PULMONARY PHYSIOLOGY

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DISCLOSURES

- I am an employee of The Sleep Wellness Institute Inc.

- I am NOT receiving direct or indirect payment from any other commercial entity for honorarium, travel or other expenses
EDUCATIONAL OBJECTIVES

- To describe the anatomy of the respiratory system

- To identify the physiology of the respiratory system

- To correlate clinical findings with anatomy of the respiratory system
EMBRYOLOGY OF THE RESPIRATORY SYSTEM

- Association between the foregut and the early respiratory system at 4-5 weeks of development
- Excerpts of the histology sections and their approximate level are shown in the cartoon of the embryonic respiratory/gastrointestinal tracts
- Initial bifurcation of foregut (oesophagus) and respiratory (trachea).
- Heart (ventral) and the dorsal aortas (dorsal) to the lung buds.
- Stomach below the lung buds.
- Narrow pleural canals outside the lung buds.
EMBRYOLOGY OF THE RESPIRATORY SYSTEM

- Week 4 - laryngotracheal groove forms on floor foregut.
- Week 5 - left and right lung buds push into the pericardioperitoneal canals (primordia of pleural cavity)
- Week 6 - descent of heart and lungs into thorax. Pleuroperitoneal foramen closes.
- Week 7 - enlargement of liver stops descent of heart and lungs.
- Month 3-6 - lungs appear glandular, end month 6 alveolar cells type 2 appear and begin to secrete surfactant.
- Month 7 - respiratory bronchioles proliferate and end in alveolar ducts and sacs.
SKIN PROBLEMS
SOLUTIONS
NOSE

Anatomy of the Nose

- Frontal sinus
- Ethmoid sinus
- Superior turbinate
- Middle turbinate
- Nasal cavity
- Inferior turbinate
- Eustachian tube opening
- Nasopharynx
- Oropharynx
- Larynx
- Laryngopharynx
NASAL PROBLEMS

**Nasal polyps**

Nasal polyps are sac-like growths of inflamed tissue lining the sinuses. They can block drainage of mucus resulting in infection or sinusitis.

- **Ostia** - Small openings connect sinuses to nose
- **Polyps** - Commonly grow near ostia

**Symptoms**
- Mouth breathing
- Nasal obstruction
- Constant runny nose
- Sense of smell loss

**Polyp risk factors**
- Asthma
- Chronic sinus infections
- Cystic fibrosis
- Hay fever
- Allergy to aspirin

**Treatment**
- Drugs can shrink small polyps
- Surgery removes large polyps, restores normal drainage; polyps can regrow

**Sinuses**

Four paired chambers in skull:
- 1 Frontal
- 2 Maxillary
- 3 Ethmoid
- 4 Sphenoid

Source: National Institutes of Health (U.S.), Intelhealth, thehealthscare.com - Graphic: Lee Hulteng, Judy Theible

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TRACHEA, BRONCHIOLES AND BRONCHI

- Trachea
- Bronchii
- Bronchioles
LUNGS

- **Trachea** “Windpipe” that provides a pathway for air to enter the lungs.
- **Lymph nodes** “Filters” that help prevent illness and infection. They are part of the lymph system.
- **Pleural space** Space between the lungs and chest wall. This space is lined on both sides by tissue called pleura.
- **Lobes** Sections of each lung. A normal pair of lungs has five lobes.
- **Bronchial tubes** Airway tubes from the trachea to the lungs.
- **Chest wall** Ribs and muscles.
- **Blood vessels** Pathways that carry blood into the lungs and throughout the body.
- **Mediastinum** (This space holds the heart.)
HISTOLOGY - ALVEOLI

- Epithelium
  1. Type I pneumocytes: large flattened cells - 95% area
  2. Type II pneumocytes - 5% area & 60% number of cells. Secrete 'surfactant'

- Surfactant overcomes surface tension preventing alveoli from collapse

- Macrophages are important for ingesting bacteria and particles, and arise from monocytes, which have escaped from the blood capillaries
VENTILATION
DIFFUSION
BLOOD FLOW
GAS EXCHANGE
VENTILATION PERFUSION RATIO

Ventilation

Concentration depends on ventilation/blood flow

Blood flow
ALVEOLAR CAPILLARY GAS EXCHANGE

Gas exchange between alveoli and capillaries from pulmonary artery to pulmonary vein.

- Capillary
- Alveolar membrane
- Respiratory membrane

Gases can dissolve & diffuse between the lungs and the circulatory system.

- Oxygen diffuses into red blood cells
- Carbon dioxide diffuses into alveolus
RESPIRATORY CONTROL

Central controller

Input
Pons, medulla, other parts of brain

Sensors
Chemoreceptors, lung and other receptors

Output
Effectors
Respiratory muscles
CENTRAL REGULATION OF BREATHING

1. CO₂ levels in the blood rise as a result of exercise.
   
   Signals a need for more oxygen

2. Breathing control centers in the brain monitor the rising CO₂ levels in the blood.

3. Nerve signals trigger contraction of muscles to increase breathing rate and depth.
PRIMARY MODULATORS OF BREATHING

- Primary central chemoreceptors (C) are located near the ventral surface of the medulla.

- The ventral medullary surface & retrotrapezoid nucleus are extremely sensitive to changes in H+.

- CO2 crosses the blood-brain barrier.

- CO2 + H2O ↔ H2CO3 ↔ H+ + HCO3

- ↑H+ activates brain chemoreceptors ➔ ↑ ventilation

- Primary peripheral chemoreceptors (carotid and aortic bodies) ➔ sensitive to PO2 & PCO2 (less).
SECONDARY MODULATORS OF BREATHING

- The cerebral cortex is responsible for voluntary control of breathing
  - Sends signals through the corticospinal and corticobulbar tracts.

- Receptors in the lung react to lung volume and irritants
  - Send feedback through the vagus nerve.

- Proprioceptors in muscles and tendons stimulate breathing, as evidenced by passive movements that increase respiratory rate.
CENTRAL SLEEP APNEA
LUNG VOLUMES AND CAPACITIES

- **6,000 mL**
  - Inspiratory Reserve Volume: 3,100 mL
  - Inhalation

- **5,000 mL**
  - VITAL CAPACITY: 4,800 mL

- **4,000 mL**
  - Inspiratory Capacity: 3,600 mL
  - Exhalation

- **3,000 mL**
  - TIDAL VOLUME: 500 mL
  - Start of record

- **2,000 mL**
  - Expiratory Reserve Volume: 1,200 mL
  - Functional Residual Capacity: 2,400 mL
  - End of record

- **1,000 mL**
  - Residual Volume: 1,200 mL
  - Total Lung Capacity: 6,000 mL

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EFFECTS OF OBESITY ON BREATHING

Central nervous system
- Decreased central respiratory drive

Airway
- Potential difficult airway
- Obstructive sleep apnea

Respiratory
- Restrictive chest physiology
- Pulmonary hypertension
- Hypoxemia/hypercapnia

Cardiovascular
- Coronary artery disease
- Congestive heart failure

Others
- Difficult vascular access
- Difficult positioning
POSITIVE AIRWAY PRESSURE

- Inspiration
- Expiration

Pressure (cm H₂O)

PEEP ≈ CPAP ≈ EPAP

Pressure support (PS) ≈ IPAP – EPAP

Time →
CPAP
CPAP VS. BPAP
ADAPTIVE SERVO VENTILATION

Servo ventilation algorithm: Decreased peak flow

If: peak flow falls below target
Then: autoSV Advanced increases pressure support

○ Missed peak flow target (sdb)
Dynamic pressure support inversely proportionate to peak flow value

ResMed
VAPS

Volume Assured Pressure Support
VAPS

IVAPS - ResMed

AVAPS - Philips
SUMMARY

- Nasal problems affect interface selection
- CPAP → OSA
- BPAP → OSA / hypoventilation
- BPAP ST / VAPS → hypoventilation (abnormal breathing drive)
- Greater weight ≠ bigger lungs in obese
- ASV → Central sleep apnea / Cheyne Stokes Respiration
- Understanding anatomy and physiology will make you a better technologist!
THANK YOU

MAYBE YOU NEED A LITTLE BREATHER

- The Dead Milkmen (Beige Sunshine)