Purpose of the respiratory system

- Promote the exchange of oxygen and carbon dioxide between the alveoli and pulmonary capillary blood (external respiration) and between the systemic capillary blood and all the cells of the body (internal respiration)

Functions

- Provide oxygen to the blood stream and remove carbon dioxide
- Enable sound production or vocalization as expired air passes over the vocal cords
- Enable protective and reflexive non-breathing air movements such as coughing and sneezing, to keep the air passages clear
- Control of Acid-Base balance in the blood and thus control the blood pH

One breath

- Normal respiratory rate is 10-15 breaths per minute.
- For inspiration, the inspiratory center sends nerve impulses along the phrenic nerve to the diaphragm and along the intercostal nerves to the external intercostal muscles to stimulate inspiration (2 seconds)
- For expiration the inspiratory center stop firing for about 3 seconds which allows the muscle to relax and the lungs to recoil
**Respiration Process**

- **Pulmonary Ventilation**
  - Movement of air into the lungs (inspiration)
  - Movement of air out of the lungs (expiration)
- **External Respiration**
  - Movement of oxygen from the lungs to the blood
  - Movement of carbon dioxide from the blood to the lungs
- **Transport of Respiratory Gases**
  - Transport of oxygen from the lungs to the tissues
  - Transport of carbon dioxide from the tissues to the lungs
- **Internal Respiration**
  - Movement of oxygen from blood to the tissue cells
  - Movement of carbon dioxide from tissue cells to blood

---

**Lower Airways**

[Image: www.aduk.org.uk/gfx/lungs.jpg]
Blood Chemistry

• Hydrogen ion concentrations and carbon dioxide—strongly influence respiration
  • The dissociation of carbonic acid increases the acidity of the blood (decreases its pH).
  • This buffering action allows large quantities of carbonic acid to be carried in the blood without major changes in blood pH.

Oxygen concentrations - have little effect on respiration

Lining of the alveoli

• Type I cells or Type I alveolar cells
  — Make up 97% of the alveolar surface
  — Very thin components of the blood air barrier
  — Coated by a thin layer of water

• Surfactant: a lipoprotein that is produced in the lungs
  — Produced by Type II cells
  — Cover the remaining 3% of the alveolar surface
  — Reduces the surface tension of fluid in the lungs and prevents the alveoli from collapsing
  — Production begins in utero at about 20 weeks gestation
- Macrophages
  - important in removing any debris that escapes the mucus and cilia in the conducting portion of the system
  - Also known as dust cells

Major muscle of respiration: diaphragm

The diaphragm is shaped like a parachute
Control of Respiratory System

- Respiratory control centers – found in the pons and the medulla oblongata
  - Control breathing
  - Adjusts the rate and depth of breathing according to oxygen and carbon dioxide levels
  - Afferent connections to the brainstem

The act of breathing is regulated by:

1. CO2, bathing the respiratory center directly
2. the chemical composition of the circulating blood, acting on the chemoreceptors in the carotid and aortic bodies
3. the degree to which the lung is distended.

Gas Exchange and Transport

- Alveolar Gas Exchange – the loading of oxygen and the unloading of carbon dioxide in the lungs
  - Gases in the blood move in and out of the alveoli because of partial pressures of gases
- Partial pressure of oxygen. Pressure oxygen exerts in the prevailing environment
- Partial pressure of carbon dioxide Pressure carbon dioxide exerts in the prevailing environment
Gas exchange and the respiratory process.

Oxygen transport

- 98.5% is bound to the iron in hemoglobin
- 1.5% dissolved in plasma bound to hemoglobin
- Oxygenated hemoglobin is called oxyhemoglobin

Oxygen cascade

- At sea level, the atmospheric pressure is 760mmHg, and oxygen makes up 21% of inspired air.
- Oxygen exerts a partial pressure of $760 \times 0.21 = 159$mmHg.
- This is the starting point of the oxygen cascade,
- As the oxygen moves down through the body to the cell, oxygen is diluted down, extracted or otherwise lost, so that at cellular level the PO$_2$ may only be 3 or 4mmHg.

Haldane effect

- Carbon dioxide loading - The Haldane Effect –
  The lower the partial pressure of oxygen and saturation of it in hemoglobin, the more carbon dioxide can be carried in the blood
Carbon dioxide

- Carbon Dioxide is produced by cells throughout the body
- There are 3 ways in which carbon dioxide is transported in the blood:

**DISSOLVED CO₂**

- Carbon dioxide is much more soluble in blood than oxygen
- About 7% of carbon dioxide is transported unchanged, simply dissolved in the plasma

**BOUND TO HEMOGLOBIN AND PLASMA PROTEINS**

- Carbon dioxide combines reversibly with hemoglobin to form carbaminohemoglobin.
- Carbon dioxide binds to amino groups on the polypeptide chains of plasma proteins
- About 23% of carbon dioxide is transported bound to hemoglobin
- Forms in regions of high Pco₂, as blood flows through the systemic capillaries in the tissues

**BICARBONATE IONS (HCO₃⁻)**

- The majority of carbon dioxide (70%) is transported as bicarbonate ions
- Carbon dioxide enters red blood cells in the tissue capillaries where it combines with water to form carbonic acid (H₂CO₃).
  - This reaction is catalyzed by the enzyme carbonic anhydrase (C.A.), which is found in the red blood cells.
  - Carbonic acid then dissociates to form bicarbonate ions (HCO₃⁻) and hydrogen ions (H⁺).
The reversal of the reactions which occurs at the lungs.
- Bicarbonate ions enter the red blood cells and combine with hydrogen ions to form carbonic acid.
- This is broken down into carbon dioxide and water.
- Carbon dioxide diffuses out of the red blood cells and into the alveoli.

**Arterial Blood Gases**

**NORMAL VALUES**

- PH: 7.35 – 7.45
- PaCO2: 35 – 45 mmHg
- HCO3: 22 – 26 mEq / L
- Base Excess: -2 - +2 mEq / L
- PaO2: 80 – 100 mmHg
- SaO2: > 95%
Steps in interpreting Arterial Blood Gases

- First check the pH
  - Normal = pH 7.35 – 7.45
  - Acidosis = pH <7.35
  - Alkalosis = pH >7.45

- Then consider whether it is Corrected vs Compensated vs Uncompensated
  - Corrected or normal = all acid base parameters have returned to normal
  - Compensated = the pH is within normal limits
  - Uncompensated = the pH is not within normal limits

- Next ask yourself What is abnormal?
  - CO2
  - HCO3

Common Causes of Acid-Base Abnormalities

- Respiratory Acidosis
  - Causes
    - Hypoventilation
    - Respiratory depression
    - Paralysis
    - Chest wall disorders
    - Mechanical underventilation
  - Signs/Symptoms
    - Decreased LOC
    - Dysrhythmias
    - Palpitations
  - Intervention
    - Reversal agents
    - Mechanical Ventilation

- Respiratory Alkalosis
  - Causes
    - Alveolar Hyperventilation
    - Hypermetabolic states
    - Emotional
    - Hypoxia/High altitude
    - Mechanical overventilation
  - Signs/Symptoms
    - Headache
    - Vertigo
    - Paresthesias
  - Intervention
    - Sedatives
    - Oxygenation

Common Causes of Acid-Base Abnormalities

- Metabolic Acidosis
  - Causes
    - Impaired renal excretion of acid
    - Abnormal loss of HCO3
    - Ketoacidosis
    - Salicylates
    - Lactic acidosis r/t anaerobic metabolism
  - Signs/Symptoms
    - Nausea
    - CNS depression
    - Dysrhythmias
    - Flushed skin
  - Intervention
    - NACHO3 IV
    - Dialysis
    - Treat Underlying Causes

- Metabolic Alkalosis
  - Causes
    - Large loss of gastric contents
    - Prolonged diuretic use
    - Ingestion of bicarbonate
  - Signs/Symptoms
    - Diaphoresis
    - Shallow breathing
    - Nausea/vomiting
  - Intervention
    - Replace electrolyte losses
    - Treat underlying cause

ARterial Blood Gases

RESPIRATORY SYSTEM
- Regulation of CO2
  - ↓ ventilation causes ↓ pH
  - ↑ ventilation causes ↑ pH
- The respiratory system responds rapidly to a change in pH (minutes to hours)

RENAL SYSTEM
- Regulation of HCO3
  - ↓ bicarbonate causes ↓ pH
  - ↑ bicarbonate causes ↑ pH
- The renal system responds slowly to a change in pH (hours to days)
Acid or Base?

• Acidic (pH < 7.35)
  – PaCO₂ ↑↑↑
  – HCO₃↓↓↓
  – Presence of Lactic Acid

• Basic (pH > 7.45)
  – PaCO₂ ↓↓↓
  – HCO₃↑↑↑
  – Absorption of alkalizing agents

ABG Examples

<table>
<thead>
<tr>
<th>pH</th>
<th>pCO₂</th>
<th>HCO₃</th>
<th>pO₂</th>
<th>SaO₂</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.56</td>
<td>23</td>
<td>19</td>
<td>98</td>
<td>99.9%</td>
</tr>
</tbody>
</table>

Analysis: pH = 7.56, pCO₂ = 23, HCO₃ = 19, pO₂ = 98, SaO₂ = 99.9%

• pH – 7.56, pH = alkalosis, uncompensated
  pCO₂ – 40 normal
  HCO₃ – 29 high
  pO₂ – 82
  SaO₂ – 95.5%

Analysis: the pH is not WNL, it is alkalotic. The CO₂ is normal so this is not a respiratory issue. The HCO₃ is high. This is a metabolic issue!! Metabolic Alkalosis

ABG interpretation

• pH – 7.19
• pCO₂ – 68
• HCO₃ – 25
• pO₂ – 54
• SaO₂ – 84.2%
When normal breathing fails…

Oxygen delivery
- Nasal canula
- Oxygen mask-venturi
- 100% non rebreather
- C-pap: continuous positive airway pressure (OSA)
- Bi-pap (bi-level positive airway pressure)

Alteration in Respiratory Function
Exacerbation of COPD

- COPD is a slowly progressive disease of the airways and is characterized by gradual loss of lung function
- In the US, COPD includes chronic bronchitis, emphysema or a combination of the 2
- It is the fourth leading cause of death in the United States

Number one cause is............

Other precipitating factors

- Environmental pollution
- Occupational exposure
- Predisposition due to genetic makeup-alpha 1 antitrypsin deficiency
COPD-Chronic Bronchitis

- Chronic cough with sputum production on a daily basis
  - minimum of 3 months per year for not less than 2 years
- May have chronic hypoxemia with loss of CO2 drive for respirations

Bronchitis

- Airway changes lead to hypersecretion of mucus and impaired cilia which lead to a chronic productive cough
- Bronchial wall thickening leads to progressive obstruction to air flow

“Blue bloater”

COPD-Emphysema

- Emphysema is defined by abnormal and permanent enlargement of the airspaces that are distal to the terminal bronchioles. This is accompanied by destruction of the airspace walls, without obvious fibrosis (ie, there is no fibrosis visible to the naked eye)
- When emphysema is advanced, the patient must work hard to expel air from their lungs
- Breathing can consume up to 20 percent of the resting energy.
Altered dynamics of breathing

- Diaphragm is pushed down
- Intercostal space enlarges as lung expands
- Must use neck muscles to aid in respiration
- “Purse lip breathing” on exhalation

COPD-Emphysema

- Primary signs and symptoms
  - shortness of breath
  - or the feeling of not being able to get enough air
- Treatments focus on relieving symptoms and avoiding complications.
Lung Volume Reduction Surgery

- Lung Volume Reduction Surgery is the removal of exterior lung in order to reduce the size of the lungs by about 30% in patients with severe emphysema.
- The goal is for the remaining healthier portion of lung to perform better.
- Lung volume reduction surgery is the “trimming” of the lung in order to improve the dynamics of breathing:
  - Helps the diaphragms to rise back up
  - Allows room for the chest to return to a more normal configuration

Indications for LVRS?

- NETT trial—Emphysema in the upper lobes of the lung
- End-Stage Emphysema
- Medical treatment has been maximized
- Quality of life remains severely impaired
- Lung transplantation not a perfect option
REVIEW QUESTION

A patient with an acute exacerbation of COPD is minimally responsive, tachypneic, and tachycardic. ABG results include pH 7.20, PaO2 55mmHg, CO2 68mmHg. The nurse anticipates that the next intervention will be:

A. Instituting BiPAP
B. Endotracheal intubation
C. Application of low flow oxygen via NC
D. Administration of 50mg sodium bicarb to correct acidosis

REVIEW QUESTION

A patient with long-standing history of COPD is admitted for worsening dyspnea and desaturation. She is on home O2 therapy at 2lpm. Her admission vitals are temp 38.2, HR 104, BP 130/60, RR 28, SaO2 88%. For this patient the nurse knows that increasing the FiO2 should:

A. Improve the patient’s oxygenation
B. Only be done on the basis of ABG results
C. Be avoided because it may weaken the patient’s respiratory drive
D. Only be used as a last resort because it may increase hypoxemic vasoconstriction

Asthma

Normal bronchiol  Asthmatic bronchiol
Definition of asthma

• A chronic inflammatory disorder of the airways that involves many different cells, including mast cells, eosinophils, and T lymphocytes. This inflammation causes recurrent episodes of wheezing, dyspnea, and cough.

Pathogenesis

• Airway inflammation with airway reactivity
  — Contraction of the airway smooth muscles
  — Microvascular leakage
  — Bronchial hyper-responsiveness
• Asthma differs from other airway diseases because of
  — Absence of bronchiolitis
  — Lack of fibrosis
  — Absence of granulation tissue

Early asthma response (EAR)

• With exposure to a trigger, there mobilization of histamines, prostaglandin and leukotrienes.
• This causes
  — Airway smooth muscle constriction
  — Mucous hypersecretion
  — Mucosal edema

Late asthma response (LAR)

• Includes mobilization of lymphokines and other chemotactic compounds that may cause lymphocytes, neutrophils and eosinophils to migrate to the site of airway hyperreactivity
LAR results in

• Damage to the respiratory epithelium
• Amplification of the inflammatory process
• Propagation of the inflammatory response along other airways

Goal of respiratory care

• Assess lung function
• Support respirations: medication, respiratory therapy
• Allow for rest, do not over sedate
• Assist in the identification of underlying cause
• Prepare to transfer if respiratory failure is eminent

Mechanisms of action for first line asthma medication

• Beta-agonists Albuterol, Ventolin, Proventil, Xopenex, Serevent
  — Stimulates beta-receptors in lung and directs shifts in calcium to allow bronchial smooth muscle relaxation
  — used to decrease bronchospasm
  — Affects EAR phase

Anti-inflammatory therapy

• Corticosteroids (Flovent or Prednisone)
  — Inhibits mucosal mast cell production
  — Stabilizes cell membrane
  — Examples are
  — Affects LAR response
Advair

- Beta 2 agonist; Beta 2-Adrenergic agonist, Long-Acting Corticosteroid inhalant (Oral)
- Maintenance treatment of asthma; maintenance treatment of COPD
- In a large, randomized clinical trial (SMART, 2006), salmeterol was associated with a small, but statistically significant increase in asthma-related deaths (when added to usual asthma therapy)

Leukotrine blockers (Singular)

- Works by blocking leukotrienes which are powerful substances that are involved in the inflammatory process associated with asthma.
- Also found to control allergy symptoms

Status asthmaticus

- An acute exacerbation of asthma that remains unresponsive to initial treatment with bronchodilators.
- A severe form with bronchospasm, airway inflammation, and mucus plugging that can cause difficulty breathing; carbon dioxide retention; hypoxemia; and respiratory failure.
- The typical clinical presentation involves persistent wheezing with retractions. However, not all children with severe asthma wheeze; some may present with cough, dyspnea, or emesis
Status Asthmaticus

• Extensive airway inflammation with associated
  – mucous plugging
  – epithelial sloughing
  – inflammatory cellular infiltrate of the mucosa and submucosa
  – PULMONARY EMERGENCY

Patients who are at risk for a severe asthma attack

• Poor control of allergens or asthma triggers in the home and/or workplace.
• infrequent use of a peak flow monitor and inhaled corticosteroids

Treatment

• Continuous use of an asthma nebulizer and injections of drugs such as epinephrine and prednisone for asthma are often necessary.
• Other therapies may include terbutaline injections, magnesium sulfate (induces smooth muscle relaxation of the airways), and leukotriene inhibitors, which are anti-inflammatory drugs.
• Mechanical ventilation

Air leak syndromes

• Pulmonary air-leak syndromes involve dissection of air out of the normal pulmonary airspaces.
• Air-leak syndromes include pulmonary interstitial emphysema, pneumomediastinum, pneumothorax, pneumopericardium, pneumoperitoneum, and subcutaneous emphysema
• Treatment is based on cause
• If the leak is large in the chest a chest tube is needed to remove the air.
Thoracic Surgery

- Primarily cancer surgery.
- Cancer surgery dependent on stage of tumor and requires margins free of disease and removal of surrounding lymph nodes.
- It is most effective therapy for early stage non-small cell carcinoma of the lung.

Lobectomy

- Removal of a lobe of the lung and surrounding lymph nodes.
**Pneumonectomy**
- Required when a lobectomy or one of its modifications is not sufficient to remove the local disease or its metastases
- Mortality can range from 6-11%

**Segmentectomy**
- This surgery removes a segment of the lobe of the lung
- With this surgery it is not technically possible to remove all adjacent lobar lymph nodes
- Mortality 2-5%

**Pneumonectomy**
- There are no drainage tubes with a pneumonectomy so that the surgical area can fill with fibrin and blood exudates in order to stabilize the mediastinum and prevent its shift
- First few days after surgery it is imperative to be fluid restrictive in order to prevent reperfusion pulmonary edema

**Wedge resection**
- Can be done by video-assisted thoracotomy or through an open thoracotomy
- Takes out a biopsy or wedge of the lung
Equipment in all resections

- Pain: Epidurals or IV PCA, peripheral nerve catheters, and On-Q pumps
- Respiratory: Chest physiotherapy and incentive spirometry
- Chest tubes, JPs and Blakes except pneumonectomy

Goals of Post-op care.

- Chest tube and drain monitoring (except pneumonectomies)
- Wound surveillance
- Mobilization
- Accurate fluid monitoring Fluid management: more for all surgeries unless heart failure patient or pneumonectomy
- Pain control
- Aggressive respiratory care

Nursing Care

- Milk and strip chest tubes only if you see it contains fragments of a blood clot or lung tissue that could occlude the tube. DO NOT DO IT ON A ROUTINE BASIS
- Maintain tubing free of dependant loops to prevent fluid from backing into the chest

Nursing care

- Allay patient fears and pain with chest tube insertion and removal
- Make sure tube connections are tight and taped
- Monitor chest tube output every 4 hours if not more frequently
Nursing care

- No longer need daily chest x-rays when chest tubes are in
- Do not clamp chest tubes unless absolutely necessary and this is only for a brief time or by physician order to see if chest tube can be removed
- Recommended dressing for chest tubes sterile gauze dressing

Which of the following are incorrect in the management of chest tubes?

- 1. OK to clamp the tube when the patient ambulates or gets up to the bathroom
- 2. If a patient is on suction, they may ambulate on portable suction
- 3. It is ok to keep the chest tubes hanging on an IV pole even when the patients are in bed
- 4. Increasing chest tube suction or stripping the chest tube tubing may be detrimental to lung tissue.