

Unit 2: Anatomy of the Respiratory and Circulatory Systems

Subject: Human Anatomy

Unit 2: Anatomy of the Respiratory and Circulatory Systems

(Respiratory System • Organs of the Respiratory Tract • Circulatory System - Structure of the Heart • Major Arteries & Veins with Applied Anatomy)

2.1 Respiratory System — Overview and Functions

The **respiratory system** sustains life by exchanging gases between air and blood and by supporting voice and smell. It works as a two-zone conduit:

- **Conducting zone:** nose → pharynx → larynx → trachea → bronchi → terminal bronchioles (warms, filters, humidifies air; no gas exchange).
- **Respiratory zone:** respiratory bronchioles → alveolar ducts → **alveoli** (site of gas exchange across a thin blood-air barrier).

Core functions

- Ventilation: mechanical movement of air by the thoracic pump (diaphragm & intercostals).
- Gas exchange: O2 in, CO2 out at alveoli.
- Air conditioning & defense: cilia, mucus, IgA, cough/sneeze reflexes.
- Phonation: laryngeal vocal folds.
- Olfaction: nasal cavity roof (olfactory epithelium).
- Acid-base balance: CO2 regulation influences blood pH.

2.2 Structure of the Organs of the Respiratory Tract

2.2.1 Nose & Paranasal Sinuses

- External nose with nares opens into the nasal cavity, divided by a septum (vomer + perpendicular plate + cartilage).
- **Turbinates (conchae):** create turbulence → warming & humidification.
- Epithelium: respiratory (ciliated pseudostratified columnar with goblet cells); olfactory mucosa at roof.
- Sinuses: frontal, ethmoidal, sphenoidal, maxillary—lighten skull, condition air, resonate voice.

 Applied: deviated septum, sinusitis, epistaxis; Jala Neti (saline rinse) improves nasal hygiene when done correctly.

2.2.2 Pharynx (nasopharynx, oropharynx, laryngopharynx)

Muscular tube shared by respiratory & digestive systems; houses tonsils (immune role).

Applied: sleep-disordered breathing (enlarged tonsils), aspiration risks.

2.2.3 Larynx (voice box)

- Cartilages: single (thyroid, cricoid, epiglottis) and paired (arytenoid, corniculate, cuneiform).
- Vocal folds: true (phonation) vs false (vestibular).
- **Muscles & nerves:** intrinsic muscles adjust tension and glottis; chiefly innervated by branches of **vagus nerve** (superior laryngeal & recurrent laryngeal).

Applied: hoarseness (recurrent laryngeal injury), laryngospasm, safe voice use in teaching.

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2.2.4 Trachea & Bronchial Tree

- Trachea: C-shaped hyaline cartilage rings; posterior muscular wall (trachealis); lined by ciliated respiratory epithelium.
- Bifurcates at carina → right main bronchus (shorter, wider, more vertical) & left main bronchus.
- Further divides: lobar (secondary) → segmental (tertiary) bronchi → bronchioles → terminal bronchioles → respiratory bronchioles.

Conducting vs respiratory portions

Feature	Conducting	Respiratory
Structures	Nose to terminal bronchioles	Respiratory bronchioles → alveoli
Epithelium trend	Ciliated → simple cuboidal	Simple squamous (Type I pneumocytes)
Function	Air conditioning & defense	Gas exchange

2.2.5 Lungs, Pleura & Segments

- Right lung: 3 lobes (upper, middle, lower); Left lung: 2 lobes + lingula.
- Pleura: visceral (on lung) & parietal (lining thoracic wall) with pleural cavity (thin fluid film).
- Bronchopulmonary segments (surgical units): pyramidal, each with its own segmental bronchus & artery; disease can be localized/resected by segments.

2.2.6 Alveoli & the Blood-Air Barrier

- Alveolar wall cells:
 - o Type I pneumocytes: thin squamous; gas diffusion.
 - Type II pneumocytes: produce surfactant (reduces surface tension, prevents collapse).
 - Alveolar macrophages: phagocytosis.
- **Blood-air barrier:** surfactant → Type I cell → fused basement membrane → capillary endothelium.

Applied: neonatal respiratory distress (surfactant deficiency), pneumonia (alveolar exudate), pulmonary edema (thickened barrier).

2.2.7 Pulmonary & Bronchial Circulation; Lymph & Nerves

- Pulmonary arteries carry deoxygenated blood from right ventricle → capillaries around alveoli → pulmonary veins return oxygenated blood to left atrium.
- Bronchial arteries (from aorta) nourish airway walls; bronchial veins drain partly to azygos system.
- Lymphatics: superficial & deep networks → hilar nodes → tracheobronchial nodes.
- Innervation:
 - Parasympathetic (vagus): bronchoconstriction, mucus 1.
 - Sympathetic: bronchodilation, mucus ↓.
 - **Applied:** asthma (bronchoconstriction & inflammation) responds to bronchodilators and controlled breathing techniques.

2.2.8 Mechanics of Breathing

- **Primary muscle: diaphragm** (domes descend → thoracic volume ↑).
- External intercostals: elevate ribs (inspiration).
- Internal intercostals (interosseous): forced expiration.
- Accessory inspiratory muscles: sternocleidomastoid, scalenes (in distress or effort).

Phase	What happens	Energy
Quiet inspiration	Diaphragm contracts; ribs elevate	Active
Quiet expiration	Elastic recoil of lungs & chest wall	Passive
Forced expiration	Abdominals + internal intercostals	Active

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Yoga/clinical link: diaphragmatic (abdominal) breathing improves lower-lobe ventilation, reduces accessory neck muscle overuse, supports vagal tone. Avoid prolonged breath-holds in uncontrolled hypertension, cardiac disease, glaucoma.

2.3 Circulatory System — Structure of the Heart

2.3.1 Position & Coverings

- Location: mediastinum; 2/3 left of midline; apex at 5th left intercostal space, mid-clavicular line.
- Pericardium: fibrous (outer) + serous (parietal & visceral/epicardium).

2.3.2 Layers of the Heart Wall

Epicardium (visceral pericardium) → **Myocardium** (cardiac muscle; thickest) → **Endocardium** (endothelium + CT).

2.3.3 Chambers, Valves & Flow

- Right atrium (from SVC/IVC/coronary sinus) → tricuspid valve → right ventricle → pulmonary valve → pulmonary trunk/arteries.
- Left atrium (from pulmonary veins) → mitral valve → left ventricle → aortic valve → aorta.
- Chordae tendineae + papillary muscles prevent AV valve prolapse.

Heart sounds: S1 (AV valves close; start systole), **S2** (semilunar close; start diastole). **Murmurs** = turbulent flow (e.g., regurgitation/stenosis).

2.3.4 Conduction System

SA node (pacemaker, RA) \rightarrow **AV** node (delay) \rightarrow **Bundle** of His \rightarrow right & left bundle branches \rightarrow Purkinje fibers (ventricular depolarization).

Autonomics: sympathetic ↑ rate & force; parasympathetic (vagus) ↓ rate.

2.3.5 Coronary Circulation

- Right coronary artery (RCA): SA nodal branch (often), right marginal, posterior interventricular (PDA in right-dominant hearts).
- Left coronary artery (LCA): LAD (anterior interventricular) & circumflex.
- **Venous drainage:** great/middle/small cardiac veins → **coronary sinus** → RA.

Applied: LAD occlusion = "widow-maker" myocardial infarction; angina (ischemia), revascularization options.

2.3.6 Cardiac Cycle (overview)

- **Diastole:** ventricular filling (passive → atrial kick); AV valves open.
- **Systole:** isovolumetric contraction → ejection; semilunar valves open.
- Stroke volume (SV) × Heart rate (HR) = Cardiac output (CO).

Practitioner note: avoid intense **kumbhaka** or strong **bandhas** in unstable cardiac conditions; favor gentle, paced breathing and low-intensity movement with medical clearance.

2.4 Major Arteries and Veins of the Body — with Applied Anatomy

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2.4.1 Arterial Tree (high-yield map)

Aorta

- Ascending aorta → coronary arteries.
- Arch of aorta →
 - 1. Brachiocephalic trunk → right common carotid & right subclavian,
 - 2. Left common carotid.
 - 3. Left subclavian.
- Thoracic aorta: intercostals, bronchial, esophageal branches.
- Abdominal aorta:
 - Unpaired viscera: Celiac trunk (foregut), SMA (midgut), IMA (hindgut).
 - **Paired:** renal, suprarenal, gonadal, lumbar.
 - Ends as common iliac arteries → external iliac (→ femoral) & internal iliac (pelvic).

Upper limb pathway: subclavian → **axillary** → **brachial** (→ **radial** & **ulnar**).

Lower limb pathway: external iliac \rightarrow femoral \rightarrow popliteal \rightarrow anterior tibial (\rightarrow dorsalis pedis) & posterior tibial (\rightarrow plantar).

Palpable pulse points (exam & clinic)

	Site	Artery	Note	
	Neck	Carotid	Palpate one side at a time	
	Arm	Brachial	BP cuff placement (mid-arm, artery alignment)	
	Wrist	Radial	Common pulse check; Allen test before cannulation	
	Groin	Femoral	Central pulse; hemorrhage control	
	Knee	Popliteal	Deep; knee slightly flexed	
Ankle/Foot Posterior tibial , Dorsalis pedis Peripheral vascular check (diabetes)				

2.4.2 Venous System (deep vs superficial; key conduits)

- Superior vena cava (SVC): returns blood from head, neck, upper limbs, thorax; formed by brachiocephalic veins (internal jugular + subclavian). Azygos drains thoracic wall to SVC.
- Inferior vena cava (IVC): returns from abdomen, pelvis, lower limbs; tributaries include common iliac, renal, hepatic veins.

Portal system: portal vein = splenic + superior mesenteric; carries nutrient-rich blood to liver → hepatic veins → IVC.

Porto-systemic anastomoses: esophageal, umbilical, rectal (varices risk in portal hypertension).

Superficial veins of clinical use

- Upper limb: cephalic, basilic, median cubital (common venipuncture).
- Lower limb: great saphenous (medial; graft source), small saphenous (posterior calf).
 Applied: varicose veins (valve failure), DVT (calf pain, swelling; risk → pulmonary embolism); early mobilization, calf pumps, hydration help prevention.

2.5 Integrated Applied Anatomy — From Lab to Mat

- Breathing practice: prioritize diaphragmatic & long exhale patterns to mobilize lower ribs and favor vagal tone. Avoid strong breath retentions in uncontrolled hypertension/ischemia.
- Posture & lungs: upright/seated postures improve functional residual capacity vs prolonged slumped sitting; gentle thoracic extension aids ventilation.
- Pulse/BP skills: know radial (routine), brachial (BP), and carotid (emergency) pulse sites; correct cuff size &

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placement prevent false readings.

• Vascular care: during long sessions, encourage ankle pumps and walking breaks in at-risk participants to reduce venous stasis.

Unit Summary

The **respiratory system** conducts, conditions, and exchanges gases: air travels from nose to alveoli, where a microscopic **blood-air barrier** enables O₂-CO₂ exchange. Mechanics depend on the **diaphragm, intercostals**, chest wall, and lung elasticity. The **heart**—a valved, four-chambered pump with its own conduction and coronary blood supply—drives circulation. From the **aorta** flow the great arteries; blood returns via the **caval** and **portal** systems, supported by deep and superficial veins. Applied understanding guides safe breathing practices, accurate pulse/BP assessment, and vascular health during yoga and community work.

Key Terms

- Conducting zone / Respiratory zone Alveolus (Type I/II), Surfactant
- Pleura (visceral/parietal) Diaphragm Bronchoconstriction/Bronchodilation
- Pericardium (fibrous/serous) SA/AV node, Purkinje Coronary arteries (RCA, LCA, LAD, Circumflex)
- Systole/Diastole, S1/S2 Aorta (arch branches, abdominal branches)
- SVC/IVC Portal vein & porto-systemic anastomoses DVT, Varicose veins
- Pulse sites
 Allen test
 Functional residual capacity

Self-Assessment

MCQs

- 1. **Surfactant** is produced by:
 - a) Type I pneumocytes b) Type II pneumocytes c) Alveolar macrophages d) Goblet cells
- 2. The right main bronchus is:
 - a) Longer and narrower b) Shorter, wider, more vertical c) Longer and more horizontal d) Absent in many people
- 3. **S1** corresponds to closure of:
 - a) Aortic & pulmonary valves b) Mitral & tricuspid valves c) Only aortic valve d) Only mitral valve
- 4. The **widow-maker** infarct typically involves the:
 - a) Circumflex artery b) Right marginal artery c) LAD (anterior interventricular) d) Posterior interventricular artery
- 5. **Great saphenous vein** drains into the:
 - a) Popliteal vein b) Femoral vein c) External iliac vein d) IVC directly

Answer key: 1-b, 2-b, 3-b, 4-c, 5-b

Short Answer

- 1. Trace the airflow from nares to alveoli and name two defenses that condition/clean the air.
- 2. Describe the **blood-air barrier** and explain why edema impairs gas exchange.
- 3. Sketch the pathway of blood through the **heart** starting from the SVC/IVC to the aorta, naming all valves.
- 4. List the arch of aorta branches and two abdominal aorta unpaired branches with their territories.
- 5. Name **four pulse points** and one clinical use for each.

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Reflective/Application

- 1. In a seated breathing practice, place one hand on the **upper chest** and one on the **abdomen**. Describe how the movement changes when you shift to **diaphragmatic breathing**. How does your perceived calm change after 3 minutes?
- 2. During community screening, you palpate a **weak dorsalis pedis** pulse on one side. What **history questions** and **follow-up checks** will you perform next?

End of Unit 2: Anatomy of the Respiratory and Circulatory Systems

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