

CHAPTER 14

HEART

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ANATOMY AND PHYSIOLOGY

| Expected Position | Variant Positions |
|---|--|
| <ul style="list-style-type: none"> • In mediastinum • Left of midline • Above diaphragm • Between medial/lower borders of lungs • Behind sternum • 3rd to 6th intercostal cartilage | <ul style="list-style-type: none"> • Body build • Chest configuration • Diaphragm level • Dextrocardia <ul style="list-style-type: none"> • Heart positioned to the right, either rotated or displaced, or as a mirror image • If the heart and stomach are placed to the right and the liver to the left, this habitus is termed <i>situs inversus</i> |

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STRUCTURE

- **Pericardium**
 - Tough, double-walled, fibrous sac encasing and protecting the heart
 - Several milliliters of fluid are present between the inner and outer layers of the pericardium, providing for low-friction movement
- **Epicardium**
 - Thin outermost muscle layer covering heart, inner layer of pericardium
- **Myocardium**
 - Thick, muscular middle layer responsible for pumping
- **Endocardium**
 - Innermost layer, lining chambers and covering valves

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STRUCTURE (CONT.)

- **Chambers**
 - Two upper chambers are the right and left *atria*
 - Thin-walled chambers that act primarily as reservoirs for blood returning to the heart from the veins throughout the body
 - Two bottom chambers are the right and left *ventricles*
 - Thick-walled chambers that pump blood to the lungs and throughout the body
- **Septum**: divides right and left heart
- **Valves**: permit the flow of blood in only one direction
- **Atrioventricular (AV)**
 - Tricuspid valve, which has three cusps (or leaflets), separates the right atrium from the right ventricle
 - Mitral valve, which has two cusps, separates the left atrium from the left ventricle
- **Semilunar**
 - Two semilunar valves, each has three cusps
 - Pulmonic valve separates the right ventricle from the pulmonary artery
 - Aortic valve lies between the left ventricle and the aorta

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CARDIAC CYCLE: SYSTOLE

- **Ventricles contract**
 - Blood is ejected from the left ventricle into the aorta and from the right ventricle into the pulmonary artery
- **Mitral and tricuspid valves close = S1 = "lub"**
(*first heart sound*)
- Pressure continues to rise
- **Aortic and pulmonic valves open**
 - Blood ejected into arteries
- Pressure falls
- **Aortic and pulmonic valves close = S2 = "dub"**
(*second heart sound*)

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CARDIAC CYCLE: DIASTOLE

- **Mitral and tricuspid valves open**
- **Blood moves from atria to ventricles = S3**
(*third heart sound*)
- **Ventricles dilate**, an energy-requiring effort that draws blood into the ventricles as the atria contract, thereby moving blood from the atria to the ventricles
- **Atria contract** as ventricles are almost filled
- **Causes complete emptying of atria = S4**
(*fourth heart sound*)

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ELECTRICAL ACTIVITY

- Intrinsic electrical conduction system enables the heart to contract within itself
- Coordinates the sequence of muscular contractions taking place during the cardiac cycle
 - Sinoatrial node (SA node)
 - AV node
 - Bundle of His
 - Purkinje fibers
- An electrocardiogram (ECG) is a graphic recording of electrical activity during the cardiac cycle

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ELECTROCARDIOGRAM (ECG)

- ECG waves
 - **P wave**: the spread of a stimulus through the atria
 - **PR interval**: the time from initial stimulation of the atria to initial stimulation of the ventricles
 - **QRS complex**: the spread of a stimulus through the ventricles
 - **ST segment and T wave**: the return of stimulated ventricular muscle to a resting state
 - **U wave**: a small deflection sometimes seen just after the T wave related to repolarization of Purkinje fibers
 - **Q-T interval**: the time elapsed from the onset of ventricular depolarization until the completion of ventricular repolarization

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INFANTS AND CHILDREN

- Heart assumes adult function early in fetal life
- Changes at birth:
 - Ductus arteriosus and interatrial foramen ovale close
 - Right ventricle assumes pulmonary circulation
 - Left ventricle assumes systemic circulation
- Ventricle muscle mass increases over first year
- Heart lies more horizontally and apex higher
 - Adult heart position reached by age of 7 years—therefore we can use the adult landmarks for patients above the age of 7

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PREGNANT WOMEN

- Maternal blood volume increases 40% to 50% over prepregnancy level
 - Heart works harder to accommodate the increased heart rate and stroke volume required for the expanded blood volume
- Left ventricle increases in both wall thickness and mass
- Heart shifts to more horizontal position
 - Uterus enlarges and the diaphragm moves upward
- For most pregnant women, the cardiac and abdominal changes result in a functional murmur, usually a systolic ejection murmur (SEM)

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OLDER ADULTS

- Heart size may decrease (is this counterintuitive?)
- Left ventricular wall thickens
- Valves fibrose and calcify
- Heart rate slows
- Stroke volume decreases
- Cardiac output during exercise declines by 30% to 40%
- Endocardium thickens
- Myocardium becomes less elastic
- Electrical irritability may be enhanced

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OLDER ADULTS (CONT.)

- ECG tracing changes
 - First-degree AV block
 - Bundle branch blocks
 - ST-T wave abnormalities
 - Premature systole (atrial and ventricular)
 - Left anterior hemiblock
 - Left ventricular hypertrophy
 - Atrial fibrillation

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CARDIAC HISTORY CONSIDERATIONS: HISTORY OF PRESENT ILLNESS

- Chest pain
 - Onset and duration
 - Character
 - Location
 - Severity
 - Associated symptoms
 - Treatment
 - Medications

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PAST MEDICAL HISTORY

- Cardiac surgery and hospitalization
- Congenital heart disease
- Rhythm disorder
- Acute rheumatic fever, unexplained fever, swollen joints, inflammatory rheumatism
- Kawasaki disease
- Chronic illness

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FAMILY HISTORY

- Long QT syndrome
- Marfan syndrome
- Diabetes
- Heart disease
- Dyslipidemia
- Hypertension
- Congenital heart defects
- Family members with cardiac risk factors

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PERSONAL AND SOCIAL HISTORY

- Employment
 - Physical demands
 - Environmental hazards
- Tobacco use
- Nutritional status
- Usual diet
- Weight
- Alcohol consumption
- Known hypercholesterolemia/triglycerides
- Relaxation/hobbies
- Exercise
- Illicit drug use

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INFANTS

- Tiring easily during feeding
- Breathing changes
- Cyanosis
- Weight gain as expected
- Knee-chest position or other favored position
- Mother's health during pregnancy

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CHILDREN

- Tiring during play
- Naps
- Positions at play and rest
- Headaches
- Nosebleeds
- Unexplained joint pain
- Unexplained fever
- Expected height and weight gain
- Expected physical and cognitive development
- Barrel chest

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PREGNANT WOMEN

- History of cardiac disease or surgery
- Dizziness or faintness on standing
- Indications of heart disease during pregnancy
 - Progressive or severe dyspnea
 - Progressive orthopnea
 - Paroxysmal nocturnal dyspnea
 - Hemoptysis
 - Syncope with exertion
 - Chest pain related to effort or emotion

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OLDER ADULTS

- Common symptoms of cardiovascular disorder
 - Confusion and syncope
 - Palpitations
 - Coughs and wheezes
 - Hemoptysis
 - Shortness of breath
 - Chest pain and tightness
 - Incontinence, impotence, and heat intolerance
 - Fatigue
 - Leg edema

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OLDER ADULTS (CONT.)

- Previous diagnosis of heart disease
- Drug reactions
- Potassium depletion
- Digitalis toxicity
- Interference with activities of daily living
- Ability of the patient and family to cope with the condition
- Orthostatic hypotension

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EXAMINATION AND FINDINGS

- The examination of the heart includes the following:
 - Inspecting
 - Palpating
 - Percussing the chest (limited value, but might be asked to perform on NBCE Part IV exam)
 - Auscultating the heart
- In assessing cardiac function, it is a common error to listen to the heart first
 - It is important to follow the proper sequence

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EQUIPMENT

- Stethoscope with bell and diaphragm
- Marking pencil
- Centimeter ruler

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INSPECTION

- Apical impulse
 - Should be visible at about the midclavicular line in the fifth left intercostal space
 - In some patients, it may be visible in the fourth left intercostal space
 - It should not be seen in more than one space if the heart is healthy
 - Obscured by obesity, large breasts, or muscularity

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PALPATION

- Textbook: Precordial palpation sequence
 - Apex
 - Up the left sternal border
 - Base
 - Down the right sternal border
 - Into the epigastrium or axillae if the circumstance dictates
- Easier to remember: APETM @ 2 2 3 4 5
 - Aortic @ 2RICS
 - Pulmonic @ 2LICS
 - Erb's Point @ 3LICS
 - Tricuspid @ 4LICS
 - Mitral @ 5LICS
- A PET Monkey

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PALPATION (CONT.)

- Apical impulse
 - *Point of maximal impulse* (PMI)
 - Point at which the apical impulse is most readily **seen** or **palpated**
 - If it is more vigorous than expected, characterize it as a *heave* or *lift*
 - *Thrill*: a fine, palpable, rushing vibration; a palpable murmur
- Carotid artery palpation

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PERCUSSION

- Of limited value in defining borders of heart or determining its size
- Left ventricular size is better judged by the location of the apical impulse
- Right ventricle tends to enlarge in the anteroposterior diameter rather than laterally
- Obesity, unusual muscular development, and some pathologic conditions can easily distort the findings
- Chest radiograph is far more useful in defining the heart borders
- But, if you're asked to perform on Part IV...

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AUSCULTATION

- There are five traditionally designated auscultatory areas, located as follows:
 - Aortic valve area
 - Second right intercostal space at the right sternal border
 - Pulmonic valve area
 - Second left intercostal space at the left sternal border
 - Erb's Point/Second pulmonic area
 - Third left intercostal space at the left sternal border
 - Tricuspid area
 - Fourth left intercostal space along the lower left sternal border
 - Mitral (or apical) area
 - Apex of the heart in the fifth left intercostal space at the midclavicular line

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AUSCULTATION (CONT.)

- Assess overall rate and rhythm
- Frequency
- Intensity
- Duration
- Pathology

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HEART SOUNDS

- Basic heart sounds
 - S₁, or S₂ most distinct
 - Splitting
 - S₃ and S₄ difficult to hear
- Extra heart sounds
 - Gallops
 - Mitral snaps
 - Ejection clicks
 - Friction rubs

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HEART SOUNDS (CONT.)

- Heart murmurs
 - Timing and duration
 - Pitch
 - Intensity
 - Pattern
 - Quality
 - Location and radiation
 - Respiratory phase variations

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RHYTHM DISTURBANCE

- Determine the steadiness of the heart rhythm, which should be regular
- If it is irregular, determine whether there is a consistent pattern
 - Irregular but occurring in a repeated pattern may indicate sinus dysrhythmia, a cyclic variation of the heart rate
 - Patternless, unpredictable, irregular rhythm may indicate heart disease or conduction system impairment

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INFANTS

- Examine newborn at birth or at 2 to 3 days for circulation transition signs.
- Heart function examination includes skin, lungs, and liver.
- Inspect color of skin and mucous membranes.
- Look for enlargement of heart and position if dyspneic.
- Heart sounds are difficult to assess; vigor and quality are indicators of heart function.
- Heart rates vary with eating, sleeping, and waking.
- Murmurs are common until 48 hours of age.

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CHILDREN

- Bulging precordium if long-standing heart enlargement = barrel chest
- Sinus arrhythmia a physiologic event of childhood
- Other arrhythmias usually ectopic in origin (supraventricular and ventricular ectopic beats) and only occasionally require investigation

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CHILDREN (CONT.)

- Heart rates more variable than in adult
- Expected heart rates variable with child's age
- Most murmurs in infants and children are the result of congenital heart disease
 - Kawasaki disease accounts for most acquired murmurs
 - Some murmurs are innocent, caused by the vigorous expulsion of blood from the left ventricle into the aorta; it increases in intensity with activity and diminishes when the child is quiet (still murmur)

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CHILDREN (CONT.)

- Child with known heart disease
 - Weight gain or loss
 - Developmental delays
 - Cyanosis
 - Clubbing of fingers or toes

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PREGNANT WOMEN

- Heart position shifts as size and position of uterus changes
- Apical impulse shifts up and laterally 1 to 1.5 cm
- Heart sounds change with increased blood volume
 - Audible splitting of S_1 and S_2
 - S_3 may be readily heard after 20 weeks of gestation
 - Systolic ejection murmurs (SEMs) may be heard over the pulmonic area in 90% of pregnant women
- No significant change in the ECG

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OLDER ADULTS

- Slow down pace of examination
 - Positions that may be uncomfortable or perhaps too difficult
 - May not be able to lie flat for an extended time
 - May not be able to control their breathing pattern at your request
 - An abrupt position change may cause a transient lightheadedness because of a drop in arterial pressure

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OLDER ADULTS (CONT.)

- Apical impulse is harder to find
 - Increased anteroposterior chest diameter
 - Obesity
- S_4 heart sound is more common
 - May indicate decreased left ventricular compliance
- Early, soft, physiologic murmurs may result from aortic lengthening, tortuosity, and sclerotic changes

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OLDER ADULTS (CONT.)

- Common ECG changes
 - First-degree AV block
 - Bundle branch blocks
 - ST-T wave abnormalities
 - Premature systole (atrial and ventricular)
 - Left anterior hemiblock
 - Left ventricular hypertrophy
 - Atrial fibrillation
 - Occasional ectopic beats

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ABNORMALITIES

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CARDIAC DISORDERS

- Angina
 - Pain caused by myocardial ischemia
- Bacterial endocarditis
 - Bacterial infection of the endothelial layer of the heart and valves
- Congestive heart failure – left sided
 - Heart fails to propel blood forward with its usual force, resulting in congestion in the pulmonary circulation
- Congestive heart failure – right sided
 - Heart fails to propel blood forward with its usual force, resulting in congestion in the systemic circulation
- Pericarditis
 - Inflammation of the pericardium

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CARDIAC DISORDERS (CONT.)

- **Cardiac tamponade**
 - Excessive accumulation of effused fluids or blood between the pericardium
- **Cor pulmonale**
 - Enlargement of the right ventricle secondary to chronic lung disease
- **Myocardial infarction**
 - Ischemic myocardial necrosis caused by abrupt decrease in coronary blood flow to a segment of the myocardium
- **Myocarditis**
 - Focal or diffuse inflammation of the myocardium

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ABNORMALITIES IN HEART RATES AND RHYTHMS

- **Conduction disturbances**
 - Conduction disturbances either proximal to the bundle of His or diffusely throughout the conduction system
- **Sick sinus syndrome**
 - Arrhythmias caused by a malfunction of the sinus node

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INFANTS AND CHILDREN

- **Tetralogy of Fallot**
 - Ventricular septal defect
 - Pulmonic stenosis
 - Dextroposition of the aorta
 - Right ventricular hypertrophy
- **Ventricular septal defect**
 - Opening between the left and right ventricles
- **Patent ductus arteriosus**
 - Failure of the ductus arteriosus to close after birth

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INFANTS AND CHILDREN (CONT.)

- **Atrial septal defect**
 - Congenital defect in the septum dividing the left and right atria
- **Acute rheumatic fever**
 - Systemic connective tissue disease occurring after streptococcal pharyngitis or skin infection

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OLDER ADULTS

- **Atherosclerotic heart disease (coronary artery disease)**
 - Caused by deposition of cholesterol, other lipids, and by a complex inflammatory process
- **Mitral insufficiency/regurgitation**
 - Abnormal leaking of blood through the mitral valve, from left ventricle into left atrium
- **Senile cardiac amyloidosis**
 - Amyloid, fibrillary protein produced by chronic inflammation or neoplastic disease, deposition in the heart

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COMPARISON OF SOME TYPES OF CHEST PAIN

| Cardiac | Musculoskeletal | Gastrointestinal |
|---|---|---|
| Presence of cardiac risk factors | History of trauma | History of indigestion |
| Specifically noted time of onset | Vague onset | Vague onset |
| Related to physical effort or emotional | Related to physical effort | Related to food consumption or psychosocial stress |
| Disappears if stimulating cause can be terminated | Continues after cessation of effort | May go on for several hours; unrelated to effort |
| Commonly forces patients to stop effort | Patients often can continue activity | Patients often can continue activity |
| Patient may awaken from sleep | Delays falling asleep | Patient may awaken from sleep, particularly during early morning |
| Relief at times with nitroglycerin | Relief at times with heat, nonsteroidal antiinflammatory drugs, or rest | Relief at times with antacids |
| Pain often in early morning or after washing and eating | Worse in evening after a day of physical effort | No particular relationship to time of day; related to food, tension |
| Greater likelihood in cold weather | Greater likelihood in cold, damp weather | Anytime |

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ANGINA PECTORIS

| Pathophysiology | Subjective Data | Objective Data |
|---|--|--|
| <ul style="list-style-type: none"> • Occurs when myocardial oxygen demand exceeds supply • Can be recurrent or present as initial incidence | <ul style="list-style-type: none"> • Substernal pain or intense pressure radiating to the neck, jaws, and arms, particularly the left • Often accompanied by shortness of breath, fatigue, diaphoresis, faintness, and syncope | <ul style="list-style-type: none"> • No definitive examination findings suggest angina • Tachycardia, tachypnea, hypertension, and/or diaphoresis • Ischemia may lead to presence of crackles due to pulmonary edema or a reduction in the S1 intensity or an S4 • Physical examination may suggest other comorbidities that place the patient at higher risk for angina symptoms, such as COPD, xanthelasma, hypertension, evidence of peripheral arterial disease, abnormal pulsations on palpation over precordium, murmurs, or arrhythmias |