Chapter 13
The Respiratory System

Slides 13.1 – 13.30

Lecture Slides in PowerPoint by Jerry L. Cook

Copyright © 2003 Pearson Education, Inc. publishing as Benjamin Cummings
Function of the Respiratory System

- gas exchanges between the blood and external environment → takes place in the alveoli

- Passageways to the lungs purify, warm, and humidify the incoming air
Organs of the Respiratory system

- Nasal cavity
- External nares (nostrils)
THE NOSE
The Nose

External Nares (nostrils)

- Structure where air enters
Anatomy of the Nasal Cavity

- Columnar epithelium
- Secretory (goblet) cell
- Cilia
- Flow of mucus
- Frontal sinus
- Sphenoid sinus
- Adenoids
- Eustachian tube opening
- Opening of maxillary sinus
- Nasopharynx (shaded area)
- Tonsil
- Pharynx
- Epiglottis
- Larynx

Adenoviral pharyngitis
Common cold
Diphtheria
Ear infections
Epiglottitis
Laryngitis
Strep throat
Tonsillitis
Anatomy of the Nasal Cavity

- **Olfactory receptors** are located in the mucosa on the superior surface.

- The rest of the cavity is lined with respiratory **mucosa**
  - Moistens air
  - Traps incoming foreign particles
Anatomy of the Nasal Cavity
Anatomy of the Nasal Cavity

- Separated from the oral cavity by the palate
  - Anterior hard palate (bone)
  - Posterior soft palate (muscle)
Q. What is a cleft palate?
Cleft Palate

**FIGURE 1** Different extents of isolated cleft palate: A) uvula, B) soft palate, C) incomplete hard palate and D) complete hard palate
Q. What causes a cleft palate, what are the effects, and what are the treatments?
Q. What causes a cleft palate, what are the effects, and what are the treatments?

- Cause – genetic defect that occurs during gestation
Q. What causes a cleft palate, what are the effects, and what are the treatments?

- **Cause** – genetic defect that occurs during gestation
- **Effects** – problems with feeding and ear disease
Q. What causes a cleft palate, what are the effects, and what are the treatments?

- **Cause** – genetic defect that occurs during gestation

- **Effects** – problems with feeding and ear disease

- **Treatment** – series of corrective surgeries
Before and After
Paranasal Sinuses

Structures

- Cavities within bones surrounding the nasal cavity
Paranasal Sinuses

- **Function** of the sinuses
  - Lighten the skull
  - Resonance chambers for speech
  - Produce mucus that drains into the nasal cavity
Organs of the Respiratory system

- Nasal cavity
- External nares (nostrils)
- Pharynx

Figure 13.1
Pharynx (Throat)

Function

• Muscular passage from nasal cavity to larynx
Pharynx (Throat)

Structures

- Three regions of the pharynx
  - Nasopharynx, Oropharynx, and Laryngopharynx
- The oropharynx and laryngopharynx are common passageways for air and food
- Auditory tubes enter the nasopharynx
The Upper Division

- Pharyngeal tonsil
- Nasal conchae
- Opening of internal auditory (pharyngotympanic) canal
- Meati
- Palatine tonsil
- Lingual tonsil
- Nasopharynx
- Oropharynx
- Laryngopharynx
Larynx (Voice Box)

Function

- Routes air and food into proper channels
- Plays a role in speech
Structures of the Larynx

- **Thyroid cartilage**
  - Largest hyaline cartilage
  - Protrudes anteriorly (Adam’s apple)
Structures of the Larynx

- **Epiglottis**
  - Superior opening of the larynx
  - Routes food to the esophagus and air toward the trachea
Structures of the Larynx

- **Vocal cords (vocal folds)**
  - Vibrate with expelled air to create sound (speech)
- **Glottis** – opening between vocal cords
Vocal Cords Up Close While Singing
Trachea (Windpipe)

- Connects larynx with bronchi
- Lined with ciliated mucosa
- Walls are reinforced with C-shaped hyaline cartilage
Cilia in the Trachea w/Allergens
Q. Why is it important that the trachea is reinforced with cartilage rings?

Q. What is the advantage of the fact that the rings are incomplete posteriorly?
Q. Why is it important that the trachea is reinforced with cartilage rings?
A. The cartilage reinforcements keep the trachea patent during the pressure changes that occur during breathing.

Q. What is the advantage of the fact that the rings are incomplete posteriorly?
Q. Why is it important that the trachea is reinforced with cartilage rings?
A. The cartilage reinforcements keep the trachea patent during the pressure changes that occur during breathing.

Q. What is the advantage of the fact that the rings are incomplete posteriorly?
A. The incomplete rings of the posterior tracheal surface make it flexible, allowing a food bolus traveling through the posterior esophagus to bulge anteriorly.
Organs of the Respiratory system

- Nasal cavity
- External nares (nostrils)
- Larynx
- Pharynx
- Trachea
- Right primary bronchus
Primary Bronchi

- Formed by division of the trachea
- Enters the lung at the hilus (medial depression)
- Bronchi subdivide into smaller and smaller branches
- Right bronchus is wider, shorter, and straighter than left
Bronchi, Bronchial Tree, and Lungs

- Larynx
- Primary bronchi
- Secondary bronchi
- Tertiary bronchi
- Bronchioles
- Cardiac notch
- Trachea
- Pulmonary artery
- Pulmonary vein
- Alveolar duct
- Alveoli
Organs of the Respiratory system

- Nasal cavity
- External nares (nostrils)
- Oral cavity
- Larynx
- Pharynx
- Trachea
- Apex of left lung
- Right primary bronchus
- Base of left lung
- Diaphragm
Lungs

- Occupy most of the thoracic cavity
  - Apex is near the clavicle (superior portion)
  - Base rests on the diaphragm (inferior portion)
- Each lung is divided into lobes by fissures
  - Left lung – two lobes
  - Right lung – three lobes
Lungs

Figure 13.4b
Coverings of the Lungs

- **Pulmonary (visceral) pleura** covers the lung surface

- **Parietal pleura** lines the walls of the thoracic cavity

- **Pleural fluid** fills the area between layers of pleura to allow gliding
Respiratory Unit

Look for Crash Course Link Under today’s date.
Respiratory Tree Divisions

1. Primary bronchi
2. Secondary bronchi
3. Tertiary bronchi
4. Bronchioli
5. Terminal bronchioli
The Respiratory Tree

- Cricoid cartilage
- Tracheal cartilages
- Primary bronchi
- Secondary bronchi
- Tertiary bronchi
Bronchioles

- Smallest branches of the bronchi (Figure 13.5a)
Bronchioles

- Terminal bronchioles end in alveoli

Figure 13.5a
Respiratory Zone

- **Structures**
  - Respiratory bronchioli
  - Alveolar duct
  - Alveoli

- **Function**
  - Site of gas exchange
Zones of the Respiratory System

Hyaline cartilage plates

Conducting Zone
- Smooth muscle
- Respiratory bronchiole
- Alveoli

Respiratory Zone
- Elastic fibers
Alveoli

- **Structure** of alveoli
  - Alveolar duct
  - Alveolar sac
  - Alveolus

- **Function**
  - Gas exchange takes place within the alveoli in the respiratory membrane
Describe three reasons why the alveoli are ideal sites for gas exchange.

Alveolar Sac Structure

Alveoli are chambers of simple squamous epithelium. They connect to one another and to the alveolar duct. They form a sponge-like arrangement of gas-filled spaces in lung tissue.
1. Alveolar tissue is composed of simple squamous epithelium. This is ideal for gas exchange because....

2. Each alveolus are tiny interconnected circular sacs. This is ideal for gas exchange because....

3. The alveolus are surrounded by many capillaries. This is ideal for gas exchange because....
Pulmonary Ventilation (overview)

- Completely mechanical process
- Depends on volume changes in the thoracic cavity
- Volume changes lead to pressure changes, which lead to the flow of gases to equalize pressure
Pulmonary Ventilation

- Two phases
  - Inspiration – flow of air into lung
  - Expiration – air leaving lung
Pulmonary Ventilation
Pulmonary Ventilation
Pulmonary Ventilation

Diagram 9.4a) - Inspiration

Diagram 9.4b) - Expiration
Inspiration

- Diaphragm and external intercostal muscles contract
- The size of the thoracic cavity increases
- External air is pulled into the lungs due to an increase in intrapulmonary volume
Inspiration

Changes in anterior-posterior and superior-inferior dimensions

- Ribs elevated as external intercostals contract
- External intercostal muscles
- Diaphragm moves inferiorly during contraction

Changes in lateral dimensions

- Full inspiration

Figure 13.7a
at Rest  
Atmospheric pressure (760 mm Hg)  
Intra-alveolar pressure (760 mm Hg)  
Diaphragm

during Inspiration  
Atmospheric pressure (760 mm Hg)  
Intra-alveolar pressure (758 mm Hg)
Exhalation

- Largely a passive process which depends on natural lung elasticity
- As muscles relax, air is pushed out of the lungs
- Forced expiration can occur mostly by contracting internal intercostal muscles to depress the rib cage
Exhalation

Figure 13.7b
Respiratory Membrane (Air-Blood Barrier)

- Thin simple squamous epithelial layer lining alveolar walls
- Pulmonary capillaries cover external surfaces of alveoli
Respiratory Membrane (Air-Blood Barrier)

Figure 13.6
Gas Exchange

- Gas crosses the respiratory membrane by diffusion
  - Oxygen enters the blood
  - Carbon dioxide enters the alveoli
- Macrophages add protection
External Respiration

- Oxygen movement into the blood
  - The alveoli always has more oxygen than the blood
  - Oxygen moves by diffusion towards the area of lower concentration
  - Pulmonary capillary blood gains oxygen
External Respiration

- Carbon dioxide movement out of the blood
  - Blood returning from tissues has higher concentrations of carbon dioxide than air in the alveoli
  - Pulmonary capillary blood gives up carbon dioxide
- Blood leaving the lungs is oxygen-rich and carbon dioxide-poor
Internal Respiration

- Exchange of gases between blood and body cells
- An opposite reaction to what occurs in the lungs
  - Carbon dioxide diffuses out of tissue to blood
  - Oxygen diffuses from blood into tissue
Internal Respiration

Figure 13.11
External Respiration, Gas Transport, and Internal Respiration

Summary

Figure 13.10
Factors Influencing Respiratory Rate and Depth

- Physical factors
  - Increased body temperature
  - Exercise
  - Talking
  - Coughing
- Volition (conscious control)
- Emotional factors
Factors Influencing Respiratory Rate and Depth

- Chemical factors
  - Carbon dioxide levels in the blood
    - Main regulatory chemical for respiration
    - Increased carbon dioxide increases respiration
    - Changes in carbon dioxide act directly on the medulla oblongata
Factors Influencing Respiratory Rate and Depth

- Chemical factors (continued)
  - Oxygen levels
    - Changes in oxygen concentration in the blood are detected by chemoreceptors in the aorta and carotid artery
    - Information is sent to the medulla oblongata
Neural Regulation of Respiration

- Neural centers that control rate and depth are located in the medulla.
Neural Regulation of Respiration

- The pons appears to smooth out respiratory rate
- Normal respiratory rate (eupnea) is 12–15 respirations per minute
- Hypernia is increased respiratory rate often due to extra oxygen needs
Neural Regulation of Respiration

Figure 13.12

Breathing control centers stimulated by:

- CO₂ increase in blood (acts directly)
- Nerve impulse from O₂ sensor indicating O₂ decrease

Nerve impulses trigger contraction of muscles

Intercostal nerves

Diaphragm

Intercostal muscles

O₂ sensor in artery (aortic arch)

Phrenic nerves

Copyright © 2003 Pearson Education, Inc. publishing as Benjamin Cummings
Nonrespiratory Air Movements

- Can be caused by reflexes or voluntary actions

- Examples
  - Cough and sneeze – clears lungs of debris
  - Laughing
  - Crying
  - Yawn
  - Hiccup
Chronic Obstructive Pulmonary Disease (COPD)

- Tobacco smoke
- Air pollution

Continual bronchial irritation and inflammation

Breakdown of elastin in connective tissue of lungs

Chronic bronchitis
Excessive mucus produced, chronic productive cough, bronchospasm

Emphysema
Destruction of alveolar walls, lung fibrosis, air trapping

- Airway obstruction or air trapping
- Dyspnea
- Frequent infections

Respiratory failure

Figure 13.13
Respiratory Disorders: Chronic Obstructive Pulmonary Disease (COPD)

- Exemplified by chronic bronchitis and emphysema
- Major causes of death and disability in the United States
Respiratory Disorders: Chronic Obstructive Pulmonary Disease (COPD)

- Features of these diseases
  - Patients almost always have a history of smoking
  - Labored breathing (dyspnea) becomes progressively more severe
  - Coughing and frequent pulmonary infections are common
Features of these diseases (continued)

- Most victims retain carbon dioxide, are hypoxic and have respiratory acidosis
- Those affected will ultimately develop respiratory failure
Eight minutes off my life... for a CIGARETTE??

I don’t want emphysema so I’m never going to start smoking!
"It's the only place they're allowed to advertise anymore."
Emphysema

- Alveoli enlarge as adjacent chambers break through
- Chronic inflammation promotes lung fibrosis
- Airways collapse during expiration
- Patients use a large amount of energy to exhale
- Over inflation of the lungs leads to a permanently expanded barrel chest
- Cyanosis appears late in the disease
Emphysema

- Alveoli with emphysema
- Microscopic view of normal alveoli
- Enlarged view of air sacs (alveoli)

Emphysema: weakened and collapsed air sacs with excess mucus

Normal healthy air sacs
Left lung of a 55-year-old patient undergoing lung transplantation. The patient had smoked 3-4 packs-a-day for the last 40 years. He had very severe emphysematous disease and pulmonary hypertension. Appreciate the balloon-nature of the lung.
Healthy Lung
Chronic Bronchitis

- Mucosa of the lower respiratory passages becomes severely inflamed
- Mucus production increases
- Pooled mucus impairs ventilation and gas exchange
- Risk of lung infection increases
- Pneumonia is common
- Hypoxia and cyanosis occur early
Chronic bronchitis is caused most often by exposure to airborne pollutants such as cigarette smoke.
X ray of lungs with chronic bronchitis
Lung Cancer

- Accounts for 1/3 of all cancer deaths in the United States
- Increased incidence associated with smoking
- Three common types
  - Squamous cell carcinoma
  - Adenocarcinoma
  - Small cell carcinoma
Squamous cell carcinoma commonly starts in the bronchi and may not spread as rapidly as other lung cancers.
Lung adenocarcinoma accounts for about 40 percent of. By the time it is detected and treatment begins, the disease have already metastasised, or spread, to other areas. This is why mortality rate due to this particular form of lung cancer is high.
Adenocarcinoma of the lung. This form of non-small cell lung cancer (NSCLC) is now the most common type. It typically starts in the peripheral region of the lung.
Small cell carcinoma

Video Assisted Thoracoscopy: Thoracoscopy for the Staging of Lung Cancer
Sudden Infant Death syndrome (SIDS)

- Apparently healthy infant stops breathing and dies during sleep
- Some cases are thought to be a problem of the neural respiratory control center
- One third of cases appear to be due to heart rhythm abnormalities
The Faces of SIDS
Asthma

- Chronic inflamed hypersensitive bronchiole passages
- Response to irritants with dyspnea, coughing, and wheezing
When You Have Asthma

- Bronchial tube
- Muscles: The bronchial tubes are wrapped with muscles
- Bronchiole: Smaller branches of the bronchial tubes
- Mucus lines the bronchial tubes
- Inflamed airway
- Alveoli with trapped air
- Extra mucus
- Tight muscle