The Respiratory System

Student Objectives:

- Compare and contrast structural and functional differences found in health and disease
- Apply critical thinking skills in various anatomical and physiological situations

Terms for review:

- Recall the definitions and locations of the following terms
  - Pathogen
  - Diffusion
  - Solubility
  - Cellular respiration
  - Diaphragm
  - Scalenus
  - Sternocleidomastoid
  - Pectoralis minor
  - Internal and external intercostals
  - Internal and external obliques
  - Rectus abdominis
  - Transverse abdominis
  - Mediastinum
  - Serous membranes (visceral and parietal)
  - Serous fluid
  - Pleura
  - pH

Terms:

- Define the following terms
  - External respiration
  - Internal respiration
  - Cellular respiration
  - Conducting zone
  - Anatomical dead space
  - Respiratory zone
  - Surfactant
  - Phonation
  - Articulation
  - Pleural fluid
  - Pulmonary ventilation
  - Compliance
  - Pneumothorax
  - Quiet breathing
  - Forced breathing
  - Saturation
  - Valsalva maneuver
  - Oxyhemoglobin
  - Dissociation
  - Boyles law
  - Intrapleural pressure
  - Alveolar pressure
  - Dalton’s law
  - Hypercapnia
  - Hypocapnia
  - Ventilation–perfusion coupling
  - Affinity

Overview:

- Explain the primary functions of the respiratory system
- Identify and describe the organs and structures of the respiratory system.
- Describe the location of the anatomical structures.
- Discuss how and why the respiratory system conditions air
- Describe the histology or cellular make-up of the anatomical structures.
- Explain the function of each and every micro and macro structure listed below.
- Explain the importance of the respiratory and conducting zones
- List which structures make up the conducting zone and the respiratory zone
- List the structures found in the upper respiratory system and the lower respiratory system
- Discuss how the histology changes as you move down the respiratory tract
- Explain how the delicate respiratory exchange surfaces are protected from pathogens, debris and other hazards
- Trace the blood supply for the lungs
- Discuss details of sound production.
Anatomy

I. Lungs
   A. Subdivisions
      1. Lobes – superior, middle, inferior
      2. Fissures (difference between right and left)
         a. Oblique / horizontal (right lung only)
      3. Lobules
   B. Surface anatomy
      1. Apex
      2. Base
      3. Cardiac notch
      4. Hilus
      5. Costal surface
      6. Mediastinal surface or medial surface
      7. Pleural membrane
         a. Parietal pleura
         b. Pleural cavity
            i. Pleural fluid
         c. Visceral pleura

II. Layers of walls
   A. Mucosa
      1. Epithelium
      2. basal lamina (basement membrane)
      3. Lamina propria
   B. Submucosa
   C. Muscularis
      1. skeletal support
   D. Serosa or adventitia

III. Upper respiratory system
   A. Nasal cavity
      1. anatomy
         a. External nares (naris, choanae)
         b. Roof – ethmoid and sphenoid bones
         c. Floor
            i. hard palate (maxillary and palatine bones)
         d. Vestibule
         e. Nasal septum
         f. Conchae (turbinates) - superior, middle, inferior
         g. Meatuses – superior, middle, inferior
         h. Olfactory epithelium
         i. Internal nares (posterior nasal aperture, choanae)
         j. (Paranasal) sinuses
            • Maxillary
            • Frontal
            • Ethmoid
            • Sphenoid
      2. Histology
         a. Pseudostratified ciliated columnar epithelium
            i. Goblet cells
         b. Lamina propria – lots of vessels
   B. Pharynx (throat)
      1. Anatomy
         a. Nasopharynx
            i. Eustachian tube (auditory tube or pharyngotympanic)
            ii. Pharyngeal tonsil (adenoids)
            iii. Soft palate
         b. Oropharynx
i. Fauces – opening from mouth
ii. Uvula
iii. Palatine tonsils
iv. Lingual tonsils
c. Laryngopharynx – continuous with esophagus and larynx

2. histology
   a. nasopharynx – same as nasal mucosa
   b. oropharynx – stratified squamous epithelium
   c. laryngopharynx – stratified squamous epithelium

IV. Lower respiratory system

A. Larynx – voice box
   1. Anatomy
      a. Glottis
      b. Cartilages
         i. Epiglottis
         ii. Thyroid cartilage
            • Laryngeal prominence (Adam’s apple)
         iii. Cricoid cartilage
         iv. Arytenoid cartilages (2)
         v. Corniculate cartilages (2)
         vi. Cuneiform cartilages (2)
      c. Ventricular folds (vestibular) - false vocal cords
      d. Vocal folds – true vocal cords
   2. histology
      a. above vocal folds – stratified squamous epithelium
      b. below vocal folds – ciliated columnar epithelium
         i. goblet cells
         ii. cilia

B. Trachea
   1. histology
      a. pseudostratified ciliated columnar epithelium
         i. goblet cells
         ii. cilia
      b. Tracheal cartilages
      c. Trachealis muscle
         i. allows expansion when swallowing
         ii. controls diameter of lumen for cough
      d. adventitia

C. Bronchi (bronchus) and bronchioles
   1. anatomy
      a. Primary (main) bronchi
         i. Carina
            • Right bronchus
            • Left bronchus
      b. Secondary bronchi (lobar bronchi)
      c. Tertiary bronchi (segmental bronchi)
      d. Bronchioles
      e. Terminal bronchioles
      f. Respiratory bronchioles
   2. histology
      a. simple columnar ep → simple cuboidal ep → simple squamous ep
      b. decreased cilia
      c. decreased goblet cells
      d. decreased cartilage
      e. increased smooth muscle

D. Alveoli
   1. Anatomy
a. Alveolus
   i. Extensive capillary network associated
   ii. Elastic fibers
b. Alveolar ducts
c. Alveolar sacs
d. Alveoli
   i. Type I alveolar cell (squamous alveolar cell) – simple squamous epithelial cell
   ii. Type II alveolar cell (septal cell, great alveolar cell)
      • Surfactant
   iii. Alveolar macrophage (dust cell)
E. Respiratory membrane (air-blood barrier)
   1. alveolar wall
   2. fused basal lamina
   3. capillary wall

Physiology
I. Introduction
   A. Blood supply
   B. Conducting portion
      1. conditioning air
      2. sound production
         a. sound
         b. loudness
         c. pitch
         d. resonance
         e. vowel sounds and enunciation
   3. Structures
      a. Nasal cavity, Pharynx, Larynx, Trachea, Bronchi, Bronchioles and Terminal bronchioles
C. Respiratory portion
   1. alveoli
      a. Anatomy
         i. Extensive capillary network associated
         ii. Elastic fibers
      b. Histology
         i. Type I alveolar cell – simple squamous epithelial cell
         ii. Type II alveolar cell (septal cell)
            • Surfactant
         iii. Alveolar macrophage (dust cell)
      iv. Interalveolar pores
D. Surfactant
II. Clinical Applications
   A. Normal versus collapsed lung
   B. Lung cancer
   C. Compression of bronchial tubes
III. Pulmonary Ventilation
   A. Movement of Air
      1. Boyles Law: gas pressure and volume
      2. Pressure and airflow to lungs
   B. Mechanics of Respiratory Movement
      1. Inspiration
         a. Quiet inspiration – diaphragm, external intercostals
         b. Forced inspiration - sternocleidomastoid, scalenes, pectoralis minor
      2. Expiration
         a. Quiet expiration – only relaxation of inspiratory muscles
         b. Forced expiration – abdominal muscles (external oblique, internal oblique, rectus abdominus, transverse abdominus), internal intercostals
      3. Pressure changes
a. Intrapleural pressure
   i. Intrapleural space (pleural cavity)
b. Alveolar pressure
4. Compliance of lungs
5. Clinical applications

C. Respiratory volumes and rates
   1. Volumes and capacities
      a. Tidal Volume
      b. Inspiratory capacity
      c. Inspiratory reserve volume
      d. Expiratory reserve volume
      e. Vital capacity
      f. Residual volume
      g. Functional residual capacity
      h. Total lung capacity
   2. Rates
      a. Respiratory rate
      b. Respiratory minute volume
   3. Alveolar ventilation and anatomic dead space

IV. Gas Exchange
   A. The Gas Laws
      1. Dalton’s Law: partial pressures
      2. Henry’s Law: diffusion between liquids and gases
         a. Hyperbaric oxygenation
   B. Diffusion and Respiratory Function
      1. External Respiration
      2. Internal Respiration
      3. Efficiency of diffusion
   C. Gas Pickup and Delivery
      1. Oxygen transport
         a. Hemoglobin and Oxygen partial pressure
         b. Hemoglobin and CO2 partial pressure
         c. Hemoglobin and pH: Bohr Effect
         d. Hemoglobin and BPG
         e. Fetal hemoglobin
      2. Carbon dioxide transport
         a. Plasma
         b. Carbonic acid
            i. Chloride Shift
         c. Hemoglobin

V. Control of Respiration
   A. Local regulation
   B. Innervation
   C. Respiratory centers of Brain
      1. Medulla
         a. Respiratory rhythmicity centers
            i. Dorsal respiratory group (DRG)
            ii. Ventral respiratory group (VRG)
         b. CNS stimulants/depressants alter respiratory rates
      2. Pons
         a. Pneumotaxic Center
         b. Apneustic Center
D. Respiratory Reflexes
   1. Chemoreceptor reflexes
      a. Hypercapnia and hypoventilation
      b. Hypocapnia and hyperventilation
   2. Baroreceptor reflexes
   3. Hering-Breuer reflexes
      a. Inflation reflex
      b. Deflation reflex
   4. Protective reflexes
   5. Voluntary control

VI. Clinical Abnormalities
   A. Hypoxia
      1. hypoxic hypoxia
      2. anemic hypoxia
      3. ischemic hypoxia
      4. histotoxic hypoxia
   B. smoking and the respiratory system
   C. aging and the respiratory system

Clinical applications:
Tracheostomy
Ondine's Curse
Cystic fibrosis
Laryngitis
Anaphylaxis
Asthma
Pneumonia
Respiratory distress
Pleurisy
Pneumothorax
Chronic obstructive pulmonary disease
   Emphysema
   Chronic bronchitis
   Lung cancer
Tuberculosis
Pulmonary Edema
Cystic fibrosis
Smoking

Slides:
I. Trachea
   A. mucosa
      1. Epithelium
         a. pseudostratified ciliated columnar epithelium
         b. goblet cells
      2. lamina propria
      3. submucosa
      4. muscularis
   B. tracheal cartilage
      1. hyaline cartilage
   C. trachealis muscle
   D. adventitia
II. lung tissue
   A. alveolar duct
   B. alveolar sac
   C. alveoli
   D. type I alveolar cell
E. type II alveolar cell  
F. dust cell  
G. capillary  
H. bronchiole  
I. respiratory bronchiole  
J. respiratory membrane  

III. pneumonia  
IV. emphysema  
V. smoker’s lung  
VI. asthma  

Sheep Plucks  
- Trachea  
- Tracheal cartilages  
- Trachealis muscle  
- Carina  
- Primary bronchi  
- Secondary bronchi (lobar bronchi)  
- Tertiary bronchi (segmental bronchi)  
- Bronchioles  
- Lungs  
- Lobes – superior, middle, inferior  
- Lobules  
- Apex  
- Base  
- Cardiac notch  
- Hilus  
- Oblique fissures  
- Horizontal fissures  
- Costal surface  
- Mediastinal surface or medial surface  
- Visceral pleura  
- Larynx  
- Epiglottis  
- Thyroid cartilage  
- Cricoid cartilage  
- Surfactant