Disclosure

- No planner, presenter, or speaker has any vested interest in the content to be discussed in this presentation.
- Your participation in this presentation will not guarantee that you will pass Certification exam.
- To receive CE Credits:
  - Sign the attendance sheet
  - Attend 80% of the course
  - Complete course evaluation

Objectives

- Review the 4 pathophysiologic changes related to Pulmonary System:
  - Ventilation Problem
  - Gas Exchange Problem
  - Airway Obstruction Problem
  - V/Q mismatch Problem
- Differentiate b/w Obstructive and Restrictive Pulmonary diseases
- Describe signs & symptoms, lab findings, diagnostic test of various disease processes
Gas Exchange
- Process by which gases move across the alveolar-capillary membrane
- Passive diffusion—down the concentration gradient
- Measures:
  - ABG’s
  - Pulse Oximetry
  - A-a gradient
  - P/F Ratio

A-a Gradient—
Degree of Respiratory Failure
- Alveolar O2-arterial O2
- $pA02 = \text{pressure of O2 in the alveoli (FiO2} \times 6)$
- $paO2 = \text{pressure of O2 in the arterial blood (ABG)}$
- If A-a gradient is $\frac{1}{3}$ of $pA02$ or less = NORMAL

Normal Diffusion

A-a Gradient Calculation

<table>
<thead>
<tr>
<th>FiO2</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
</tr>
</thead>
<tbody>
<tr>
<td>pA02 (FiO2 x 6)</td>
<td>300</td>
<td>360</td>
<td>420</td>
<td>480</td>
</tr>
<tr>
<td>paO2 (ABG)</td>
<td>70</td>
<td>75</td>
<td>78</td>
<td>84</td>
</tr>
<tr>
<td>A-a Gradient</td>
<td>230</td>
<td>285</td>
<td>342</td>
<td>396</td>
</tr>
</tbody>
</table>

Ways of Assessing Gas Exchange
- Pulse Oximetry
- A-a Gradient (<10 mmHg)
  - Limited use with high FiO2
  - Varies with age
- A-a Ratio (>60%, normal >80%)
  - Trend over time
- P/F Ratio (> 300)
- ABG

Airway Obstruction
- Foreign Objects
- Excessive Secretion Production
- Airway constriction
- Cellular response to insults
Normal Ventilation & Perfusion

- Ventilation: 4 L/min
  - More in the apices of the lungs
  - Less in the bases of the lungs
- Perfusion: 5 L/min
  - More in the bases of the lungs
  - Less in the apices of the lungs

V/Q Mismatch

- V = Ventilation
- Q = Perfusion
- Optimal = area for V should match area of Q

Estimation of Shunt

- PaO2/FiO2 Ratio (P/F ratio)
  - Normal > 300
  - If < 250 = Respiratory Failure
  - ARDS < 200
- ALI (Acute Lung Injury) = 200-300
  - Example: 78/.40 = 195
  - ***Less accurate with low FiO2***
Oxygen Transport
- Transportation of gas (O2) within the circulation system
- 97% bound to Hemoglobin, 3% dissolved in plasma
- Carbon monoxide poisoning = cherry red skin, HA and confusion
- Measures:
  - Oxyhemoglobin dissociation curve

Ventilation Problems
- Spinal Cord Injury (C4 or higher)
- Neuromuscular diseases (GBS, MG)
- Phrenic nerve damage
- CNS depression
- ARDS (late stage)

Oxyhemoglobin Dissociation Curve

Gas Exchange Problems
- ARDS
- Pulmonary Edema
- Aspiration of gastric content
- Pulmonary Hypertension

Cellular Diffusion
- Process by which gases are moved between the systemic capillary bed & body tissues
- Indirect Measures:
  - Pulse Oximetry
  - Lactate Level

Pulmonary Edema
Shunt? Dead space?
**Airway Obstruction Problems**
- Foreign objects
- Aspiration
- Asthma
- Bronchitis
- Pneumonia
- ARDS

**V/Q Mismatch Problems**
- Emphysema
- ARDS

**General S/S of Respiratory Distress**
- Hypoxemia (PaO₂ < 60 mmHg)
- Restlessness
- Tachypnea
- Dyspnea
- Tachycardia
- Confusion
- Diaphoresis
- Anxiety
- Hypertension
- Irritability
- Pallor or cyanosis of skin
- Use of accessory muscles of respiration
- Abnormal breath sounds (crackles, wheezes)
- Manifestations of primary disease

**General Dx Tests for Respiratory Distress**
- CXR
- ABG
- Bedside Pulmonary Dynamic Test
  - FVC = Forced Vital Capacity
  - PEFR = Peak Expiratory Flow Rate
  - FEV₁ = Forced Expiratory Volume in 1 sec
    - (normal is 75% of FVC)
    - Decreased in both Restrictive and Obstructive
  - FEV₁/FVC
    - Is preserved in Restrictive
    - Is decreased in Obstructive

**Lung Volume Measurement**

**Specific Diagnostic Tests**

<table>
<thead>
<tr>
<th>Ventilation Problems</th>
<th>Gas Exchange Problems</th>
<th>Obstruction Problems</th>
<th>V/Q Mismatch Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ NIF = -20</td>
<td>+ A-a Gradient</td>
<td>+ PFT</td>
<td>+ V/Q scan</td>
</tr>
<tr>
<td>+ Quality of RR</td>
<td>+ a/A Ratio</td>
<td>+ FEV₁ &lt; 20%</td>
<td>+ Pulmonary Angiogram</td>
</tr>
<tr>
<td>+ Quantity of RR</td>
<td>+ P/F Ratio</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

10/4/2013
Acid-Base Balance

- pH = 7.35-7.45
  - Low = acidosis
  - High = alkalosis

- pCO2 = 35-45 mmHg
  - Low = alkalosis
  - High = acidosis
  - Respiratory—hours

- HCO3 = 22-26 mEq/L
  - Low = acidosis
  - High = alkalosis
  - Kidneys ---Days

- Base Excess = -2 to +2
  - PaO2 = 80-100 mmHg
  - O2 Sat = 90-100%

Acid-Base Analysis--Continue

- Step 5 —Compensate or not compensate?
  - Look at trend
  - Does the secondary system adjust value to compensate for the primary cause?

- Step 6 —Complete or partial compensation
  - Re-look at the pH (w/in normal limits?)

- Step 7 —Look at your patient
  - Does the value fit the clinical picture?

Acid-Base Balance "ROME"

- Relationship between PH and major chemical regulator of each system

  “Respiratory Opposite”—
  - PH ↓, PaCO2 ↑
  - PH ↑, PaCO2 ↓

  “Metabolic Equal”—
  - PH ↓, HCO3 ↓
  - PH ↑, HCO3 ↑

Acid-Base Analysis--Example 1

- pH = 7.19
- pCO2 = 70 (70-45 = 25)
- pO2 = 44
- HCO3 = 12 (22-12 = 10)

Acid-Base Analysis

- Step 1 —look at pH
  - Acidosis or Alkalosis?

- Step 2 —look at CO2
  - Look at the difference of CO2 from the normal range = CO2 value change

- Step 3 —look at HCO3
  - Look at the difference of HCO3 from the normal range = HCO3 value change

- Step 4 —Decide on the primary cause
  - If CO2 value change > HCO3 value change → probably Respiratory
  - If HCO3 value change > CO2 value change → probably Metabolic

Acid-Base Analysis--Example 1

- pH = 7.19
- pCO2 = 70 (70-45 = 25)
- pO2 = 44
- HCO3 = 12 (22-12 = 10)

- Respiratory Acidosis, no Compensation

- Respiratory Acidosis, no Compensation
**Acid-Base Analysis--Example 2**
- pH = 7.25
- pCO2 = 28 (35 - 28 = 7)
- pO2 = 50
- HCO3 = 12 (22 - 12 = 10)

**Metabolic Acidosis, incomplete partial compensation**

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**Acid-Base Analysis--Example 2**
- pH = 7.25
- pCO2 = 28, (35 - 28 = 7)
- pO2 = 50
- HCO3 = 12 (22 - 12 = 10)

**Alkalosis**
- Respiratory
  - Poor Vent Setting
  - Pulmonary Embolism
  - Pregnancy
  - Hysterical reaction
  - Anxiety

- Metabolic
  - Antacid OD
  - NGT suctioning
  - Vomiting
  - K+ wasting diuretics

**Acute Respiratory Failure**
- Impairment in Oxygenation & Ventilation
  - PaO2 < 60 mmHg
  - PaCO2 > 50 mmHg on RA
  - ***Clinical Picture***

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**Acidosis**
- Respiratory
  - Hypoventilation
  - Over-sedation
  - Drug overdose
  - Neuromuscular diseases
  - Poor Vent settings
  - Pain

- Metabolic
  - DKA
  - Hypo perfusion
  - ASA OD
  - Renal failure
  - Shock
  - Sepsis
  - Diarrhea

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**Lung Diseases**
- Restrictive
  - Atelectasis
  - ARDS
  - Pneumonia
  - Scleroderma

- Obstructive
  - Obstruction
  - Asthma
  - Emphysema
  - Bronchitis
  - COPD
**Restrictive Lung Diseases**
- Expansion of Lung is restricted or decreased
- Lung volumes are decreased
- Compliance is decreased
- Loss of functional residual capacity (FRC)
- Shunt—perfusion without ventilation
- Problem with air flowing in

**Acute Pulmonary Embolus, Fat Embolus**
- Obstruction of pulmonary arteries by emboli
- Most thromboemboli (> 95%) originate from iliofemoral veins
- Complication of DVT (stasis, injury in the vessel wall, alterations in the coagulation-fibrinolytic system)
- Risk factors: age > 40, immobility, previous DVT, anesthesia/surgery, pregnancy/post-partum, trauma, fat embolus associated with long bone fracture
- Hemodynamic: Increase PVR & PA pressures (> 20 = PAH, >40 = RA failure)

**Restrictive Lung Diseases**
- Dyspnea
- Rapid, shallow breathing
- Hypoxemia, diffusion defect, shunt, V/Q mismatch
- Increase WOB (low compliance)
- Respiratory muscle weakness, fatigue, metabolic abnormalities, hypoxemia

**Acute Pulmonary Embolus, Fat Embolus**
- Pulmonary: Arterial hypoxemia, hyperventilation, loss of surfactant→more atelectasis & pulmonary infarct
- S/S: sudden onset of chest pain, new RBBB, ST on EKG
- DX: V/Q scan, search for DVT (anticoagulation), Pulmonary angiogram, D-dimer (not specific), CXR (basilar atelectasis, elevated diaphragm, pleural effusion)
- TX: Adequate ventilation, diffusion, & perfusion, Heparin infusion, inferior vena cava filter

**Obstructive Lung Diseases**
- Compliance is not a problem
- Airway obstruction & gas trapping are typical (TLC, FRC) → barotraumas
- Ventilation w/o perfusion (dead space)
- Difficulty in getting rid of CO2
- Increase WOB

**Acute Respiratory Failure—Treatment Goals**
- Adequate Gas Exchange as evidenced by WNL ABG
- Maintaining Cardiovascular stability as evidenced by WNL hemodynamic parameters
Acute Respiratory Infections

- Inflammation of lung parenchyma → consolidation
- S/S: Dyspnea, chest pain, wheezing cough, fever, chills, rigors, wt. loss, night sweats, fatigue, weakness, anorexia, purulent sputum, adventitious BS
- Dx: sputum gram stain, culture & sensitivity, CBC with diff, blood culture. Bacteria WBC > 15,000, CXR (localized infiltrate), bronchoscopy
- TX: Antibiotics, fluids, O2, Mechanical Ventilation

Chronic Bronchitis

- Productive cough 3 consecutive months for 2 consecutive years, increase mucous production

Aspiration

- Pathophysiology:
  - bronchospasm, atelectasis, tracheal damage,
  - bronchitis, bronchiolitis,
  - alveolar-capillary breakdown,
  - interstitial edema, alveolar congestion and hemorrhage
  - → severe hypoxemia, V/Q mismatch
- Most common:
  - aspiration of gastric content which is very caustic and can lead to immunologic changes at the cellular level that may lead to ARDS

Status Asthmaticus

- Unrelenting acute asthma, broncho-constriction despite treatment, inflammation, mucous production/plugs, increase MV
- S/S: anxiety, tachypnea, tachycardia, accessory muscle use, prolonged expiratory phase, pulsat paradoxicus > 15 mmHg, paradoxical respiration, respiratory alternans, central cyanosis, profuse diaphoresis, falling peak flows (PEFR) (<100 L/min), PEVI < 20%, hypoxemia, hypercapnia, purulent sputum, increased bronchodilator requirement
- TX: Bronchodilators, corticosteroids, O2, Hydration, antibiotics, Mechanical ventilation, low TV, sedatives, muscle relaxant
Chronic Obstructive Pulmonary Disease

- **S/S:** Chronic cough, mucous production, episodes of acute bronchitis, SOB worse with activities, decrease FEV1, decrease FVC, decrease DLCO
- **TX:**
  - Low dose O2,
  - B2 agonists (Ventolin, Alupent, Atrovent, Epi),
  - Anticholinergics (Atropine, Robinul),
  - Steroids,
  - Antibiotics,
  - Mucolytics & hydration, Expectorants,
  - promote nutrition
- If on Vent: TV 6-8 ml/kg, avoid pressure limited mode, check for auto-PEEP, allow respiratory muscle rest

**COPD--Classification**

- Stage I—FEV1 < 80% predicted
- Stage II—FEV1 50-79% predicted
- Stage III—FEV1 30-49% predicted, weight loss
- Stage IV—FEV1 < 30% or 30-49% with chronic respiratory failure

**COPD Emergent Pharmacologic Treatments**

- B-adrenergic Agents: Albuterol, Alupent, Maxair
- Anticholinergic Agents: Atrovent
- Corticosteroids

**Emphysema**

- Destruction of alveolar septae (loss of support structure), Expiratory airflow obstruction → air trapping → +V, -Q
- S/S: increased A-P diameter, ↓ exercise intolerance, mild sputum, cough
- CXR: hyperinflation, flatten diaphragm, bullae, ↑ retro-sternal space
- Tx: supportive, LVRS (to reduce the area of the lungs that are not being perfused)

**COPD Long term Pharmacologic Treatments**

- **Inhaled Corticosteroids:** Azmacort, Beclovent, Flovent, Pulmicort, AeroBid
- **Inhaled B-agonist:** Salmeterol, Serevent
- **Leukotriene Modifiers:** Singulair, Accolate
- **Inhaled Mast Cell Stabilizers:** Cromolyne, Nedocromil
- **PO B-agonists:** Albuterol extended-release tablets, Volmax
- **PO Prednisone**
- Methyloxanthines
**ARDS**

- Causes: Direct (aspiration) or Indirect (SIRS)
- Mortality Rate 50%
- Increase Capillary leak into interstitium
- Diffuse bilateral infiltrates → Pulmonary Edema
- V/Q abnormalities
- Decreased lung compliance & Atelectasis
- Shunt, Hypoxemia & Dyspnea
- P/F ratio < 200

**ARDS--Treatment Goals**

- Treat etiology of initial injury
- Restore FRC (PEEP, mechanical ventilation, proning)
- Adequate ABG’s
- Adequate O2 delivery to tissue
- Maximize O2 supply
- Decrease O2 demand
- Avoid O2 toxicity (FiO2 < 50-60%)
- Avoid barotrauma (small TV, plateau pressure < 35 cm H2O, inverse ventilation, high frequency ventilation)

**ARDS--Phases**

- Exudative (0-4 days): Stiff lungs, type I cell destruction, alveolar edema
- Proliferative (3-10 days): Type II proliferation (neutrophils), surfactant production, hyaline membranes
- Late (7-14 days): Capillary loss, fibrosis

**Pulmonary Hypertension**

- Pulmonary Arterial Hypertension
  - Idiopathic or familial PH (PAH)
  - PH due to other causes (Type 2 through 5)
- Pulmonary Venous Hypertension (2 & 3)
  - Left sided heart disease
  - Associated with hypoxia (COPD, interstitial lung disease, alveolar hypoventilation)
- Pulmonary Artery Pressure > 25 mmHg
- Endothelial dysfunction leads to remodeling of the pulmonary vessel wall → exaggerated vasoconstriction and impaired vasodilatation.

**ARDS--Clinical Features**

- Dyspnea
- Tachypnea
- Increased WOB
- Bilateral diffuse infiltrates (*honeycomb pattern*)
- PaO2 low despite FiO2 level, high A-a gradient

**Pulmonary Hypertension Continued**

- Dx Tests: Echo, CXR, 12 lead EKG, V/Q scan, CT Chest, 6 min walk test, Right Heart Cardiac Cath, serology testing, PFT, Sleep study
- Tx: anticoagulation, O2, diuretics, calcium Channel blockers, Remodulin, Flolan, Ventavis, Tracleer, Revatio
How does blood transfusion assist with tissue oxygenation?

1. If there is more RBC's, oxygen delivery to the tissue can be done quickly and efficiently
2. If there is more RBC's, blood pressure will improve which can enhance tissue perfusion
3. If there is more RBC's, more oxygen can be picked up from the alveoli to be delivered
4. All of the above

Sample Question # 1

A patient with a pulmonary embolus is requiring increasing oxygen requirements. An arterial blood gas results are as follows: pH 7.29, PaCO2 50 mmHg; PaO2 60 mmHg; SaO2 90%; HCO3 24 mEq/L. What is the most likely explanation for these results?

1. Metabolic acidosis
2. Respiratory failure
3. Hyperventilation
4. Respiratory acidosis

Sample Question # 2

The oxygen dissociation curve describes several factors that shift the curve to the right, decreasing the oxygen affinity for the hemoglobin. These factors are:

1. Tidal volume, functional residual volume, and anatomic dead space
2. pH, PCO2, and temperature
3. Alveolar perfusion and diffusion gradients
4. Alterations in barometric pressure

Sample Question # 5

Which of the following are symptoms of carbon monoxide asphyxia?

1. Headache and altered mental status
2. Hypoventilation and sweating
3. Bradycardia and diplopia
4. Cyanosis and hypertension

Sample Question # 3

A patient's ABG values are: pH 7.35, pCO2 48, pO2 62, HCO3 26, O2 Sat 90%. Which of the following do these values indicate?

1. Compensated respiratory acidosis with hypoxemia
2. Respiratory alkalosis with normal oxygenation
3. Compensated respiratory alkalosis with hypoxemia
4. Respiratory acidosis with normal oxygenation

Sample Question # 6
Appropriate outcome goals for a patient with status asthmaticus include:

1. Increased pCO2 and decreased FEV1
2. Decreased peak flow rates and decreased wheezing
3. Paradoxical breathing and increased FEV1
4. Normal pCO2 and increased FEV1

Sample Question #7

Twelve hours after sustaining a compound femur fracture, a patient complains of chest pain and severe shortness of breath. The patient has a petechial rash across the chest and RR of 34. ABGs of O2 at 4 L/min are: pH 7.48, pCO2 28, pO2 68. The nurse should suspect that the patient has developed

1. A tension pneumothorax
2. A fat embolus
3. ARDS
4. Disseminated intravascular coagulation

Sample Question #8

A 66-year-old patient with a history of COPD is admitted. ABG results are: pH 7.24, pCO2 78, pO2 54, HCO3 30, O2 Sat 82%. These results indicate hypoxemia and acute:

1. Respiratory acidosis
2. Metabolic acidosis
3. Respiratory alkalosis
4. Metabolic alkalosis

Sample Question #9

Which of the following is an early finding in a patient who has sustained acute pulmonary aspiration?

1. Hypoxemia
2. Hypoventilation
3. Acidosis
4. Hypotension

Sample Question #10

A patient is admitted with acute respiratory failure, left lobar pneumonia, and COPD. Physical examination reveals severe fatigue, coarse inspiratory crackles, bronchial breath sounds in the upper left lobe, and expiratory wheezes. Relevant data also include: HR 132, RR 36, pH 7.28, pCO2 72, pO2 48, HCO3 36, Temp 102.6. Based on this information, the nurse should anticipate which of the following additional clinical findings?

1. Dyspnea and purulent sputum
2. Mediastinal shift to the right
3. Bilateral vesicular breath sounds and restlessness
4. Intermittent apneic periods.

Sample Question #11

Which of the following is true regarding oxygen transport:

1. The majority of oxygen is dissolved in plasma
2. Hemoglobin is necessary to supply tissues with sufficient oxygen levels
3. Oxygen is bound to carbon dioxide in order to be carried to the tissues
4. All of the above

Sample Question #12
A patient’s blood gas levels are: pH = 7.2, PCO2 = 55 mmHg, HCO3 = 24 mEq/L. She has a:

1. Metabolic acidosis
2. Metabolic alkalosis
3. Respiratory acidosis
4. Respiratory alkalosis

Sample Question # 13

Which pathophysiology is associated with ARDS?

1. Fluid from the left heart backing up into the pulmonary system
2. Fluid leaking into alveoli due to increased permeability of alveolar capillary membrane
3. Shunting due to decreased blood flow through pulmonary capillaries
4. Severe bronchospasm leading to impaired gas exchange

Sample Question # 16

A patient’s admission blood gas is pH = 7.39, PO2 = 54 mmHg, SaO2 = 87%, pCO2 = 62 mmHg, HCO3 = 34 mEq/L. Which diagnosis is most likely:

1. Acute pulmonary embolus
2. Chronic obstructive pulmonary disease
3. Renal failure
4. Acute poisoning

Sample Question # 14

Which of the following is indicative of early ARDS?

1. Increased compliance
2. Ventilation-perfusion ratio greater than 0.8
3. Refractory hypoxemia with a high PCO2
4. Hypoxemia despite high inspired oxygen fractions (FiO2)

Sample Question # 17

ARDS can be caused by:

1. Pancreatitis
2. Trauma
3. Disseminated intravascular coagulation
4. All of the above

Sample Question # 18
Summary

- Review the 4 pathophysiologic changes related to Pulmonary System:
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