

Respiratory System Physiology Explained!

1. How We Breathe: The Respiratory System Explained

Part of Respiratory System	Function	Source
Diaphragm	Contracts and pulls lungs down during breathing. Dome-shaped muscle at the bottom of the lungs.	
Chest Wall Muscles	Expand the chest wall during breathing. Intercostal muscles are important for chest expansion.	
Accessory Muscles	Used when someone is struggling to breathe. Include sternomastoid and abdominal muscles.	
Nerves	Help muscles work together for breathing. Needed for muscle contraction and coordination.	
Upper Airway	Structures above the vocal cords or larynx. Includes the nose, mouth, jaw, oral cavity, pharynx, and larynx.	
Lower Airway	Structures below the larynx. Includes the trachea, bronchi, bronchioles, and alveoli.	

2. The Journey of Air: From Nose to Alveoli

- Air is drawn in through the **nasal cavity**.
 - It runs into **Nasal concha**.
 - Their purpose is to create **air turbulence**.
 - This causes the air to swirl.
 - As it swirls, it picks up heat and moisture.

- The air moves through the **Nasal pharynx**.
 - Then down into the **Oral pharynx**.
 - And then the **lingual pharynx**.
- The air goes through the **Trachea**.
- It goes down the Trachea until it reaches a divide.
 - This divide is called the **Carina**.
- Air travels into the **lungs**.
 - Then to the **Bronchi**, **Bronchioles**, and **Alveoli**.
 - The Alveoli are at the end of the Bronchioles.

3. Gas Exchange: Oxygen and Carbon Dioxide

Process	Description	Source
Respiration	The exchange of oxygen and carbon dioxide. Occurs during inspiration and expiration.	
Diffusion	Gas moves from an area of higher concentration to lower concentration. This happens in the alveoli.	
Oxygen Movement	Oxygen moves from the alveoli (higher concentration) into the bloodstream (lower concentration). Normal air has 21% oxygen. Returning blood has about 15% oxygen.	
Carbon Dioxide Movement	Carbon dioxide moves from the bloodstream (higher concentration) into the alveoli (lower concentration). Air in the lungs has about 1% CO ₂ . Returning blood has about 4.5% CO ₂ .	

4. Brain Control: Regulating Our Breathing

- The **brain stem** senses the level of **Carbon dioxide** in the blood.
- CO₂ is an acid in our body.
- We use **negative pressure breathing** based on the presence of CO₂.

- Getting rid of CO₂ stimulates our breath.
- If CO₂ levels drop too low, a person breathes slower.
- If CO₂ levels rise above normal, a person breathes more rapidly and deeply.

5. Difficulty Breathing: Understanding Dyspnea

Cause	Description	Source
Pulmonary Edema	Fluid in the lungs.	
Hay Fever	Allergic reaction with cold-like symptoms. Usually caused by outdoor airborne allergens.	
Pleural Effusion	Collection of fluid outside or around the lung. Compresses the lung.	
Obstruction of the Airway	Mechanical blockage. Can be from foreign objects, vomit, or the tongue.	
Hyperventilation Syndrome	Breathing too fast causing low CO ₂ levels. Can be a panic attack.	
Environmental/Industrial Exposures	Breathing harmful substances. Examples include pesticides, cleaning solutions, and carbon monoxide.	

6. Recognizing Trouble: Signs of Inadequate Breathing

- EMTs must recognize the signs and symptoms of **inadequate breathing**.
- You need to know what to do about it.
- Poor Oxygenation happens with inadequate breathing.
- This leads to poor perfusion.
- If there is poor perfusion, the body starts to fail.
- Cellular needs are not being met.

7. Carbon Dioxide Retention and Hypoxic Drive

- Some patients have **elevated levels of Carbon dioxide** in their blood.
- This can happen if levels stay high for years.
- The respiratory center in the brain does not work properly.
- This is seen in patients with **chronic obstructive pulmonary disease (COPD)**.
- Their body gradually gets used to high CO₂ levels.
- The brain switches to a backup system to control breathing.
 - This system is based on **low levels of Oxygen**.
 - This is called a **hypoxic drive**.

8. Upper Airway Infections: Croup and Epiglottitis

Condition	Cause	Signs and Symptoms	Treatment	Source
Croup	Viral infection. Inflammation and swelling of the pharynx, larynx, and trachea. Typically seen in children 6 months to 3 years old.	Stridor and a seal bark cough.	Humidified oxygen. Cool air. Saline in a nebulizer.	
Epiglottitis	Bacterial infection. Inflammation of the epiglottis. More common in children but can occur in adults.	Tripod position. Drooling excessively. High fever.	Treat gently. Position comfortably. Provide high flow oxygen. Do not put anything in their mouths. Do not attempt to suction or place an OPA. Transport properly.	

9. Lower Airway Infections: RSV, Bronchiolitis, and Pneumonia

- **RSV (Respiratory Syncytial Virus)** is a common illness in children.
 - It causes infection in the lungs and breathing passages.
 - This can lead to **Bronchiolitis** and **pneumonia**.
 - It is very contagious.
 - Assess for signs of dehydration.
 - Treat airway and breathing problems appropriately.
- **Bronchiolitis** is a viral illness caused by RSV.
 - It usually affects newborns and toddlers.
 - The Bronchioles become inflamed, swell, and fill with mucus.
 - Provide Oxygen therapy.
 - Reassess for signs of respiratory distress.
- **Pneumonia** is an infection in the lungs.
 - It is often a secondary infection after an upper respiratory infection.
 - Bacterial pneumonia comes on quickly with high fevers.
 - Viral pneumonia is more gradual and less severe.
 - It especially affects people who are chronically or terminally ill.
 - Assess temperature.
 - Provide airway support and supplemental Oxygen.

10. Other Infectious Respiratory Diseases

- **Pertussis (Whooping Cough)** is an airborne bacterial infection.
 - It mostly affects children younger than six.
 - Patients have a fever and make a whoop sound when they breathe in after coughing.
 - It is very contagious.
 - Watch for signs of dehydration.
 - Suction may be necessary.
- **Influenza Type A** is an animal respiratory disease that infects humans.
 - It is spread through nasal secretions and aerosolized droplets.
 - Symptoms include high fever, cough, sore throat, muscle aches, headache, and fatigue.
 - It may lead to pneumonia or dehydration.
- **COVID-19 (SARS-CoV-2)** is a coronavirus similar to the common cold.

- It primarily affects the elderly, those in close quarters, and those with weakened immune systems.
- It spreads through droplets and airborne particles from sneezing or coughing.
- Symptoms can include high fever, cough, chest pain when breathing in, vomiting, diarrhea, and inability to smell.
- Respiratory problems can get worse quickly.
- **Tuberculosis (TB)** is a bacterial infection that mainly affects the lungs.
 - It can stay inactive for years.
 - Patients often have a fever, cough, fatigue, night sweats, and weight loss.
 - It is more common in homeless people, prison inmates, nursing home residents, and those with weak immune systems or who abuse substances.
 - Rust colored sputum is an identifying sign.
 - Wear gloves, eye protection, and an N95 respirator if you suspect TB.

11. Pulmonary Edema: Fluid in the Lungs

Aspect	Description	Source
What it is	Fluid backs up within the alveoli and lung tissue.	
Cause	Usually a result of congestive heart failure (CHF). The left side of the heart cannot remove blood from the lungs fast enough. Not all patients with pulmonary edema have heart disease. Can be caused by standing still for long periods. Can happen suddenly (flash pulmonary edema).	
Signs and Symptoms	Difficulty breathing with rapid shallow breaths. Frothy pink sputum from the mouth and nose in severe cases. Patients often feel better sitting upright. Wet lung sounds like crackles or rales.	
How it hinders gas exchange	Fluid fills the alveoli and separates them from capillaries. This interferes with oxygen and carbon dioxide exchange.	

12. Chronic Obstructive Pulmonary Disease (COPD)

Aspect	Description	Source
What it is	A lung disease with chronic obstruction of airflow. It is not fully reversible. An umbrella term for several lung diseases.	
Causes	Usually caused by tobacco smoke irritating the bronchi. Repeated irritation and pneumonia can scar the lungs.	
Types	Emphysema: Loss of elastic material in the lungs. Result of chronic stretching of the alveoli. Most common type of COPD. Chronic Bronchitis: Ongoing irritation of the trachea and bronchi. Excessive mucus is constantly produced. Obstruction of small airways and alveoli by mucus.	
Signs and Symptoms	Airways are weakened. Chronic oxygenation problems can lead to right-sided heart failure. Pneumonia can easily develop. Difficulty in gas exchange. Dry lung sounds like wheezes. May hear rhonchi due to mucus. Often older than 50. History of smoking. Chest tightness and fatigue. Barrel-like chest appearance. Use accessory muscles to breathe. Exhale through pursed lips. Digital clubbing (enlarged fingertips).	

13. Allergic Reactions Affecting Breathing: Asthma, Hay Fever, and Anaphylaxis

- These conditions are caused by **allergic reactions**.
 - Reactions can be from inhaling, ingesting, or injecting substances.
 - There may be no identifiable allergen.
- **Asthma** is an acute spasm of the Bronchioles.
 - It is associated with excessive mucus production and swelling of the airway

lining.

- It affects all ages but is most common in children 5-17.
- Causes characteristic **wheezing** when exhaling.
- Attacks can be caused by allergic reactions, emotional distress, exercise, or respiratory infections.
- **Hay fever** causes cold-like symptoms.
 - Symptoms include a runny nose, sneezing, congestion, and sinus pressure.
 - Caused by allergic reaction to airborne allergens like pollen, dust mites, and pet dander.
 - Usually not an emergency.
- **Anaphylaxis** is a severe allergic reaction.
 - It is characterized by severe airway swelling and dilation of blood vessels.
 - Airway swelling can totally obstruct the airway.
 - May be associated with hives, itching, or signs of shock.
 - Lung sounds may be similar to asthma.
 - **Epinephrine** is the treatment of choice.

14. Pneumothorax: Air in the Chest Cavity

- **Pneumothorax** is the partial or total accumulation of air in the **pleural space**.
- The pleural space normally has a vacuum-like pressure that keeps the lungs inflated.
- When the lung surface is disrupted, air escapes into the pleural cavity.
 - The negative vacuum pressure is lost.
- It is most often caused by **trauma**.
- It can also be caused by medical conditions.
 - A **spontaneous pneumothorax** can happen suddenly.
 - It occurs in patients with chronic lung infections or weak areas in the lungs.
 - Can occur in tall, slender males who take a deep breath and bump into something.
- The patient becomes **dyspneic**.
- They might complain of **pleural chest pain**.
- **Breath sounds are absent or decreased** on the affected side.
- A **tension pneumothorax** is a life-threatening type.
 - Pressure in the chest shifts organs and affects the heart's ability to pump.

- Signs include diminished lung sounds on one side, **JVD (jugular vein distention)**, and possibly **Tracheal deviation** (a late sign).
- Hypotension is present in tension pneumothorax.

15. Pleural Effusion: Fluid Around the Lungs

- **Pleural effusion** is a collection of fluid inside or around the lung.
- It compresses the lung.
- This causes **dyspnea**.
- It can be caused by irritation, infection, chronic heart failure, or cancer.
- Breast sounds will be decreased in the affected area.
- Patients feel better if they are sitting upright.

16. Airway Obstructions: Mechanical Blockages

- Patients with difficulty breathing may have a **mechanical obstruction**.
- This means something is blocking the airway.
- In unconscious patients, the obstruction can be vomit, a foreign object, or the tongue.
 - The tongue is the most common blockage in an unconscious person.
 - The relaxed tongue can fall back into the throat.
- If a patient was eating before having trouble breathing, consider a **foreign body obstruction**.
- A mechanical obstruction can also happen if the head is not positioned correctly.
- The sound associated with upper airway obstruction is **stridor**.

17. Pulmonary Emboli: Blood Clots in the Lungs

- A **pulmonary embolus** is anything that moves in the circulatory system and lodges somewhere.
- It obstructs blood flow.
- A pulmonary embolus is a blood clot that travels through the venous system and lodges in the **pulmonary artery** in the lungs.
- The circulation can be completely or partially cut off.
- Emboli can be blood clot fragments or foreign bodies like air bubbles.

- Signs and symptoms include:
 - Dyspnea (difficulty breathing).
 - Tachycardia (fast heart rate).
 - Tachypnea (fast breathing).
 - Varying degrees of hypoxia (low Oxygen).
 - Cyanosis (blueness around mouth or fingernails).
 - Acute chest pain (can be pinpoint pain).
 - Hemoptysis (coughing up blood).
- Large emboli can completely obstruct blood flow from the right side of the heart.
 - This can result in **sudden death**.

18. Hyperventilation: Breathing Too Fast

- **Hyperventilation** is over breathing to the point that arterial Carbon dioxide falls below normal.
- It may be an indicator of a life-threatening illness.
- The body may be trying to compensate for **acidosis** (buildup of acid in blood/tissues).
 - Breathing off CO₂ lowers the body's pH.
- It can result in **alkalosis** (buildup of excess base in body fluids).
 - This happens from breathing off too much CO₂ too fast.
- Signs and symptoms include:
 - Anxiety.
 - Dizziness.
 - Numbness and tingling in the hands and feet.
 - Painful spasms in the hands and feet (carpal pedal spasms).
- The decision about the cause should not be made outside the hospital.
- Do not have the patient breathe into a paper bag.
- Reassure the patient.
- Provide Oxygen if necessary.

19. Environmental and Industrial Exposures

- Breathing problems can be caused by **environmental or industrial exposures**.

- This includes substances like **pesticides, cleaning solutions, chemicals, chlorine, and other gases.**
- These can be accidentally released at industrial sites.
- **Chlorine gas** can cause sudden fluid buildup in the lungs (flash pulmonary edema).
- **Carbon monoxide (CO) poisoning** is a common gas exposure.
 - CO is an **odorless and highly poisonous gas.**
 - It is a leading cause of accidental poisoning deaths in the United States.
 - It is produced by fuel-burning appliances and is present in smoke.
 - Patients complain of flu-like symptoms and difficulty breathing.
 - Hemoglobin has a higher attraction to carbon monoxide than Oxygen.
 - SPO2 readings can be normal or 100% with CO poisoning.
 - High flow Oxygen is the best treatment for conscious patients.
- Ensure patients are decontaminated if exposed to harmful substances.

20. Assessment and Management of Respiratory Emergencies

Step	Details	Source
Scene Size-Up	Important step. Use PPE, especially with infectious diseases or toxic substances. Consider airborne hazardous material release if multiple people have dyspnea. Ask why 9-1-1 was called.	
Primary Assessment	Identify immediate life threats. Assess the patient's level of distress. Note age and position. Check responsiveness using AVPU scale. Ask the chief complaint. Check ABCs (Airway, Breathing, Circulation). Listen to lung sounds early. Abnormal sounds include wheezing, rales, rhonchi, or stridor. Assess pulse rate, rhythm, and quality. Evaluate for shock or bleeding. Assess perfusion (skin color, temp, condition). Make transport decision (rapid transport if life threat).	
History of Illness/Patient	Investigate the chief complaint. Determine what the patient has done for the breathing problem. Get	

SAMPLE history (Signs/Symptoms, Allergies, Medications, Past medical history, Last oral intake, Events leading up). Get OPQRST history for the illness (Onset, Provocation, Quality, Radiation, Severity, Time). PASTE assessment for shortness of breath (Progression, Associated chest pain, Sputum, Talking/Tiredness, Exercise intolerance).

Secondary
Assessment

Only do if life threats have been addressed. Use monitoring devices.

Management

Administer oxygen immediately. Administer ventilator support (BVM, pocket mask, etc.) if mental status declines or breathing is inadequate. Use airway management techniques like OPA/NPA or suctioning. Consider non-invasive ventilatory support with CPAP. Position the patient comfortably, often in a high Fowler's position. Assist with respiratory medications like inhalers or nebulizers. Monitor respiratory status. Provide emotional support. Transport promptly.
