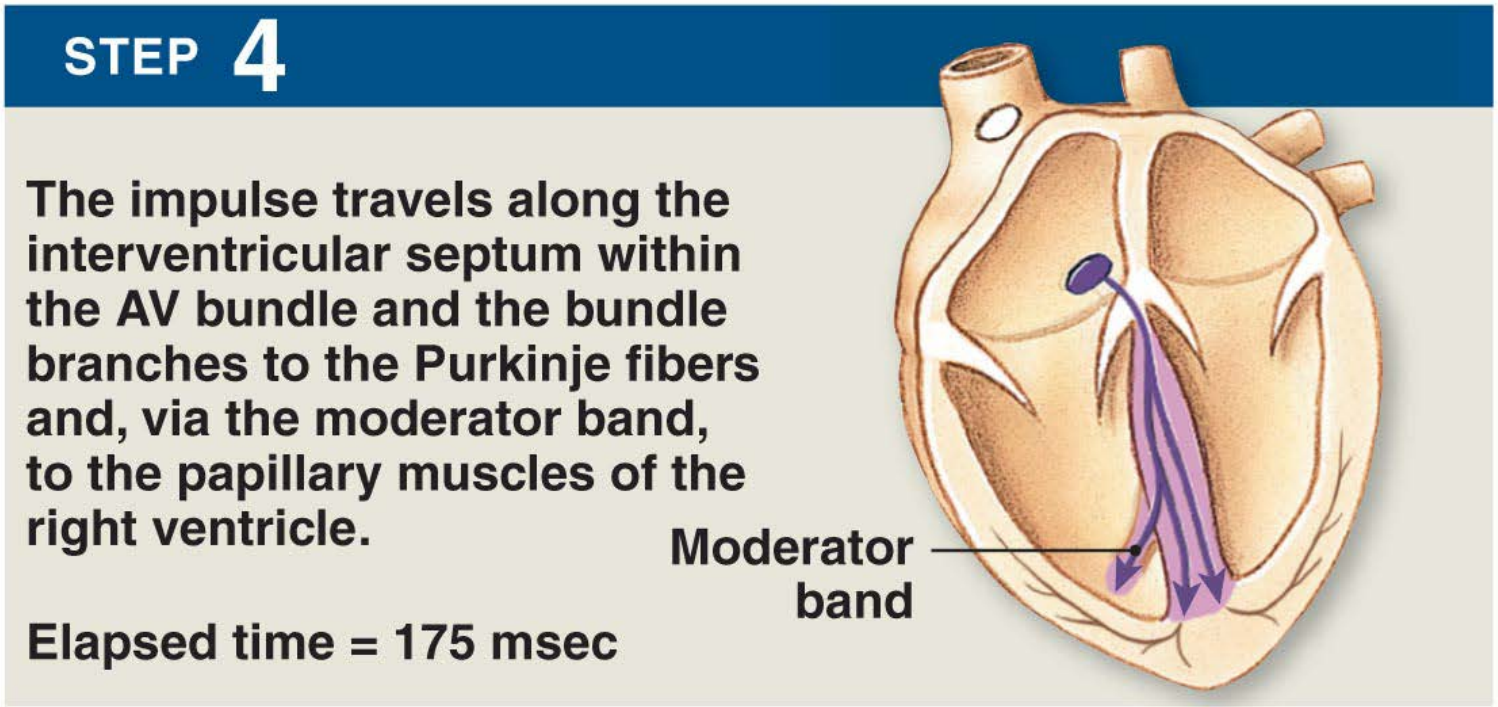


Figure 20–13 Impulse Conduction through the Heart

The Conducting System

- Purkinje Fibers
  - Distribute impulse through ventricles (Step 5)
  - Atrial contraction is completed
  - Ventricular contraction begins

The Conducting System

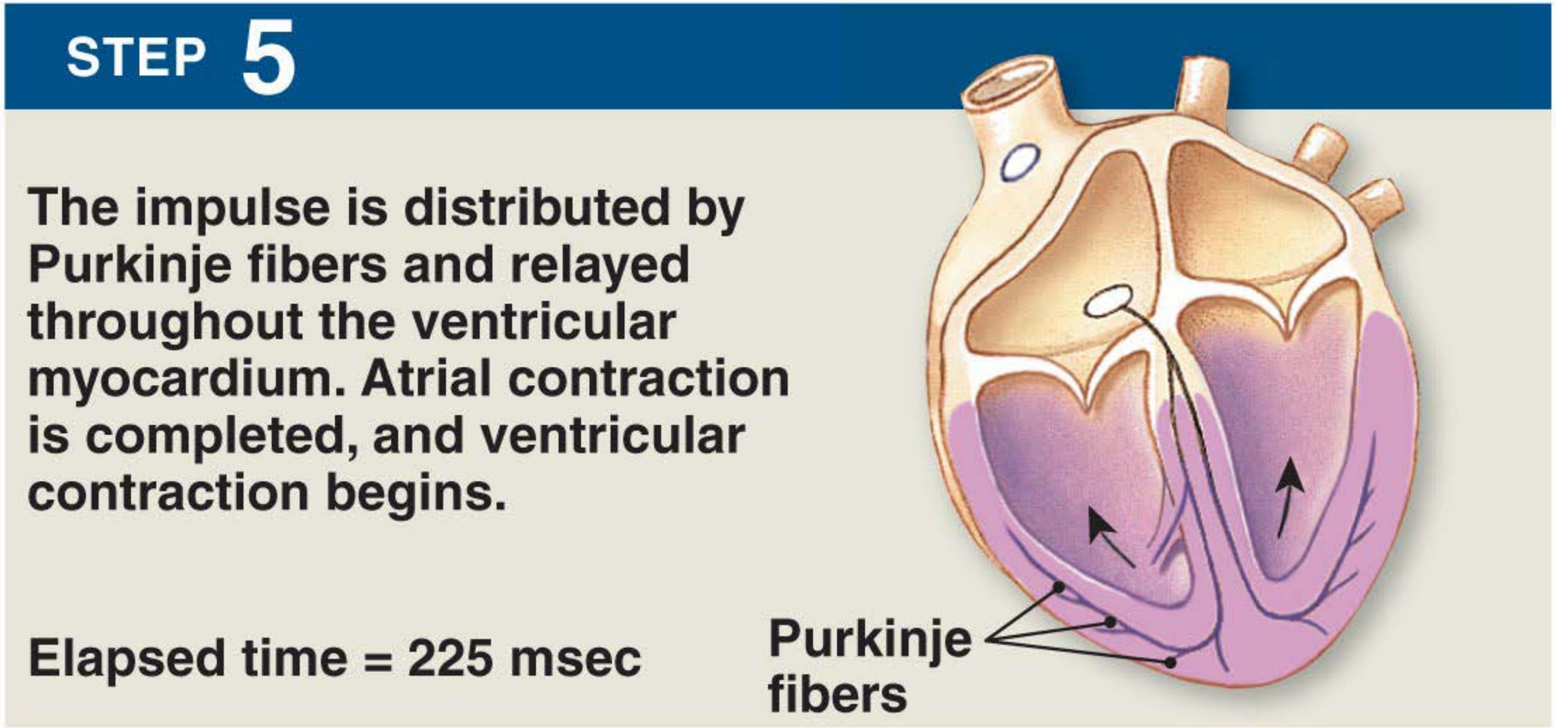


Figure 20–13 Impulse Conduction through the Heart

The Conducting System

- Abnormal Pacemaker Function
  - **Bradycardia**: abnormally slow heart rate
  - **Tachycardia**: abnormally fast heart rate
  - **Ectopic pacemaker**
    - Abnormal cells
    - Generate high rate of action potentials
    - Bypass conducting system
    - Disrupt ventricular contractions

The Conducting System

- Electrocardiogram (ECG or EKG)
  - A recording of electrical events in the heart
  - Obtained by electrodes at specific body locations
  - Abnormal patterns diagnose damage

The Conducting System

- Features of an ECG
  - **P wave**
    - Atria depolarize
  - **QRS complex**
    - Ventricles depolarize
  - **T wave**
    - Ventricles repolarize

The Conducting System

- Time Intervals Between ECG Waves
  - **P–R interval**
    - From start of atrial depolarization
    - To start of QRS complex
  - **Q–T interval**
    - From ventricular depolarization
    - To ventricular repolarization

The Conducting System

- **Contractile Cells**
  - Purkinje fibers distribute the stimulus to the contractile cells, which make up most of the muscle cells in the heart

The Cardiac Cycle

- Cardiac cycle = The period between the start of one heartbeat and the beginning of the next
- Includes both contraction and relaxation

The Conducting System

- The Cardiac Cycle
  - Begins with action potential at SA node
    - Transmitted through conducting system
    - Produces action potentials in cardiac muscle cells (contractile cells)

The Cardiac Cycle

- Phases of the Cardiac Cycle
  - Within any one chamber
    - **Systole** (contraction)
    - **Diastole** (relaxation)

The Cardiac Cycle

- Cardiac Cycle and Heart Rate
  - At 75 beats per minute
    - Cardiac cycle lasts about 800 msecs
  - When heart rate increases
    - All phases of cardiac cycle shorten, particularly diastole

The Cardiac Cycle

Eight Steps in the Cardiac Cycle

1. **Atrial systole**
   - Atrial contraction begins
   - Right and left AV valves are open
2. **Atria eject blood into ventricles**
   - Filling ventricles
3. **Atrial systole ends**
   - AV valves close
   - Ventricles contain maximum blood volume
   - Known as end-diastolic volume (EDV)

The Cardiac Cycle

Eight Steps in the Cardiac Cycle

4. **Ventricular systole**
   - Isovolumetric ventricular contraction
   - Pressure in ventricles rises
   - AV valves shut
5. **Ventricular ejection**
   - Semilunar valves open
   - Blood flows into pulmonary and aortic trunks
   - Stroke volume (SV) = 60% of end-diastolic volume

The Cardiac Cycle

Eight Steps in the Cardiac Cycle

6. **Ventricular pressure falls**
   - Semilunar valves close
   - Ventricles contain end-systolic volume (ESV), about 40% of end-diastolic volume
7. **Ventricular diastole**
   - Ventricular pressure is higher than atrial pressure
   - All heart valves are closed
   - Ventricles relax (isovolumetric relaxation)

The Cardiac Cycle

Eight Steps in the Cardiac Cycle

8. **Atrial pressure is higher than ventricular pressure**
    - AV valves open
    - Passive atrial filling
    - Passive ventricular filling
    - Cardiac cycle ends

PLAY The Heart: Cardiac Cycle

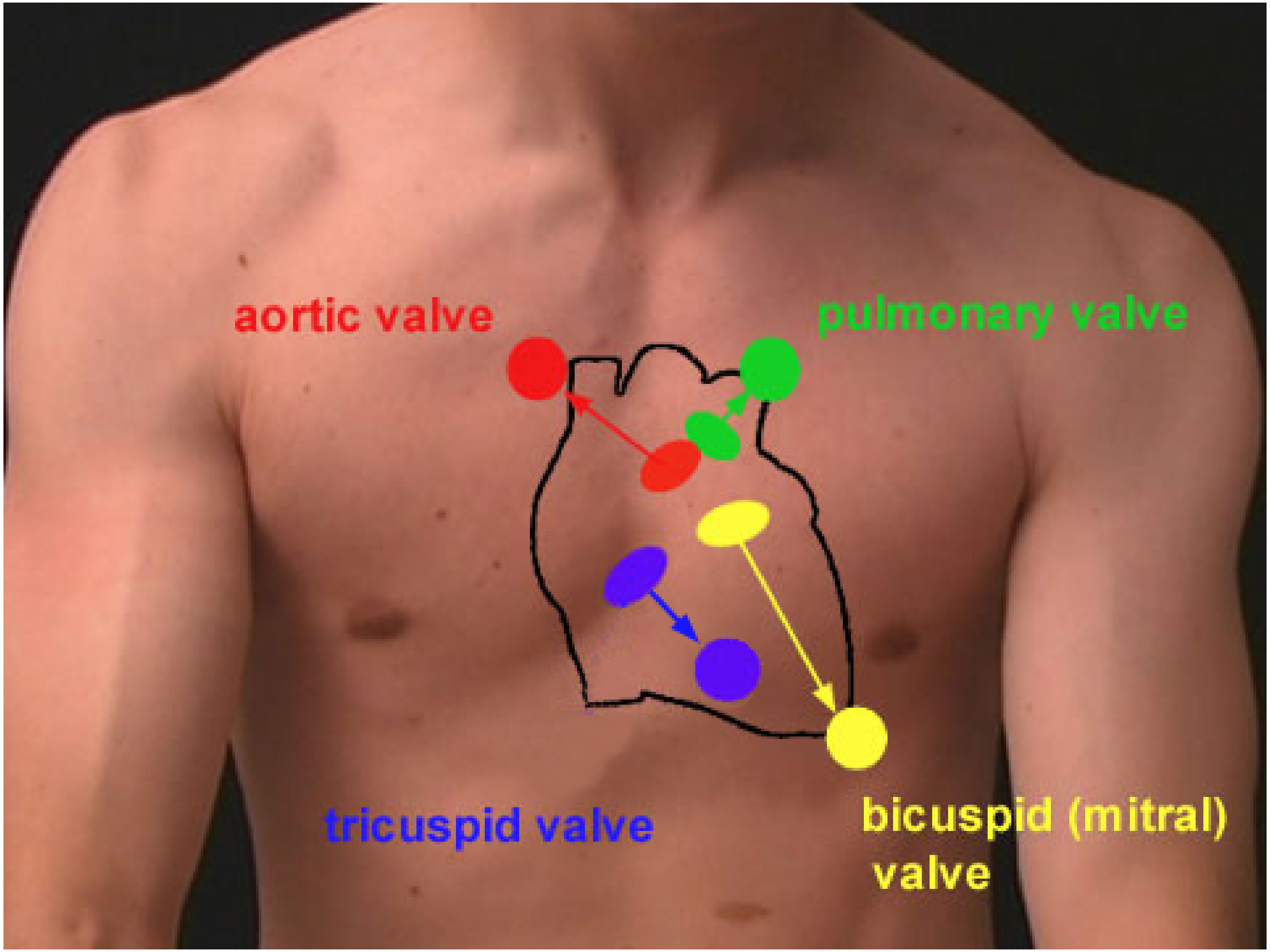
The Cardiac Cycle

- Blood Pressure
  - In any chamber
    - Rises during systole
    - Falls during diastole
  - Blood flows from high to low pressure
    - Controlled by timing of contractions
    - Directed by one-way valves

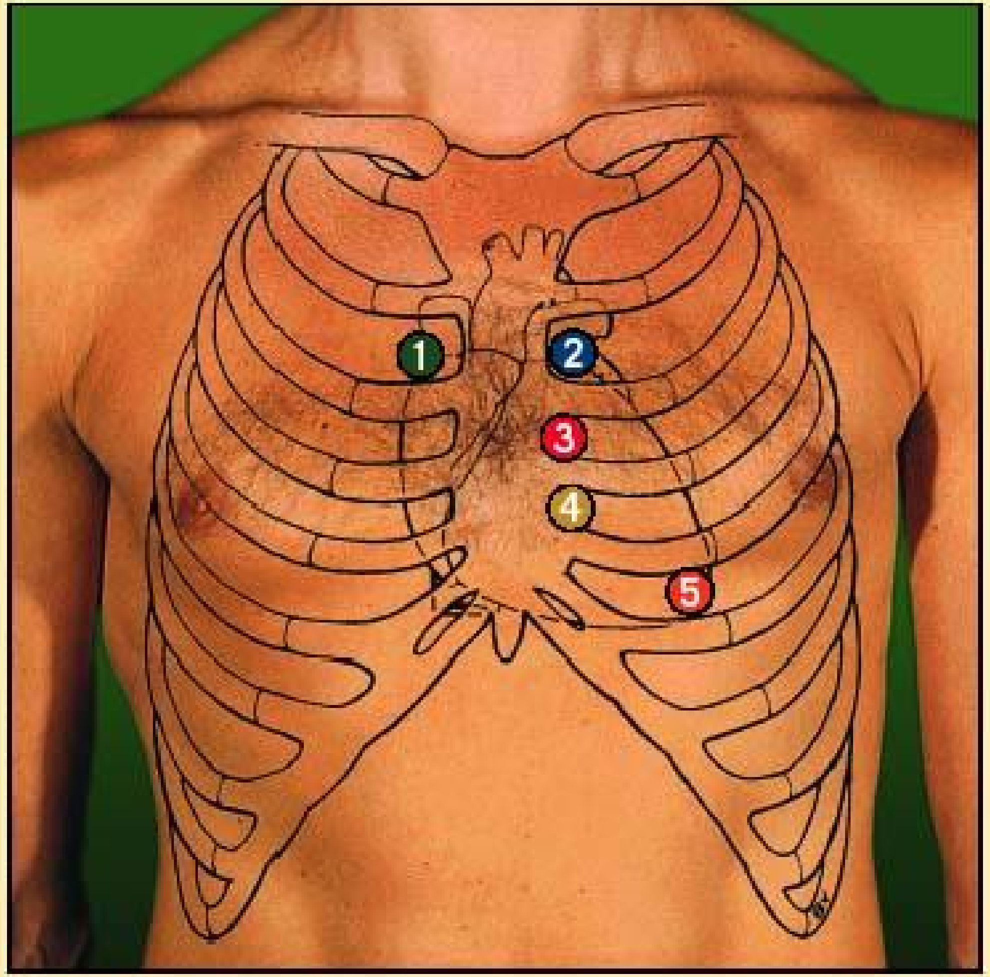
The Cardiac Cycle

- Heart Sounds
  - **S_1**
    - Loud sounds
    - Produced by AV valves
  - **S_2**
    - Loud sounds
    - Produced by semilunar valves
  - **S_3, S_4**
    - Soft sounds
    - Blood flow into ventricles and atrial contraction

The Cardiac Cycle



Locating the assessment points



1 Aortic area—second intercostal space, right sternal border

2 Pulmonic area—second intercostal space, left sternal border

3 Erb's point—third intercostal space, left sternal border

4 Tricuspid area—fourth (or fifth) intercostal space, left sternal border

5 Mitral area or apex—fifth intercostal space, left midclavicular line

The Cardiac Cycle

- Heart Murmur
  - Sounds produced by regurgitation through valves

Cardiodynamics

- The movement and force generated by cardiac contractions
  - End-diastolic volume (EDV)
  - End-systolic volume (ESV)
  - Stroke volume (SV)
    - SV = EDV – ESV
  - Cardiac output (CO)
    - The volume pumped by left ventricle in 1 minute

Cardiodynamics

- Cardiac Output
- CO = HR X SV
- CO = cardiac output (mL/min)
- HR = heart rate (beats/min)
- SV = stroke volume (mL/beat)

Cardiodynamics

- Factors Affecting Cardiac Output
  - Cardiac output
    - Adjusted by changes in heart rate or stroke volume
  - Heart rate
    - Adjusted by autonomic nervous system or hormones
  - Stroke volume
    - Adjusted by changing EDV or ESV

Cardiodynamics

- Atrial Reflex
  - Also called Bainbridge reflex
  - Adjusts heart rate in response to venous return
  - Stretch receptors in right atrium
    - Trigger increase in heart rate
    - Through increased sympathetic activity

Cardiodynamics

- Hormonal Effects on Heart Rate
  - Increase heart rate (by sympathetic stimulation of SA node)
    - Epinephrine (E)
    - Norepinephrine (NE)
    - Thyroid hormone

Cardiodynamics

- Factors Affecting the Stroke Volume
  - The EDV: amount of blood a ventricle contains at the end of diastole
    - **Filling time**:
      - duration of ventricular diastole
    - **Venous return**:
      - rate of blood flow during ventricular diastole

Cardiodynamics

- The EDV and Stroke Volume
  - At rest
    - EDV is low
    - Myocardium stretches less
    - Stroke volume is low
  - With exercise
    - EDV increases
    - Myocardium stretches more
    - Stroke volume increases

Cardiodynamics

- The **Frank–Starling Principle**
  - As EDV increases, stroke volume increases
- Physical Limits
  - Ventricular expansion is limited by
    - Myocardial connective tissue
    - The cardiac (fibrous) skeleton
    - The pericardial sac

Cardiodynamics

- End-Systolic Volume (ESV)
  - The amount of blood that remains in the ventricle at the end of ventricular systole is the ESV

Cardiodynamics

- Afterload
  - Is increased by any factor that restricts arterial blood flow
  - As afterload increases, stroke volume decreases

Cardiodynamics

- Heart Rate Control Factors
  - Autonomic nervous system
    - Sympathetic and parasympathetic
  - Circulating hormones
  - Venous return and stretch receptors

Cardiodynamics

- Stroke Volume Control Factors
  - EDV
    - Filling time
    - Rate of venous return
  - ESV
    - Preload
    - Contractility
    - Afterload

Cardiodynamics

- Cardiac Reserve
  - The difference between resting and maximal cardiac output

Cardiodynamics

- The Heart and Cardiovascular System
  - Cardiovascular regulation
    - Ensures adequate circulation to body tissues
  - Cardiovascular centers
    - Control heart and peripheral blood vessels
  - Cardiovascular system responds to
    - Changing activity patterns
    - Circulatory emergencies