OXYGEN THERAPY

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UAMS

NASAL CANNULA

- Run on 1-6 LPM of flow
- Any flow of 4-6 LPM should be humidified for patient comfort and to avoid drying out the nasal mucosa
- Percentage of oxygen delivered to the patient is varied depending on the patient's depth of breathing. The larger the breath the lower the FiO2 delivered.
- There is an approximation of FiO2 delivered by a Nasal Cannula based on the liter flow

1 LPM ~ 24%	4 LPM ~ 36%
2 LPM ~ 28%	5 LPM ~ 40%
3 LPM ~ 32%	6 LPM ~ 44%

AIR ENTRAINMENT MASK

- Provides a fixed percentage of oxygen ranging from 24% to 50%
- Two types of devices:
  1: Has multiple jet pieces that each provide a specific FiO2
  2: Has a rotating adaptor that controls the air entrainment window
- These devices are good for CO2 retainers who require a fixed FiO2 and higher flows of O2

NON-REBREATHER

- Gives up to 100% FiO2 when flowmeter is turned up to "flush"
- May not be able to give 100% if the patient is taking very large breaths
- Devise has a reservoir bag and a one way valve. The one way opens during inspiration allowing the oxygenated air into the mask and closes during expiration so that oxygen refills the bag during expiration, instead of CO2

HIGH FLOW NASAL CANNULA

- High Flow Nasal Cannula
  - Provides flows for 2 LPM to 12 LPM
  - Requires humidification

COMFORT FLOW NASAL CANNULA

- Comfort Flow Nasal Cannula
  - Provides flows up to 40 LPM
  - Provides a fixed FiO2 via an oxygen/air blender
  - Must be heated and humidified
  - Great alternative for hypoxic respiratory failure

BIPAP/CPAP

- CPAP-Continuous Positive Airway Pressure
  - Provides continuous pressure to keep the alveoli open on exhalation to improve oxygenation
  - Used to treat conditions, such as fluid overload and obstructive sleep apnea
- BiPAP- Bilevel Positive Airway Pressure
  - Provides CPAP as well as IPAP (Inspiratory Positive Airway Pressure)
  - The IPAP assists the patient with taking a deeper breath which can improve Co2 removal (this is not considered a "ventilator", it only enhances the patients spontaneous breath)

**PATIENTS MUST BE ABLE TO SPONTANEOUSLY BREATHE FOR BiPAP OR CPAP TX.

CARE OF THE MECHANICALLY VENTILATED PATIENT

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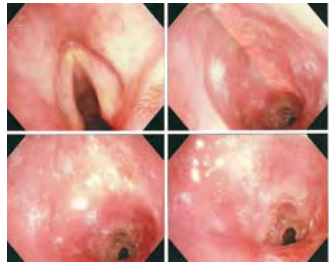
UAMS

OVERVIEW

- Artificial Airways
  - Types
  - Placement
  - Management
  - Trouble Shooting
- Mechanical Ventilation
  - Modes
  - Management
  - Trouble Shooting
  - Weaning
- Post Extubation Care

CONDITIONS THAT REQUIRE ARTIFICIAL AIRWAY

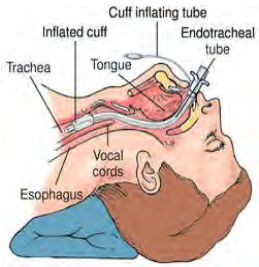
- Obstruction in the airway
  - Upper airway swelling
  - i.e. Mass/Tumor
- Protection of the airway due to failure of normal protective mechanisms
  - No gag reflex
  - Glottis malfunction
  - Decreased neurological function
- To enable mechanical ventilation



TYPES OF AIRWAYS

Oral Endotracheal Tube

- Advantages:
  - Most commonly used in the hospital
  - Easy placement and removal
  - Good for short term airway use
- Disadvantages:
  - Oral care is difficult, causing greater risk of infection and pneumonia
  - Excessive salivation
  - Coughing and biting due to gag reflex and discomfort



TYPES OF AIRWAYS

Nasal Endotracheal Tube

- Advantages:
  - Good for patients with cervical spine injury
  - Useful for patients having oral surgery or injuries
  - Useful in patients who have large oral mass or obstruction
- Disadvantages:
  - Nasal trauma and bleeding risk
  - Must use smaller tube
  - Can block Eustachian tube and sinuses possibly causing inflammation and swelling

TYPES OF AIRWAYS

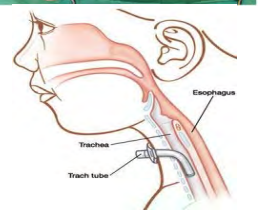
Laryngeal Mask Airway

- Advantages:
  - Easy to place correctly
  - Good for short term use in the field and the OR
- Disadvantages:
  - Difficult to maintain proper placement over long periods of time
  - Can cause irritation and tissue damage

TYPES OF AIRWAYS

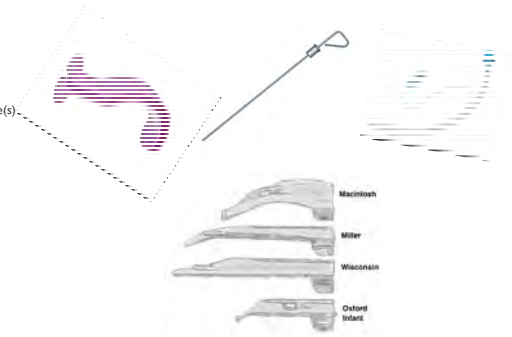
Tracheostomy Tube

- Advantages:
  - More Comfortable
  - Less aspiration of oral secretions
  - Facilitate gradual weaning for patients who have had multiple weaning failures
- Disadvantages:
  - Surgical procedure with risk of bleeding and infection
  - Permanent incision must have time to heal once trach is no longer needed
  - Can cause scarring



INTUBATION EQUIPMENT

- Oral airway
- Ambu bag and mask
- ET tube
- Stylet
- Layrngoscope handle and appropriate size blade(s)
- Flexible suction catheter and Yankauer
- 10 cc syringe (for cuff inflation)
- Tube holder
- Water soluble lubricant
- Suction unit and canister
- End tidal CO2 detector, stethoscope
- Ventilator



INTUBATION PROCEDURE

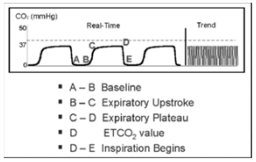
- Explain procedure and obtain consent if possible
- Select ET tube size and insert stylet (stylet should be completely inside ET tube, not sticking out of the end of the tube)
- Select Laryngoscope blade size
- Check Laryngoscope blade, light, ET tube cuff, suction, etc…prior to intubation
- Administer sedation and ventilate patient with bag and mask as breathing depth and rate decrease (use oral airway if needed)
- Position head in sniffing position
- Once ET tube is inserted remove stylet, inflate the cuff and begin bagging with ETCO2 detector in place

INTUBATION CONFIRMATION

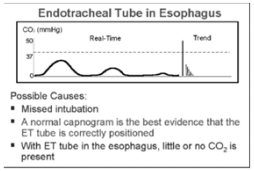
- Visualization- chest rises equally on left and right
- Auscultation- equal breath sounds over both lungs and no air heard in the stomach
- ETCO2 detector-good color change indicates CO2 or good CO2 range via monitor
- Chest X-Ray- ET tube has radiopaque line that should end 3-5 cm above the carina

AIRWAY CONFIRMATION AND MONITORING

- Capnography- the continuous measurement of exhaled CO2
  - Normal etCO2= 35-45 mmHg



- A – B Baseline
- B – C Expiratory Upstroke
- C – D Expiratory Plateau
- D $ETCO_2$ value
- D – E Inspiration Begins



Possible Causes:
- Missed intubation
- A normal capnogram is the best evidence that the ET tube is correctly positioned
- With ET tube in the esophagus, little or no CO_2 is present

AIRWAY MANAGEMENT

ET Tube

- Resuscitation bag and mask should be at bedside and visible
- An ETT holder should be in place and should be changed when it is soiled or the adhesive is worn off
- Tube placement should be checked and documented each shift as well as after the patient is moved or turned
- Oral care should be performed frequently
- Cuff pressure should be monitored (normal= 20-30 mmHg)
- Pt should be restrained as needed

Trach Tube

- Obturator, resuscitation bag and mask should be kept at the bedside and visible
- An extra trach tube should be avail.
- Trach should be secured by trach ties which should be changed when soiled
- Trach site condition should be observed and documented each shift
- Trach care should be performed each shift
- Oral care should be performed frequently
- Cuff pressure should be monitored
- Pt should be restrained as needed

AIRWAY TROUBLESHOOTING

Problem
- Audible air leak from pt's mouth

Possible Cause
- Cuff is under inflated

Solution
- Add air to cuff

Problem
- Large air leak around tube that is not fixed when adding air to cuff

Possible Cause
- Cuff has ruptured
- Pt is extubated

Solution
- Suggest exchanging the tube/reintubation

AIRWAY TROUBLESHOOTING

Problem
- Decreased breath sounds in both lungs

Possible Cause
- Tube occluded
- Kink in tube or circuit

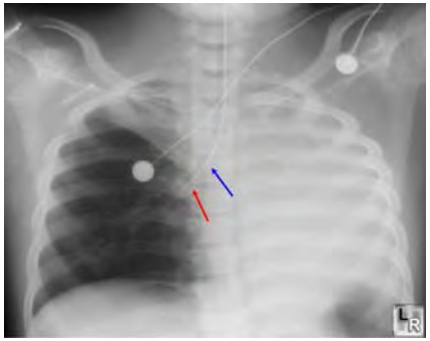
Solution
- Suction
- Examine tube and circuit for kinks or occlusions

Problem
- Decreased breath sounds in one lung

Possible Cause
- Main stem intubation
- Pneumothorax
- Severe atelectasis

Solution
- Stat CXR
- Withdraw tube based on CXR findings

AIRWAY TROUBLESHOOTING



CONDITIONS THAT REQUIRE VENT SUPPORT

50/50 Rule
- Acute severe hypoxemia- PaO2 of less than 50
- Acute ventilatory failure- Acidotic- PaCO2 greater than 50 with a pH less than 7.30

Respiratory Muscle Insufficiency
- RR greater than 30 BPM
- Increased WOB and use of accessory muscles
- NIF less than -20 cmH2O (normal=more than -60 cmH2O)

BASIC VENTILATOR MODES: CMV/AC

- Continuous Mandatory Ventilation/Assist Control
- Set rate and tidal volume (Vt)
- Pt can initiate as many breaths as they want but each breath will be given at the set Vt
- Used to allow patient to rest
- Ventilator does all the work

BASIC VENTILATOR MODES: SIMV

- Synchronized Intermittent Mandatory Ventilation
- Set rate and Vt given with each mandatory breath
- In between mandatory breaths patient can take their own breath with "pressure support"
- Good mode for weaning
- Vent does part of the work and pt does the rest (only if the pt makes effort to breathe over the set rate)

BASIC VENTILATOR MODES: CPAP/PS

- Continuous Positive Airway Pressure with Pressure Support
- Spontaneous mode of ventilation
- CPAP stents alveoli open while PS helps to augment Vt
- No set rate; patient must initiate all breaths
- Can indicate how well the patient will do once extubated

BASIC VENTILATOR MODES: APRV

- Airway Pressure Release Ventilation
- Used for patient who are unable to oxygenate with traditional ventilation despite high FiO2 and PEEP
- Uses inverse ration ventilation to keep lungs open longer for maximal oxygenation
- Risk of pneumothorax, barotrauma, decreased cardiac output

BASIC VENTILATOR SETTINGS

- FiO2
  - Fraction of inspired oxygen
  - Can deliver room air (21%) and up to 100% as required
- Tidal Volume [Vt]
  - Tidal volume
  - Volume of air delivered by the vent with each mechanical breath
- Respiratory Rate [RR] or Frequency
  - Respiratory rate
  - Number of mechanical breaths delivered each minute
- PEEP
  - Positive End Expiratory Pressure
  - Continuous pressure that keeps alveoli from collapsing at the end of expiration
- Pressure Support [PS]
  - Increase in pressure designed to support the patients own spontaneous breaths, essentially increasing their spontaneous Vt and decreasing resistance applied by ET tube

VENTILATOR ALARMS

High Pressure

- Possible causes
  - Biting ET tube
  - Kink in tube or circuit
  - Occlusion (Suction catheter left in ETT)
  - Plug (i.e. mucous or blood)
  - Tension pneumothorax
  - Pt coughing or bucking the vent

Low Pressure

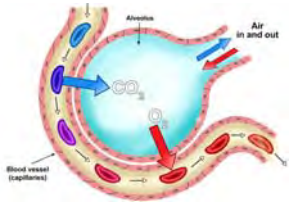
- Possible cause
  - Pt "popped off" vent; disconnected
  - Cuff not properly inflated or severe leak in circuit
  - Pt is extubated

Apnea Alarm

- Sounds when patient fails to breath within a preset period of time in a spontaneous vent mode

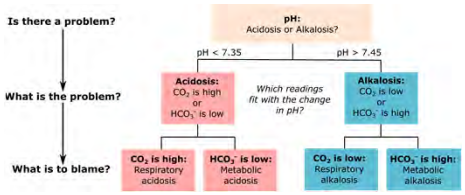
VENTILATOR MANAGEMENT

- What two vent settings control oxygenation?
  - FiO2 and PEEP
- How would you manipulate those settings to improve oxygenation?
- What two vent settings control ventilation?
  - RR and Vt
- How would you manipulate those settings to improve ventilation?



VENTILATOR MANAGEMENT

- ABG Review
  - Normal pH- 7.35-7.45
  - Normal CO2- 35-45
  - Normal HCO3- 22-26
  - Normal PaO2- 80-100
- ABG Interpretation
  - 7.25/68/96/25
  - 7.54/25/75/23
  - 7.20/43/68/17
  - 7.58/40/90/30



WEANING FROM MECHANICAL VENTILATION

Weaning should begin when initial reason for mech. ventilation is resolved!

- Wean sedation
- Place pt in spontaneous mode of ventilation
- Monitor vital signs, Vt, RR and work of breathing
- Place back on controlled mode if pt becomes tachypneic or tachycardic or in anyway unstable
- If pt passes trial they are probably ready for extubation
- Breathing tests or ABG's can be ordered to further assess pt's readiness for extubation

EXTUBATION

- Pre-oxygenate with 100% FiO2
- Suction down tube and above cuff
- Head of bed should about 45 degrees or fowler's so that patient can deep breathe and cough
- O2 device should be set up and ready and Yankauer should be ready with suction on

POST EXTUBATION

- No talking for an hour
- No food or drink until swallow can be assessed
- Vital signs and breath sounds should be closely monitored
- Incentive Spirometry should be initiated
- Pt should be up in a chair as soon as condition is appropriate

KEY POINTS

Airway placement and management

- Know tube placement and monitor while turning and cleaning pt
  - Keep airway suctioned and clean

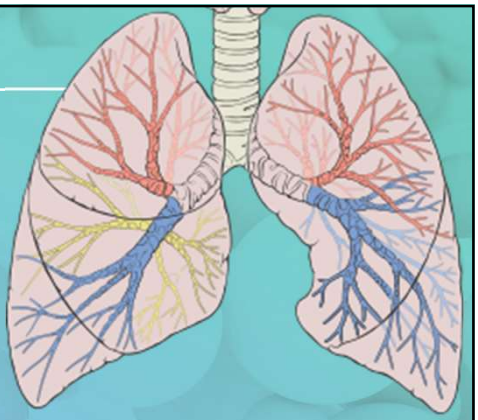
Ventilator Management

- Become proficient at ABG interpretation

PREVENTION IS KEY!!!

- Be proactive

QUESTIONS



ACUTE RESPIRATORY FAILURE

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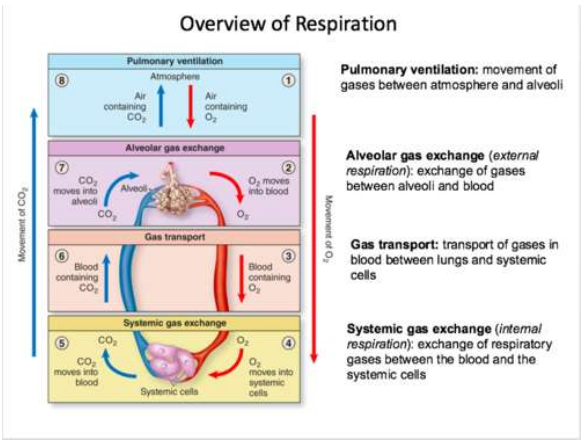
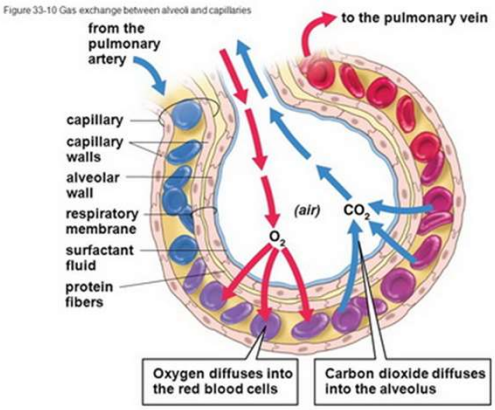
Overview of Respiration/ Gas Exchange





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Acute Respiratory Failure (ARF)

Failure

- Oxygenation
- Ventilation
- Both of the above

Altered gas exchange (room air)

- PaO_2 < 60 mm Hg
- $PaCO_2$ > 50 mm Hg
- pH ≤ 7.30

3

Failure of Oxygenation

- Hypoventilation
- Intrapulmonary shunting
- Ventilation-perfusion mismatch
- Diffusion defects
- Decreased barometric pressure
- Low cardiac output (nonpulmonary hypoxemia)
- Low hemoglobin level (nonpulmonary hypoxemia)

4

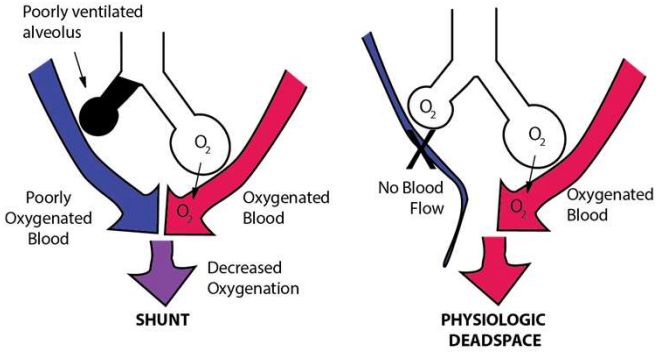
Hypoventilation

- Drug overdose
- Neurological disorders
- Abdominal or thoracic surgery
- COPD

5

Intrapulmonary Shunting

- Blood shunted from right to left side of heart without oxygenation
- Causes: atrial or ventricular septal defect, atelectasis, pneumonia, pulmonary edema
- Why does administration of higher levels of oxygen *not* help in shunt disorders?



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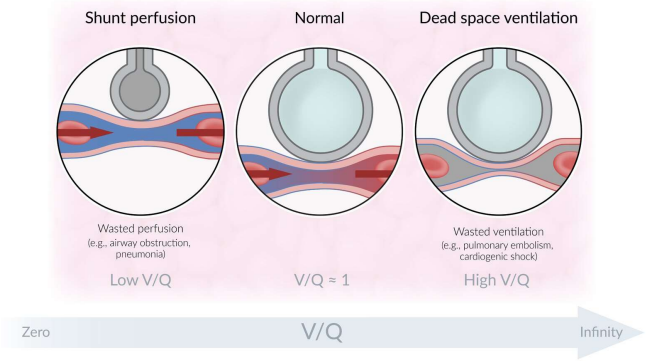
V/Q Mismatch

- Most common cause of low O_2
  - Normal ventilation (V) is 4 L/min
  - Normal perfusion (Q) is 5 L/min
  - Normal V/Q ratio is 4/5 or 0.8
- A mismatch occurs if either
  - V is decreased or
  - Q is decreased
- What are causes of this condition?



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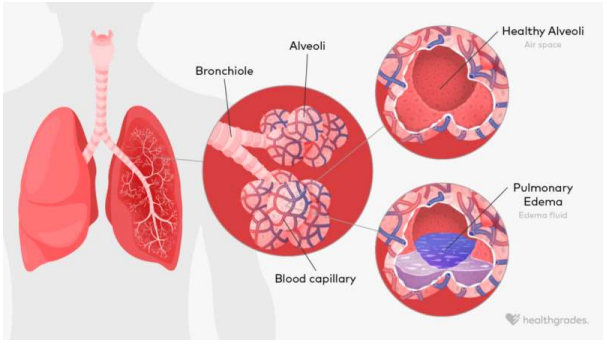
Diffusion Defects

- Diffusion of O_2 and CO_2 does not occur
  - Fluid in alveoli
  - Pulmonary fibrosis



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Low Cardiac Output

Cardiac output must be adequate to maintain tissue perfusion

Normal delivery is 600 to 1000 mL/min of oxygen

9

Low Hemoglobin

- Hemoglobin necessary to transport oxygen
- 95% of oxygen is bound to hemoglobin

10

Tissue Hypoxia

- Some conditions prevent tissues from using oxygen despite availability
  - Cyanide poisoning
- Tissue hypoxia results in anaerobic metabolism and lactic acidosis

11

Quick Quiz

The nurse suspects respiratory failure secondary to hypoventilation in a patient with:

A. Anxiety
B. Neuromuscular disease
C. Pulmonary embolism
D. Volume A/C ventilation at rate of 20 breaths/min

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Critical Thinking Challenge

- How does hemoglobin affect oxygenation?
- Why would a low cardiac output result in hypoxia?

13

Failure of Ventilation

- Hypercapnia
- Related to:
  - Alveolar hypoventilation—decrease in ventilation and hypoxemia
  - V/Q mismatch

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Assessment of Respiratory Failure

- Neurological—shows earliest signs of hypoxemia and hypercapnia
- Respiratory
- Cardiovascular
- Nutrition
- Psychosocial
- Chest x-ray
- Pulmonary function tests
- Laboratory studies
- Arterial blood gases (ABGs)
- Pulse oximetry and end-tidal CO_2

15

Interventions

- Maintain a patent airway
- Optimize O_2 delivery
- Minimize O_2 demand
- Identify and treat the cause of ARF
- Prevent complications

16

Nursing Diagnoses

- Impaired ventilation
- Ineffective airway clearance
- Infection
- Anxiety
- Impaired skin integrity
- Ineffective coping
- Ineffective breathing pattern
- Impaired gas exchange
- Impaired breathing pattern
- Fluid volume excess
- Altered nutrition

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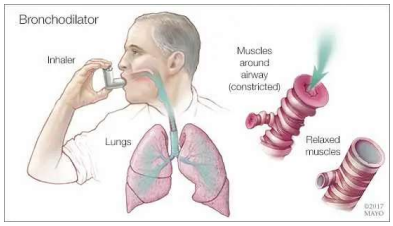
Medical Management

- Oxygen
- Bronchodilators
- Corticosteroids
- Sedation
- Transfusions
- Therapeutic paralysis
- Nutritional support
- Hemodynamic monitoring



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Respiratory Failure Concerns

! CLINICAL ALERT

Acute Respiratory Failure

Concern	Symptoms	Nursing Actions
Respiratory muscle fatigue	Diaphoresis Nasal flaring Tachycardia Abdominal paradox Muscle retractions • Intercostal • Suprasternal • Supraclavicular Central cyanosis	Improve O_2 delivery: • Administer O_2 • Ensure adequate cardiac output and blood pressure • Correct low hemoglobin • Administer bronchodilators Decrease O_2 demand: • Provide rest • Reduce fever • Relieve pain and anxiety • Decrease work of breathing • Position patient for optimum gas exchange and perfusion • Prepare for possible intubation and mechanical ventilation
Cerebral hypoxia and carbon dioxide narcosis from increased CO_2 retention	Lethargy Somnolence Coma Respiratory acidosis	Maintain airway patency Prepare for possible intubation and mechanical ventilation

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Quick Quiz

A nursing intervention to maximize airway clearance is which of the following?

A. Administer supplemental oxygen.
B. Elevate the head of bed.
C. Provide oral care every 4 hours.
D. Reposition patient every 2 hours.

20

ARDS

- Noncardiogenic pulmonary edema
- Diagnostic criteria
  - PaO_2/FiO_2 ratio of less than 200
  - Bilateral infiltrates
  - Pulmonary capillary wedge pressure < 18 mm Hg
- Acute lung injury scoring

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Case Study

Mrs. J. is a 31-year-old female admitted to the critical care unit with respiratory distress after getting the "flu." Her condition worsens; SpO_2 is 85% on Venturi mask at 0.50. ABGs show a PaO_2 of 50 mm Hg. Her chest x-ray is showing infiltrates.

- Calculate Mrs. J.'s PaO_2/FiO_2 ratio, and interpret the findings.

22

Case Study (Cont.)

Mrs. J. is placed on noninvasive positive-pressure ventilation (NPPV).

Why is this decision made?

23

Case Study (Cont.)

Within 2 hours of NPPV, Mrs. J. is getting worse. Her SpO_2 remains at 85%, and the oxygen via NPPV was 80%. Her chest x-ray shows bilateral "white out."

What treatment is indicated?

24

Quick Quiz

If the PaO_2 is 60 mm Hg and the FiO_2 is 0.6, the PaO_2/FiO_2 ratio is:

A. 100
B. 1000
C. 360
D. 3600

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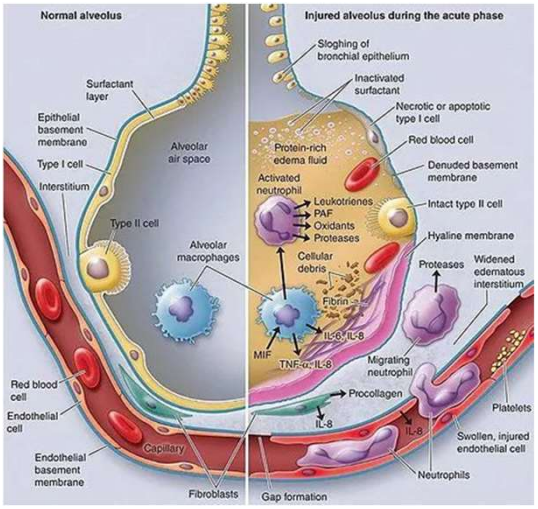
ARDS Pathophysiology

- Insult—systemic inflammatory response syndrome (SIRS)
- Release of inflammatory mediators
- Damage to alveolar-capillary membrane
- Increased capillary permeability
- Pulmonary edema (noncardiogenic)



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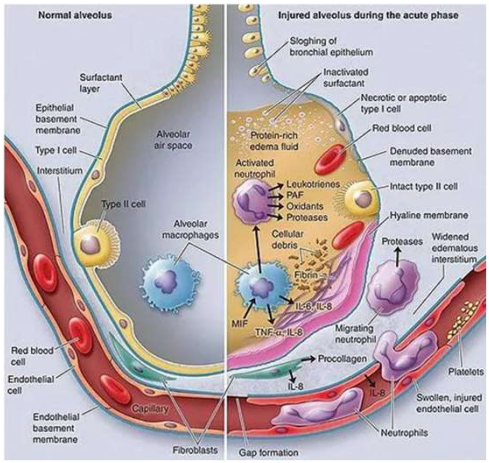
ARDS Pathophysiology (Cont.)

- Microatelectasis
- Decreased compliance (stiff lungs)
- Decreased surfactant (damage to type II pneumocytes)
- Impaired gas exchange
- V/Q mismatch



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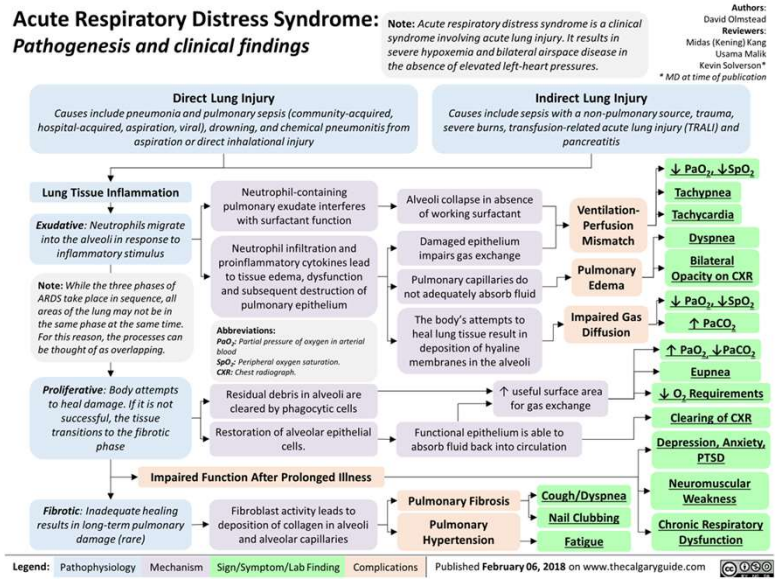
ARDS Pathophysiology



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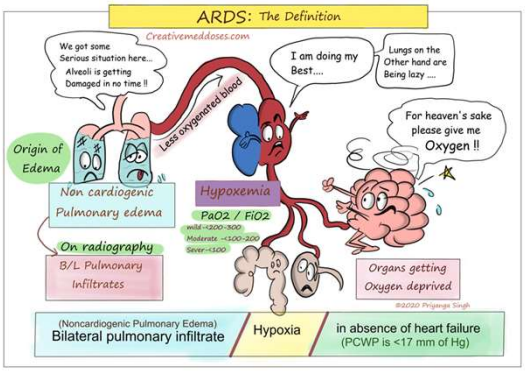
Berlin Definition – ARDS



Timing	Within 1 week of a known clinical insult of new/worsening respiratory symptoms		
Chest Imaging (x-ray or CT)	Bilateral opacities – not fully explained by effusions, lobar/lung collapse, or nodules		
Origin of Edema	Respiratory failure not fully explained by cardiac failure or fluid overload		
Oxygenation	Mild	Moderate	Severe
	P/F Ratio 201-300 (PEEP ≥ 5 cmH2O)	P/F Ratio 101-200 (PEEP ≥ 5 cm H2O)	P/F Ratio ≤ 100 (PEEP ≥ 5 cm H2O)

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Critical Thinking Challenge

- What patients would you identify as having a high risk of developing ARDS?
- Why is hyperventilation an early sign seen in patients developing ARDS?
- What related ABG abnormality will be seen?

30

Case Study (Cont.)

- What is a possible etiology of ARDS in Mrs. J.?

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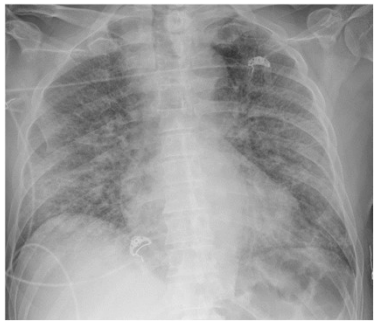
Symptoms of ARDS



- Dyspnea and tachypnea
- Hyperventilation with normal breath sounds
- Respiratory alkalosis
- Increased temperature and pulse
- Worsening chest x-rays that progress to "white out"
- Increased PIP on ventilation
- Eventual severe hypoxemia

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Treatment of ARDS

- Treat the cause
- Oxygenation and ventilation
  - Positive end-expiratory pressure (PEEP)
  - Possible nontraditional modes of ventilation: high-frequency, pressure-control, and inverse-ratio

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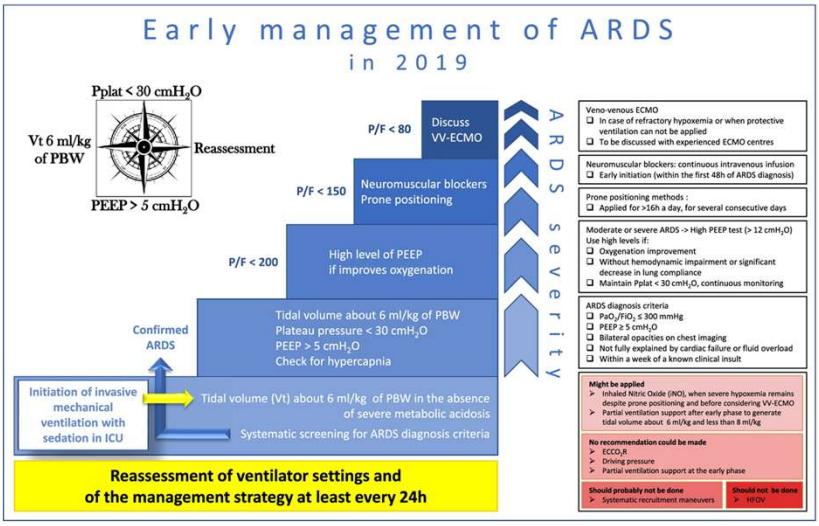
ARDS Treatment/Management



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Case Study (Cont.)

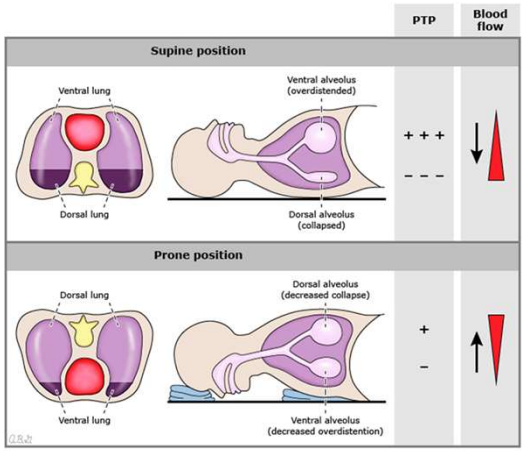
Mrs. J. is placed on volume assist/control (V-A/C) ventilation: rate 16 breaths/min, V_T 8 mL/kg, FiO_2 0.80, and PEEP 10 cm.

What is the rationale for these settings, including PEEP?

35

Treatment of ARDS

- Comfort
  - Sedation
  - Pain relief
  - Neuromuscular blockade
- Decrease O_2 consumption
- Positioning
  - Prone positioning
  - Continuous lateral rotation therapy



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Case Study (Cont.)

Mrs. J.'s condition does not improve. SpO_2 is 85%, and the FiO_2 is increased to 0.90 to maintain this. A decision is made to increase the PEEP to 20 cm H_2O. About 10 minutes after the PEEP is increased, Mrs. J.'s blood pressure drops to 80/50 mm Hg. Breath sounds are equal bilaterally.

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Question

What is the likely rationale for the drop in Mrs. J.'s blood pressure?

What is the significance of the bilateral breath sounds?

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Treatment of ARDS

- Fluid and electrolyte balance
- Adequate nutrition
- Pharmacologic intervention
- Psychosocial support

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ARDS

- Be alert for complications:
  - Multiple organ dysfunction syndrome
  - Renal failure
  - Disseminated intravascular coagulation
  - Long-term pulmonary effects associated with high oxygen and other therapies

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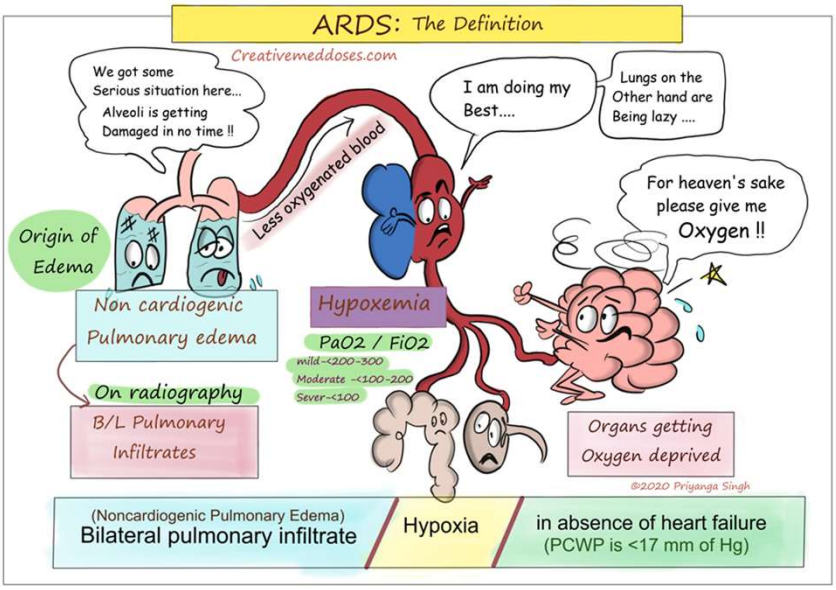
Questions?



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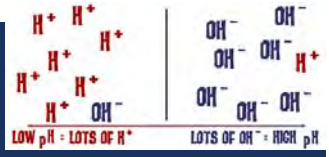
ABGS AND BEYOND: ASSESSING OXYGENATION AND VENTILATION



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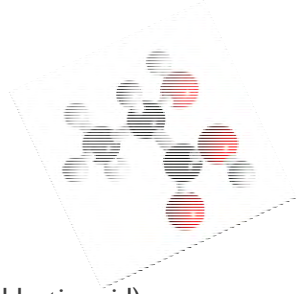
DESCRIPTION

- Arterial blood gases are used to measure the amount of oxygen, carbon dioxide, and bicarbonate in the blood, as well as the pH.
- ABGs provide information regarding physiologic phenomena

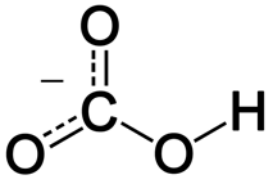
ACIDS

- Substances capable of releasing a hydrogen ion (H^+) into solution.
- Volatile acids
  - excreted through the lungs (CO_2)
- Fixed or nonvolatile acids
  - excreted by the kidneys (ketoacids and lactic acid)



BASES

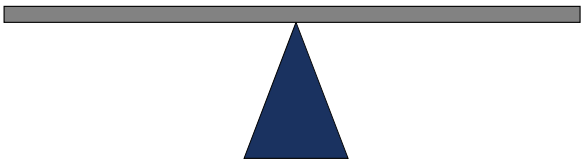
- Substances capable of combining with H^+ in solution.
- Bicarbonate (HCO_3)
  - Most important base in the blood
  - regulated by the kidneys



- Hemoglobin and plasma proteins.
- Bases are reflected in the ABGs as the HCO_3 and the base excess or base deficit.

ACID – BASE BALANCE

- Reflection of relationship between bases and acids in the blood
- Acid base balance is reflected in the pH



ELEMENTS OF ABGS: NORMAL VALUES

- pH--7.35 to 7.45
  - represents a combined effect of metabolic and respiratory factors.
  - low pH indicates acidosis
  - high pH indicates alkalosis

ELEMENTS OF ABGS: NORMAL VALUES

- PCO_2--35 to 45 mm HG
  - A measure of the partial pressure of carbon dioxide dissolved in the plasma.
  - byproduct of metabolism
  - CO_2 is excreted by the lungs and is a measure of the adequacy of ventilation.
  - CO_2 functions as an acid because it combines with water to produce carbonic acid, H_2CO_3.

ELEMENTS OF ABGS: NORMAL VALUES

- HCO_3--22 to 26 mEq/L
  - Bicarbonate ion is a base regulated by the kidneys
  - It may be adjusted to compensate for respiratory acid-base imbalance, or may be altered by other factors such as kidney disease or metabolic alterations

ELEMENTS OF ABGS: NORMAL VALUES

- PaO_2--80-100 mm Hg
  - Is the partial pressure of oxygen dissolved in arterial plasma
  - Only about 1% of total oxygen content is carried in this state, PaO_2 indicates how well oxygen is being taken up in the lungs.

ELEMENTS OF ABGS: NORMAL VALUES

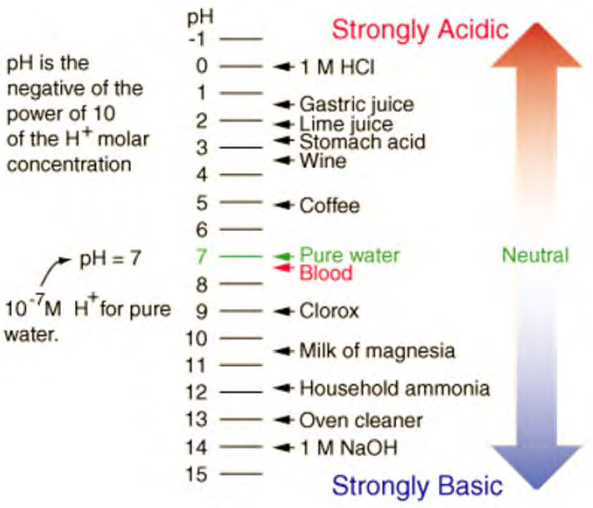
- SaO_2--95 to 98%
  - SaO_2 represents the percentage of total hemoglobin which is saturated with oxygen.
  - The vast majority of oxygen is carried in this state.
  - While saturation is usually well-correlated with PaO_2, some conditions (pH, temperature) can influence the relationship between these two parameters

ELEMENTS OF ABGS: NORMAL VALUES

- Base Excess (BE) -2 to +2
  - It represents the combined effects of HCO_3 and other bases--plasma proteins, hemoglobin and others
  - A negative base excess is sometimes referred to as a base deficit.

SUMMARY OF NORMAL VALUES

pH	**7.35 – 7.45**
PaO_2	**80 – 100 mmHg**
PCO_2	**35 – 45 mmHg**
HCO_3	**22 – 26 mEq/L**
Base Excess (BE)	**-2 - +2**
SaO_2	**95% - 98%**



STEPS IN ABG INTERPRETATION

1. Check pH
   - acidotic, alkalotic, or normal
2. Check $PaCO_2$ (respiratory parameter)
   - Elevated (acidotic), decreased (alkalotic), or normal
3. Check HCO_3 (metabolic parameter)
   - Elevated (alkalotic), decreased (acidotic), or normal
4. If abnormalities exist, determine which of the major acid/base imbalances is present

STEPS IN ABG INTERPRETATION CONT'D

5. Determine whether any compensation mechanisms are involved

6. Check PO_2 and O_2 saturation
   - normal, elevated, or decreased

7. Observe patient
   - evaluate vital signs and physical parameters

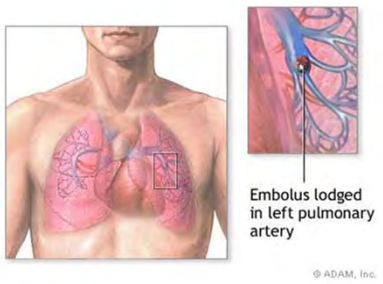
Evaluate why patient presents any abnormal values which are present and implement appropriate actions to correct the acid/base imbalance

RESPIRATORY ACIDOSIS (ELEVATED $PACO_{2)}$

- Caused by hypoventilation of any etiology
  - COPD
  - Oversedation, head trauma, anesthesia, or reduced function of respiratory center.
  - Neuromuscular disease
  - Inappropriate mechanical ventilation
  - Other causes of hypoventilation (sleep apnea)

RESPIRATORY ALKALOSIS
(LOW PACO2)

- Hyperventilation
  - Hypoxemia
  - Nervousness and Anxiety
  - Pulmonary Embolus
  - Pregnancy
  - Inappropriate Mechanical Ventilation
  - Compensation for Metabolic Acidosis



METABOLIC ALKALOSIS
(ELEVATED HCO_3)

- Caused by a loss of nonvolatile acid or increase in HCO_3
- Gastric loss of acid
- HCO_3 during cardiac arrest
- Baking soda
- Massive blood transfusion – citrate – lactate - bicarbonate
- Increased excretion of H^+, K^+, and Cl^- due to :
  1. Diuretics
  2. Cushings Syndrome
  3. Corticosteroids
  4. Aldosteronism

METABOLIC ACIDOSIS (DECREASED HCO_3)

Caused by a gain in nonvolatile acid which uses up HCO_3 or loss of HCO_3

Increase in immeasurable anions:

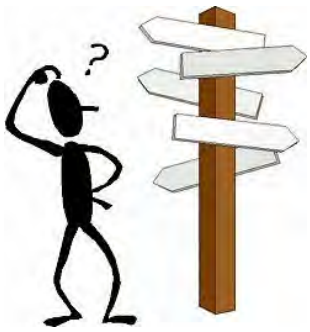
- Diabetic ketoacidosis
- Renal failure
- Lactic Acid
- Poisoning: salicylates, ethylene glycol, methyl alcohol, paraldehyde

No increase in immeasurable anions:

- Diarrhea
- Drainage of pancreatic juice
- Treatment with Diamox
- Treatment with ammonium chloride
- Renal tubular Acidosis

CLINICAL SIGNS OF ACIDOSIS (CNS DEPRESSION)

- Depressed thought processes
- Delayed reaction times
- Slurred speech
- Somnolence
- Incoordination
- Confusion
- Semi-coma
- Death



CLINICAL SIGNS OF ALKALOSIS (CNS EXCITATION)

- Anxiety
- Paresthesia
- Tremors
- Nausea
- Tetany
- Convulsions
- Death

ANION GAP

- The anion gap refers to a difference in the routinely measured cations (positively charged particles, such as Na^{+}, Ca^{++}, and Mg^{++}) and anions (negatively charged particles , such as HCO_3^{-} and Cl^{-})

ANION GAP

- The formula for the anion gap is:
  - AG= Na^+ - (HCO_3^- + Cl^-)
- The normal anion gap is 8-16 mEq/L

ANION GAP

- Na 138
- $HCO3^-$ 11
- Cl^- 99
- AG = Na^+ - ($HCO3^-$ + Cl^-)
  138 - (11 + 99)
  = 138 - 110
  = 28

ANION GAP – WHY DO WE CARE?

- Assists in differential diagnosis of the type of metabolic acidosis
- An **elevated** anion gap acidosis suggests an increase in plasma level of unmeasured cations (**accumulation of acids** is not adequately buffered by a base)
- A **nonelevated** anion gap acidosis reflects the **loss of bicarbonate**, rather than an increase in acid production or a decrease in acid excretion.

COMMON DISORDERS OF METABOLIC ACIDOSIS

Metabolic Acidosis with elevated anion gap

MUDPILERS

M – Methanol ingestion

U – Uremia

D – Diabetic, alcoholic, or starvation ketoacidosis

P – Paraldehyde injestion

I – Isoniazid, salicylate, or iron poisoning

L – Lactic acidosis

E – Ethylene glycol ingestion

R – Rhabdomyolysis

S – Salicylates

Metabolic Acidosis with normal anion gap

HARD-UP

H – Hyperalimentation

A – Acetazolamide

R – Renal tubular acidosis, renal insufficiency

D – Diarrhea and diuretics

U – Uteroenterostomy

P – Pancreatic fistula

RESPIRATORY ACIDOSIS
PH IS LOW AND PACO2 IS HIGH

pH	**7.30** ACID
PCO_2	**65** ACID
PO_2	**90**
HCO_3-	**26**
BE	**0**
SaO_2	**95%**

RESPIRATORY ALKALOSIS
HIGH PH ALONG WITH A LOW $PACO_2$

pH	**7.5** BASE
PCO_2	**30** BASE
PO_2	**90**
HCO_3-	**26**
BE	**0**
SaO_2	**95%**

METABOLIC ACIDOSIS

PH IS LOW WITH A LOW HCO_3^- AND/OR BE

pH	**7.30 ACID**
PCO_2	**35**
PO_2	**92**
HCO_3-	**18 ACID**
BE	**-3 ACID**
SaO_2	**97%**

METABOLIC ALKALOSIS

HIGH PH ALONG WITH A HIGH HCO_3^- AND/OR BE

pH	**7.5 BASE**
PCO_2	**40**
PO_2	**95**
HCO_3-	**35 BASE**
BE	**+3 BASE**
SaO_2	**96%**

PHENOMENA

- Compensation
  - Body's ability to regulate pH by adjusting either the rate of ventilation (excretion of CO_2) or the renal excretion of HCO_3)
  - Mechanism by which an abnormal $PaCO_2$ or HCO_3 may be accompanied by a normal or near-normal pH

COMPENSATION CONT'D

- In other words, it is the body's attempt to normalize pH.
- Common compensatory mechanisms involve regulating the amount of CO_2 (respiratory compensation-fast response) or the amount of HCO_3- (metabolic compensation-slower response)

HOW?

- Respiratory acidosis due to increased $PaCO_2$
  - Compensation: Kidneys excrete more acid and less HCO_3- resulting in increased HCO_3-
- Respiratory alkalosis due to decreased $PaCO_2$
  - Compensation: Kidneys excrete HCO_3-
- Metabolic acidosis due to decreased HCO_3-
  - Compensation: Hyperventilation to decrease $PaCO_2$
- Metabolic alkalosis due to increased HCO_3-
  - Compensation: Hypoventilation to increase $PaCO_2$

COMPENSATION

Primary Disorder	Cause	Compensation	Effect on ABGs
Metabolic Acidosis	•Excess nonvolatile acids •Bicarbonate deficiency	Rate & depth of respirations increase → eliminates additional CO2	↓ pH ↓ HCO3 ↓ PaCO2
Metabolic Alkalosis	•Bicarbonate excess	Rate & depth of respirations decrease → retaining CO2	↑ pH ↑ HCO3 ↑ PaCO2
Respiratory Acidosis	•Retained CO2 & excess carbonic acid	Kidneys conserve bicarbonate to restore carbonic acid : bicarbonate ratio 1:20	↓ pH ↑ PaCO2 ↑ HCO3
Respiratory Alkalosis	•Loss of CO2 & deficient carbonic acid	Kidneys excrete bicarbonate and conserve H+ to restore carbonic acid : bicarbonate ratio	↑ pH ↓ PaCO2 ↓ HCO3

COMPENSATION CONT.

- There are two types of compensation
  - Partial Compensation
    - pH, $PaCO_2$, and HCO_3 are all abnormal
  - Full Compenstion
    - pH is normal, $PaCO_2$ and HCO_3 are abnormal

ASSESSMENT OF ACID-BASE BALANCE

- Look at the pH, and determine if it is low (acidotic), normal, or high (alkalotic)
- Look at the CO_2 and HCO_3 and determine if these values "match" the pH.
  - For example, you would expect a normal pH to go along with a normal CO_2 and HCO_3-. A normal pH with abnormal CO_2 and HCO_3 indicates compensation.

PARTIAL COMPENSATION

- pH 7.18
- $pC0_2$ 34
- $HC0_3$ 12
- $Pa0_2$ 84
- $Fi0_2$ .21
- P/F ratio 400

PARTIAL COMPENSATION

- pH 7.22
- $pC0_2$ 59
- $HC0_3$ 35
- $Pa0_2$ 35
- $Fi0_2$ .21
- P/F Ratio 167

NAME THAT ABG

pH	**7.42**
PCO_2	**50**
PO_2	**80**
HCO_3-	**32**
BE	**2.5**
SaO_2	**95%**

NAME THAT ABG

pH	**7.37**
PCO_2	**32**
PO_2	**90**
HCO_3	**18**
BE	**-2.5**
SaO_2	**98%**

NAME THAT ABG

pH	**7.39**
PCO_2	**64**
PO_2	**65**
HCO_3	**37**
$Fi0_2$	**.30**
P/F Ratio	**217**

NAME THAT ABG

pH	**7.45**
PCO_2	**27**
PO_2	**65.5**
$HC0_3$	**19.1**
$Fi0_2$	**.40**
$SP0_2$	**.88**

WHAT ABOUT THIS ONE?

pH	**7.20**
PCO_2	**65**
PO_2	**55.5**
$HC0_3$	**12**
$Fi0_2$	**.80**
$SP0_2$	**.88**

PHYSIOLOGIC PHENOMENA

- Oxygenation
  - Ability of the lungs to deliver fresh O_2 to the blood in the pulmonary capillary beds
  - Reflected in the partial pressure of oxygen (PaO_2) and the percent saturation of oxygen (SaO_2) in the arterial blood

OXYGENATION DEFINITION

- Amount of oxygen carried in the arterial blood that is bound to the hemoglobin molecule.
- It is reflected as SaO_2 (the percent of hemoglobin in saturated with oxygen)
- The driving force for SaO_2 is the PaO_2 (partial pressure of dissolved oxygen in the blood)

ASSESS OXYGENATION

- Look at the PaO_2, which is a good indicator of O_2 uptake in the lungs.
- Assess the SaO_2 as an indicator of O_2 content (CaO_2)
- While PO_2 and SaO_2 are related, the vast majority of the total O_2 content is reflected in the SaO_2
- Consider the hemoglobin content of the blood

PHENOMENA CONT'D

- Ventilation
  - Ability of the body to rid itself of carbon dioxide (CO_2)
  - Reflected in ABGs as partial pressure of CO_2 ($PaCO_2$)

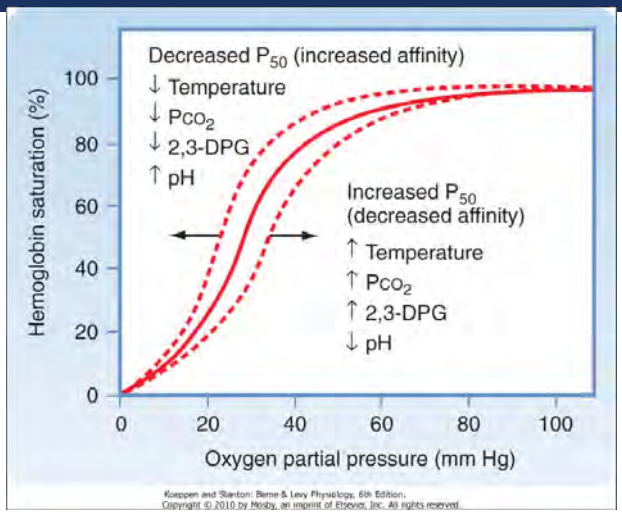
ASSESS OXYGEN DELIVERY

- The 'bottom line' of respiration is the delivery of O_2 to the body's cells and removal of carbon dioxide
- For this to occur, the oxygenated blood must be delivered to the tissues and deoxygenated blood returned to the heart

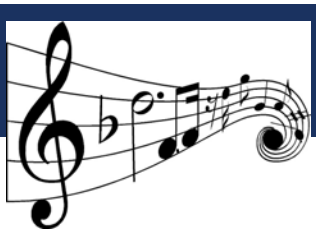
TWO WAYS TO ASSESS O2 DELIVERY

- Oxygen delivery and uptake by tissues can be measured using a properly equipped pulmonary artery catheter
- Basic physical assessment cues:
  - Short of breath or hyperventilating
  - Blood pressure, pulse rate and rhythm, skin temperature and color
  - Distention of the neck veins, Auscultation of a gallop or murmur
  - Crackles at the bases of the lungs

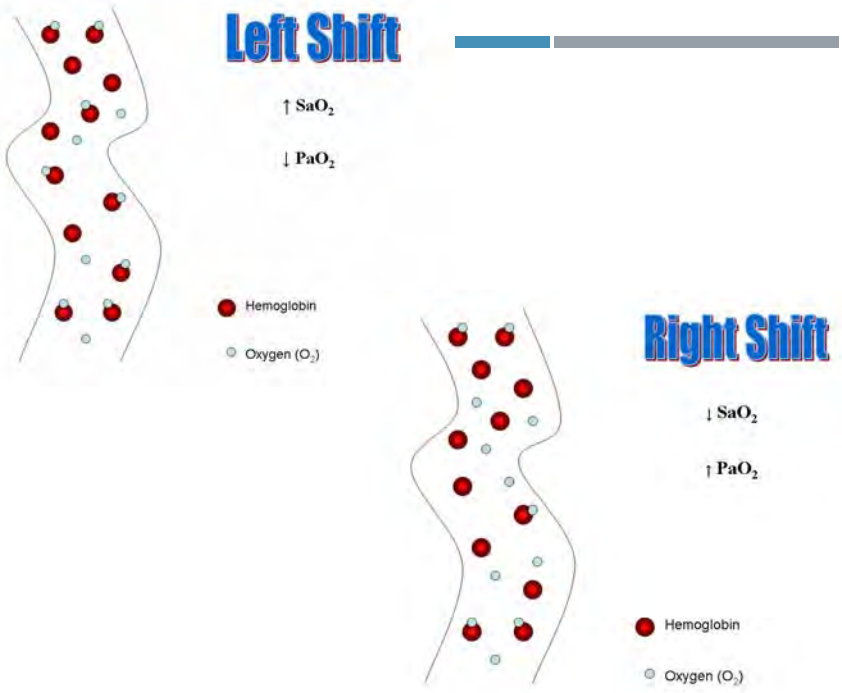
OXYHEMOGLOBIN DISSOCIATION CURVE



LET'S SING A SONG…..



PaO2	SaO2
30	60
60	90
40	75



A patient with renal failure has the Following ABG:

pH	**7.38**
$PaC0_2$	**29**
HCO_3^-	**17**

This Imbalance is MOST LIKELY:

1. Compensated metabolic acidosis
2. Compensated respiratory acidosis
3. Compensated respiratory alkalosis
4. Compensated metabolic alkalosis

A patient has had an NG tube to intermittent Suction for 4 days following abdominal Surgery, her ABGs are:

pH	**7.51**
$PaC0_2$	**45**
HCO_3^-	**31**

This Imbalance is MOST LIKELY:

1. Compensated metabolic acidosis
2. Compensated respiratory acidosis
3. Uncompensated metabolic acidosis
4. Uncompensated metabolic alkalosis

A semi-comatose diabetic patient is admitted to The ED with the following ABGs:

pH	**7.28**
$PaC0_2$	**35**
HCO_3^-	**16**

This Imbalance is MOST LIKELY:

1. Compensated metabolic acidosis
2. Compensated respiratory acidosis
3. Uncompensated metabolic acidosis
4. Uncompensated metabolic alkalosis

A patient suspected of over-dosing has The following ABG's:

pH	**7.24**
$PaC0_2$	**65**
HCO_3^-	**22**

This Imbalance is MOST LIKELY:

1. Compensated metabolic acidosis
2. Compensated respiratory acidosis
3. Uncompensated respiratory acidosis
4. Uncompensated metabolic alkalosis

ABGs drawn from a patient in septic shock are:

pH	**7.25**
$PaC0_2$	**36**
HCO_3^-	**14**

This Imbalance is MOST LIKELY:

1. Uncompensated respiratory alkalosis
2. Uncompensated respiratory acidosis
3. Uncompensated metabolic acidosis
4. Uncompensated metabolic alkalosis

A 48 year old female is receiving large doses of diuretics for persistent left ventricular failure. She is somewhat irritable this A.M. and displays tremulous activity.

Renal panel:
K^+ is 2.5
Cl^- is 84

pH	**7.58**
$PaC0_2$	**43**
HCO_3^-	**33**
B.E.	**+9**
$Pa0_2$	**76**

This Imbalance is MOST LIKELY:

1. Compensated metabolic alkalosis
2. Uncompensated respiratory acidosis
3. Uncompensated metabolic acidosis
4. Uncompensated metabolic alkalosis

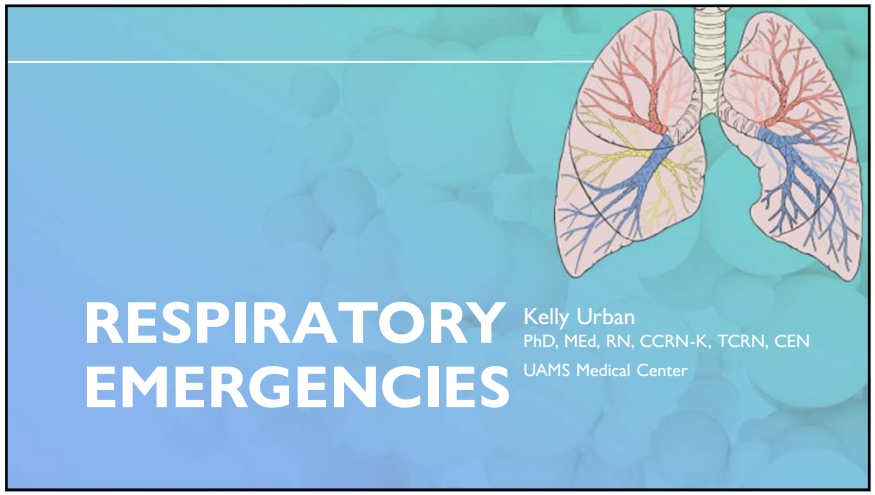
A COPD patient has the following ABGs:

pH	**7.39**
$PaC0_2$	**50**
HCO_3-	**28**

After analyzing this, the nurse should:

1. Request another test
2. Compare these results to the patients baseline
3. Call the lab to verify the results
4. Notify the physician stat

QUESTIONS?



1

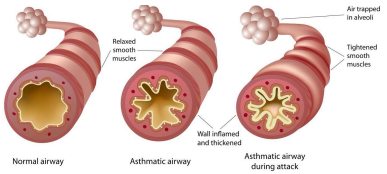
Respiratory Emergencies:

- Asthma
- COPD
- Pneumothorax/Hemothorax
- PE

2

Asthma

- Chronic, reversible obstructive pulmonary disease
- Caused by airway inflammation, bronchospasm (airway hyper-responsiveness) to stimuli, and mucus plugging (resulting in airway remodeling)



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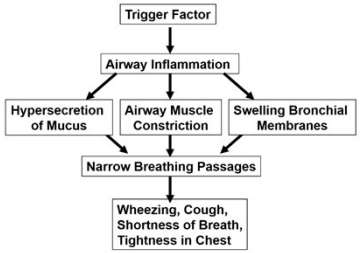
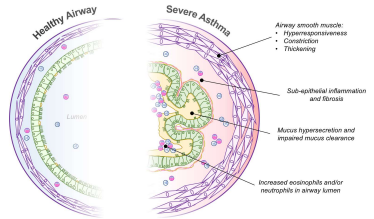
Asthma Pathophysiology





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Classification of Asthma Severity

	Days with Symptoms	Nights with Symptoms	PEF or FEV1	PEF Variability
Step 1: Mild intermittent	Up to 2/week	Up to 2/month	80% or greater	< 20%
Step 2: Mild persistent	3-6/week	3-4/month	80% or greater	20-30%
Step 3: Moderate persistent	Daily	5/month or more	> 60% to < 80%	> 30%
Step 4: Severe persistent	Continual	Frequent	Up to 60%	> 30%

5

Clinical Presentation

- Extreme dyspnea – forcing air out of lungs
  - Prolonged expiratory phase
- Wheezing
  - On expiration
  - As disease progresses: wheezing on inspiration
- Harsh coughing
- Restlessness
- Inability to speak in complete sentences
- Use of accessory muscles
- Pallor/cyanosis (late sign)

6

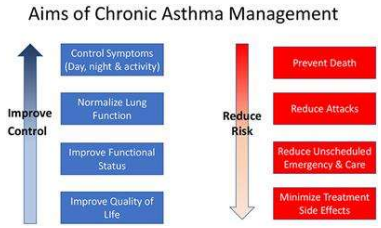
Diagnostic Procedures

- Labs: CBC, CMP
- ABGs
  - May initially be normal or respiratory alkalosis
  - Later – respiratory acidosis with hypoxemia and hypercarbia
- Objective Measure of Airflow Obstruction
  - Decreased expiratory flow rate /peak flow (PEF)
  - Decreased forced vital capacity(VC) and forced expiratory volume (FEV1)
  - Increased functional residual capacity (FRC) and Residual volume (RV)
- Sputum Cultures
- CXR: initially may be normal, then may show hyperinflation, lowered diaphragm

7

Asthma Management

- Quick Relief (rescue): as needed for rapid, short-term symptom relief during an asthma attack
- Long-term asthma control



8

Asthma Management

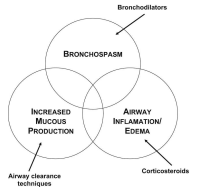
4 Strategies for Outpatient Management (long-term)

1. Objective Measures of Lung Function
2. Environmental Control Measures & Avoidance of Risk Factors
3. Comprehensive Pharmacologic Therapy
4. Patient Education

9

Interventions for Asthma

- Airway
  - Prepare for advanced airway management
  - Position patient to facilitate maximum ventilation
  - Assist with removal of secretions
- Breathing
  - Provide supplemental oxygen as needed
- Circulation
  - Establish IV access
- Administer medications as ordered
  - RSI medications
  - Bronchodilators (short-acting beta agonists, magnesium sulfate)
  - Rescue medications (short-acting beta agonists, anticholinergics, corticosteroids)



10

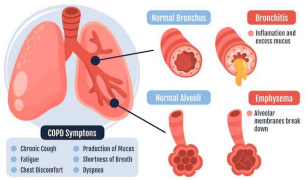
Status Asthmaticus

- Acute, severe, and prolonged asthma exacerbation
- Life-threatening emergency
- Bronchospasm does NOT respond to conventional therapy
  - Worsening hypoxemia → respiratory acidosis → respiratory arrest

11

Chronic Obstructive Pulmonary Disease (COPD)

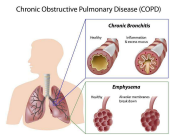
- Characterized by chronic or recurrent airflow obstruction
- Irritants/diseases/genetic factors cause bronchial mucosa edema and smooth muscle contraction resulting in increased airway resistance



Risk Factors
- Smoking
- Environmental pollution
- Occupational exposure to chemicals
- Tuberculosis
- Aging
- Heredity

12

COPD – Comparison of Chronic Obstructive Bronchitis and Emphysema



Chronic Obstructive Bronchitis

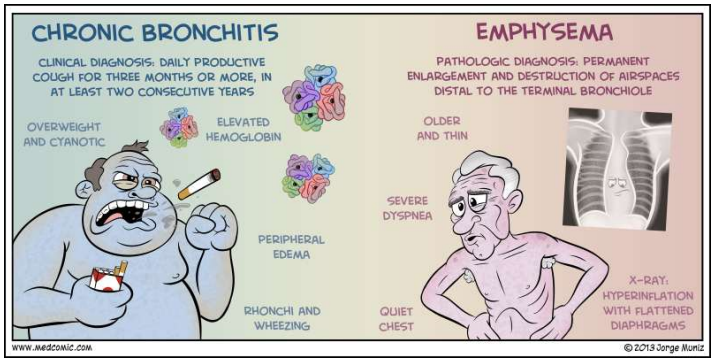
- "Blue Bloater"
- Productive Cough
- Stocky Build
- Onset 40-50 yr
- Normal RR
- Hypoxemia
- Increased PaCO2
- Cyanosis
- Polycythemia
- Corpulmonale (x-ray – cardiomegaly)
- Peripheral Edema
- Risk for PE

Emphysema

- "Pink Puffer"
- Cough uncommon
- Thin
- Onset 50-70 yr
- Tachypnea (PaCO2 usually low or normal until end stage)
- PaO2 normal or slightly low
- Barrel chest
- Accessory muscle use
- Leans forward while sitting
- Pursed-lip breathing
- Hyperresonance on percussion
- Lung overinflation, diaphragm low

13

COPD



14

COPD – Diagnostic Procedures

- ABGs: hypoxemia, hypercarbia
- CBC with differential:
  - Secondary polycythemia (due to chronic hypoxemia)
  - Increased hematocrit
- BNP: help to differentiate btwn COPD and heart failure
- Sputum: culture and sensitivity
  - Mucoid sputum – stable chronic bronchitis
  - Purulent sputum – exacerbation
- Chest x-ray: hyperinflation, flattened diaphragm, increased retrosternal air space, and long, narrow heart shadow
- PFT measurements: essential for diagnosis and assessment of severity of disease

15

COPD Interventions

- ABCs
- Supplemental O2 (CPAP or BPAP?)
- IV access
- Position patient to facilitate breathing
- Cardiac/Pulse ox monitoring
- Administer medications as ordered:
  - Beta-adrenergic agonist and anticholinergic agent combinations
    - For high-risk or very severe airflow limitation
  - Bronchodilators (long acting)
    - Improves lung fxn, reduces SOB, improves mucus clearance
  - Mucolytic agents
  - Anti-inflammatory drugs (inhaled and oral steroids)
  - Antibiotics
  - Heliox (controversial)
  - Antidepressants
  - Nicotine patches
  - Corticosteroids (typically 7 to 10 days)

Patient Education

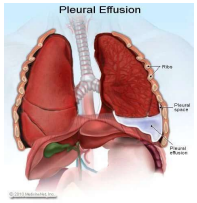
- Stop Smoking
- Optimal Body Positioning for air exchange
- Small, frequent meals
- Exercise
- Coughing/Deep-breathing exercises
- Hydration
- Medication Compliance

16

Pleural Effusion

- Collection of excess fluid (> 15 ml) in the pleural space
- May result from:
  - Increased subpleural capillary pressure (heart failure) – most common
  - Decreased capillary oncotic pressure (liver/renal failure)
  - Inflammatory conditions (infections such as PNA)
  - Impairment/obstruction of lymphatic flow

Fluid Appearance:
- Hemorrhagic
- Chylous (white/thick)
- Purulent (empyema)



17

Pleural Effusion

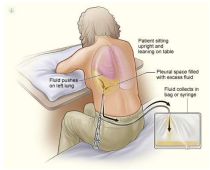
PMH (Predisposing Factors)
- CV Disease/PE
- Bacterial Pneumonia
- Malignant Disease (lung, breast)
- Tuberculosis
- Pancreatitis
- Abdominal surgery (subphrenic or hepatic abscess)

Assessment
- Tachypnea
- Anxious
- Use of accessory muscles
- Dullness to percussion
- Breath sounds diminished to absent over effusion

18

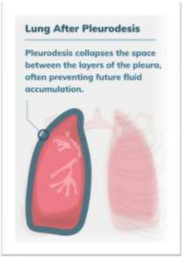
Pleural Effusion - Diagnostics

- CBC with differential (elevated WBC possible)
- Chest xray: lat decubitus more reliably detects smaller pleural effusions
- Sonography: identify location for thoracentesis
- Chest CT, spiral CT
- Thoracentesis for fluid analysis
- ECG

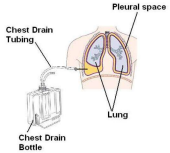


19

Pleural Effusion - Interventions



- ABCs
- O2 as needed
- IV access
- Cardiac/Pulse ox monitoring
- Assist with thoracentesis procedure/chest tube placement
- Pleurodesis
- Medications
  - Analgesics
  - Antibiotics



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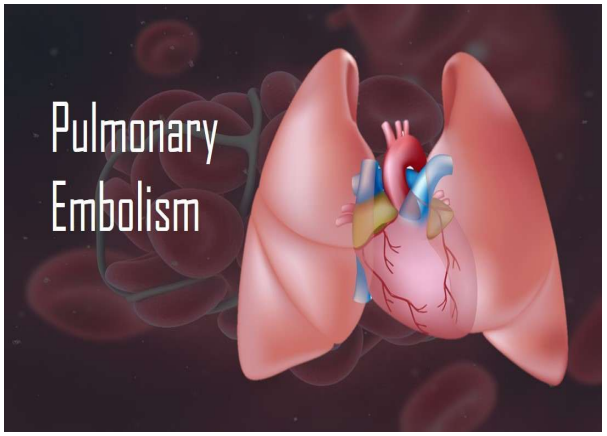

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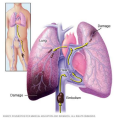
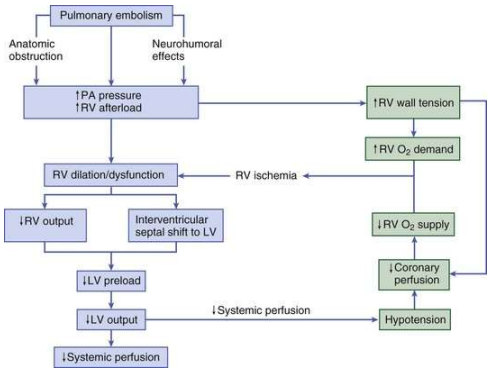
Pulmonary Embolus



- Free-floating Thrombus: material that travels to the vascular system in the lungs where it lodges and occludes a vessel
- Can be blood clots, tumor cells, cardiac vegetation, fat, amniotic fluid, air, or nitrogen
- Causes partial or total occlusion of pulmonary artery vessel – infarction
- Affected area of the lung is ventilated but inadequately perfused

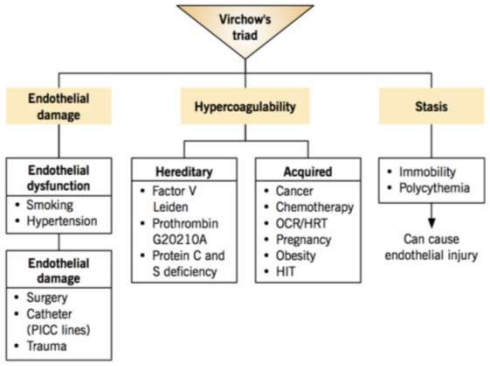
22

Effects of PE



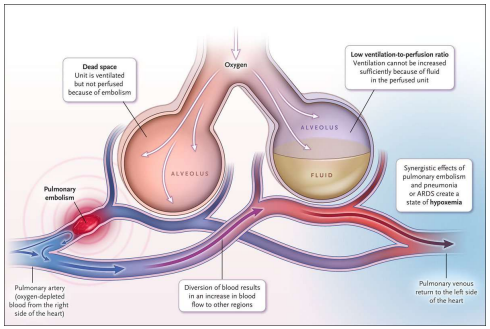
23

PE Risk Factors



24

Ventilation/Perfusion Mismatch



25

PE Clinical Presentation - Submassive

- Sudden onset of dyspnea at rest or with exertion (may be only symptom), Orthopnea
- Chest discomfort/pleuritic pain
- Flu-like symptoms
- Restlessness, apprehension
- Tachypnea/tachycardia
- Fever
- Scattered rales
- Cough
- Hemoptysis
- Can be asymptomatic (silent PE)

26

PE Clinical Presentation - Massive

- Sudden death
- Shock/hypotension
- Impending doom
- Tachypnea, severe dyspnea, cyanosis
- Rales, hemoptysis
- Tachycardia, perspiration, JVD

27

PE Diagnostics

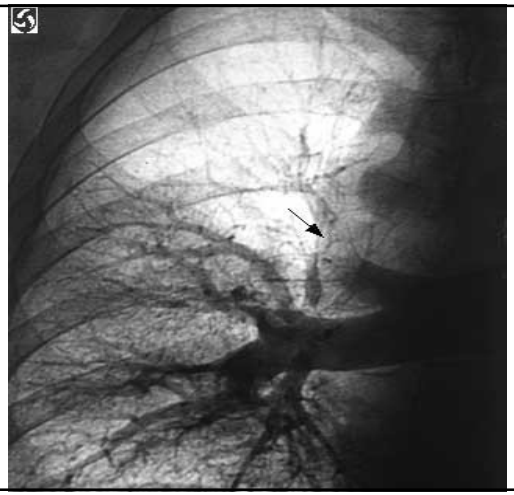
- Hx of precipitating factors
- Labs
  - CBC with differential (normal or increased leukocytes)
  - Erythrocyte sedimentation rate (elevated)
  - Fibrin split products (increased fibrin degradation products)
  - D-Dimer (more specific test for fibrin split products; + if > 500 ng/mL
- ABG's – non-specific
- CXR – non-specific – may show atelectasis 24-72 hours after insult
- Vitals –(HR up, RR up, BP down) – non- specific
- Lung sounds – maybe rales (crackles)

28

PE Diagnostics Continued

- V/Q scan – non-invasive, suggestive, not definitive
  - Important to use when multidetector CT angiography unavailable
- Venous Doppler – not definitive - tells if DVT is present
- D-dimer – not definitive – tells if by-products of a clot are present
- Echo – dilated RV – massive PE (McConnell's Sign)
- Pulmonary angiography – definitive (invasive)
- **CT Angiography – definitive (non-invasive)**
- ECG – nonspecific ST-segment and T-wave abnormalities most common findings
  - Tall, peaked P waves, right axis deviation, right bundle branch block

29



30

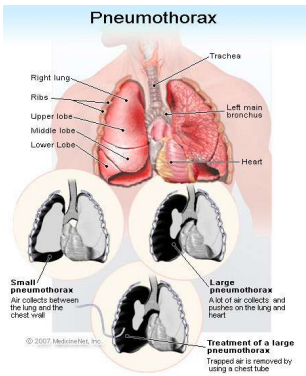
PE Treatment

- ABCs
- O2 as needed
- IV access
- Cardiac/Pulse ox monitoring
- Medications:
  - Heparin, low-molecular-weight heparin
  - Fibrinolytics
  - Analgesia

31

Pneumothorax (Simple & Open)

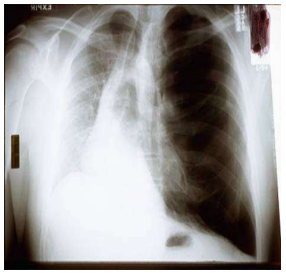
- Simple or open
- Mechanism:
  - Simple–blunt
  - Open–penetrating
- Assessment findings
  - Decreased or absent breath sounds
  - Dyspnea, tachypnea
  - Tachycardia
  - Subcutaneous emphysema
  - Sucking chest wound (open)
- Interventions
  - Depends on severity



32

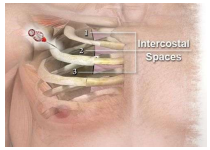
Tension Pneumothorax

- Life threatening
- Assessment findings
  - Severe respiratory distress
  - Diminished or absent breath sounds on injured side
  - Hypotension
  - Distended neck, head, and upper extremity veins
  - Tracheal deviation (late sign)
  - Cyanosis (late sign)

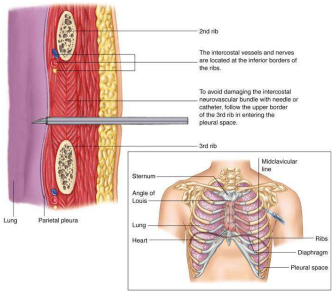


33

Tension Pneumothorax



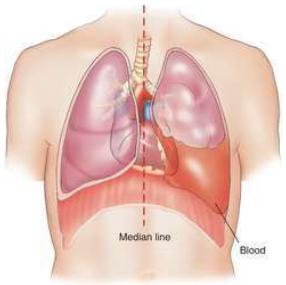
- Interventions
  - Immediate needle decompression
    - 14-gauge needle
    - Second intercostal space, midclavicular line
    - Placement controversies
  - Prepare for chest tube



34

Hemothorax

- Mechanism: Blunt or penetrating
- Assessment findings
  - Dyspnea, tachypnea
  - Chest pain
  - Signs of shock
  - Decreased breath sounds on injured side
- Intervention
  - Chest tube



35

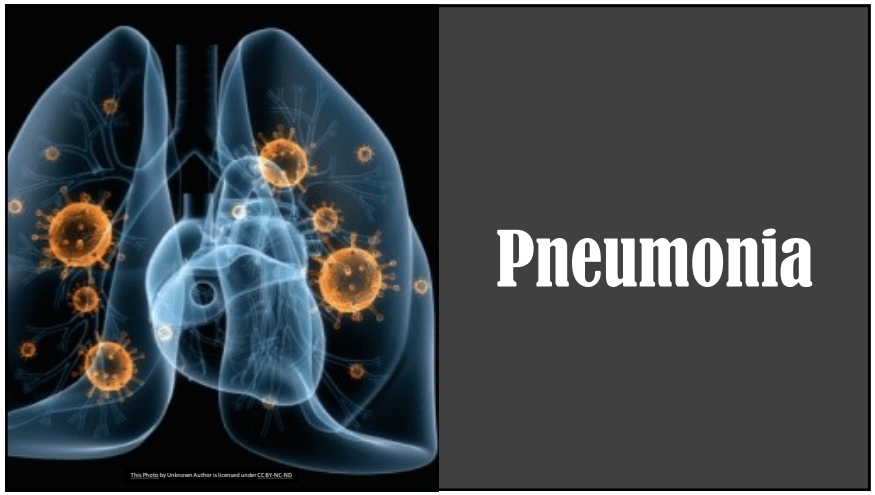
Chest Drainage Systems

- Notify physician
  - Initial output is > 500 mL
  - More than 200 mL/hour for 2–4 hours
- Clamping chest tube is contraindicated

36

Questions?

37

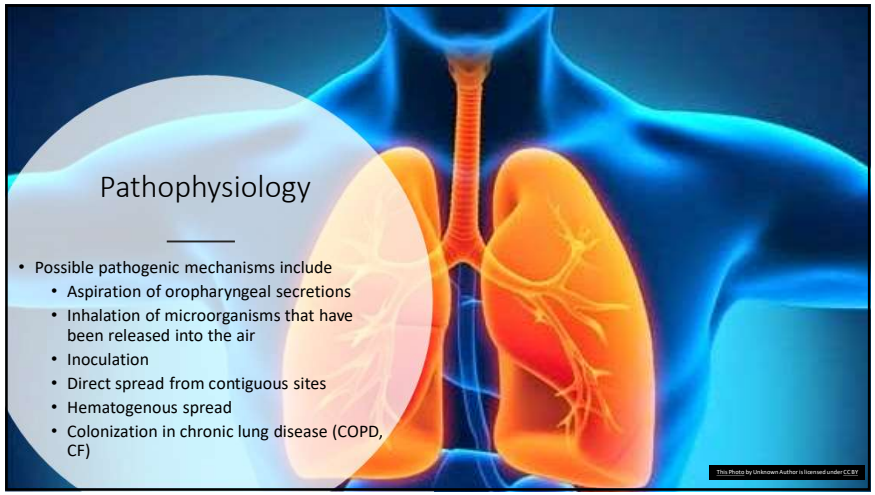


1

Pneumonia

- An inflammatory process of the alveolar space cause by infection.
- Involves lower respiratory tract.
- Caused by bacteria, virus, fungi, protozoa, or parasites.
- 6th leading cause of death in the US.
- The air sacs swell and fill with fluid or pus, causing shortness of breath and intense coughing.

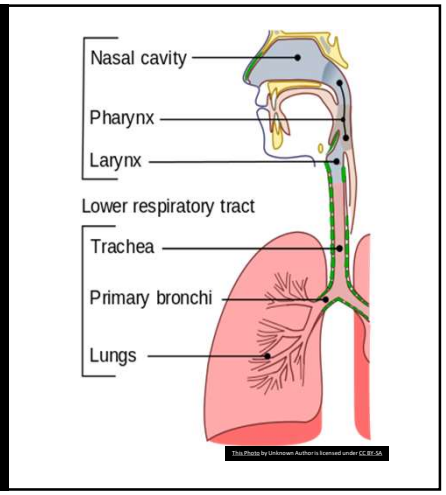
2



3

Pathophysiology

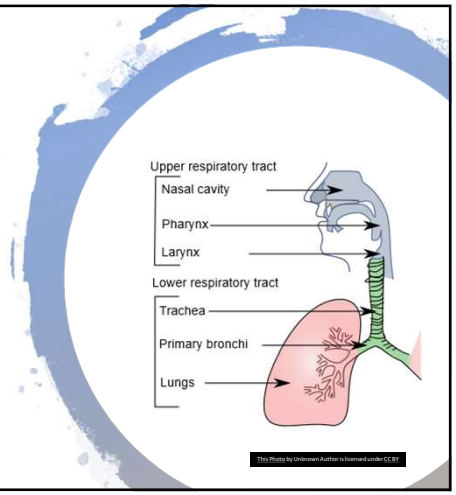
- Important aspects of the pulmonary defense system
  - Upper airway defenses
    - Nasopharyngeal filtration
    - Mucosal adherence
    - Bacterial interference
    - Saliva
    - Secretory Immunoglobulin A



4

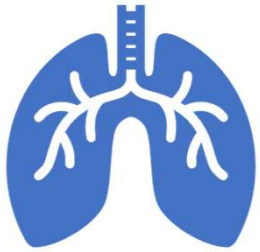
Pathophysiology

- Lower airway defenses
  - May be decreased with age or underlying disease processes
    - Cough reflex
    - Mucociliary clearance
    - Humoral factors
    - Cellular factors



5

Pneumonia



- Neutrophils, the offending organism, and fluid from surrounding blood vessels fill the alveoli, interrupting oxygen transportation, which leads to hypoxia.
- Mucus production is increased, which can obstruct airflow and further decrease gas exchange.
- Consolidation, a feature of bacterial pneumonia, occurs when normally air-filled alveoli are filled with fluid and debris. Consolidation is the result of replacement of air in the alveoli by transudate, pus, blood, cells or other substances.

6

Etiology & Risk Factors

- **Previous stroke or problems swallowing**
- **Age**
  - Infants from birth to age two are at risk for pneumonia, as are individuals age 65 or older.
- **Weakened immune system**
  - This includes people who take medications (steroid drugs and anti-cancer drugs) that weaken the immune system and people with HIV, AIDS, or cancer.
- **Drug abuse**
  - This includes excessive alcohol consumption and smoking.
- **Certain medical conditions**
  - Asthma, cystic fibrosis, diabetes, and heart failure raises risk for pneumonia.

7

Predisposing Factors (Treatment-related)

- Surgery
- Artificial airway
- Saline lavage during suctioning of ETT or tracheostomy
  - Ineffective in liquefying secretions
  - Dislodges more bacteria than suctioning alone
  - Not completely removed with suctioning, allowing colonized saline to move to dependent areas of the lung
- Bronchoscopy
- Mechanical ventilation
- NGT
- Aspiration
  - Leakage of pharyngeal flora around ETT cuff
  - Gastric colonization is likely with pH of >4. Bacteria can migrate upward to be aspirated into the lungs.
    - Secondary to drugs altering the pH (e. g., PPIs)
    - Secondary to continuous enteral feeds
    - Pneumonia rates of patients on vents correlate directly with increased gastric pH levels.
- Supine position

8

Predisposing Factors (Infection Control)

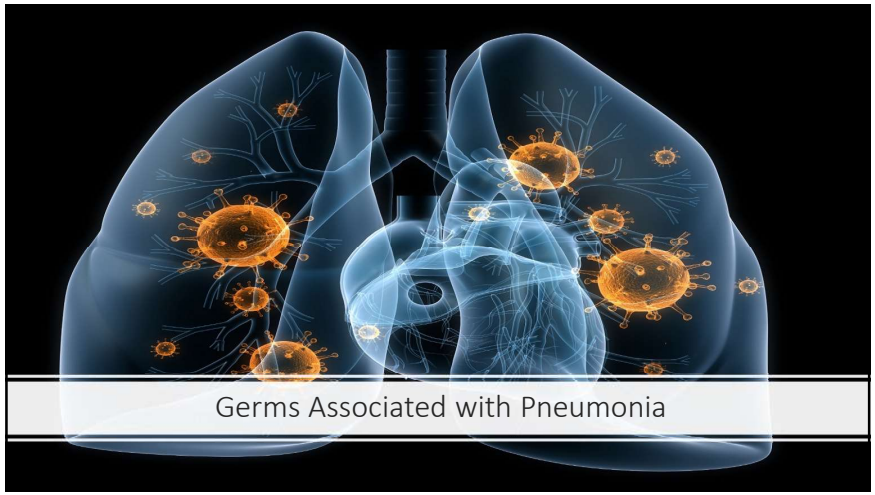
- POOR HANDWASHING
- FAILURE TO WEAR/CHANGE PPE BETWEEN PATIENTS (E. G., SAME GLOVES)
- CONTAMINATED WATER FOR HUMIDIFICATION
- CONTAMINATED EQUIPMENT
- CHANGING VENT TUBING MORE OFTEN THAN EVERY 48 HOURS

9

Predisposing Factors (Environmental Factors)

- Encountering droppings or dust from:
  - Bats or birds
  - Rabbits
  - Farm animals
- Recent stay in hotel or cruise ship
- Flu is present in your community

10



Germs Associated with Pneumonia

11

Germs Associated with Pneumonia

- Most common type of bacterium is *Streptococcus pneumoniae* (pneumococcal pneumonia)
  - Especially in older adults.
  - Decreasing due to decreased smoking & immunizations.
- *Mycoplasma pneumoniae* – mild form called "walking pneumonia"
  - Spread by droplet nuclei.
  - Epidemics.
- *Haemophilus influenzae*
  - More likely to cause bacteremia.
  - Seen more in elderly population, COPD & CF patients.

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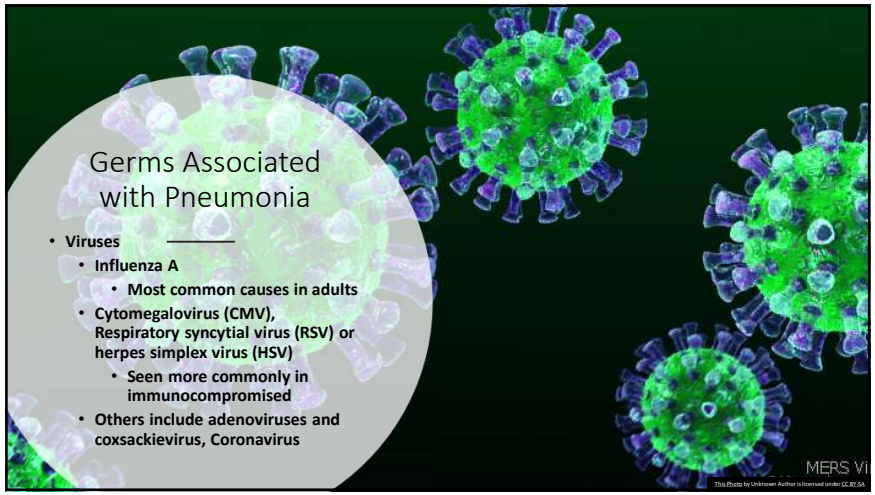
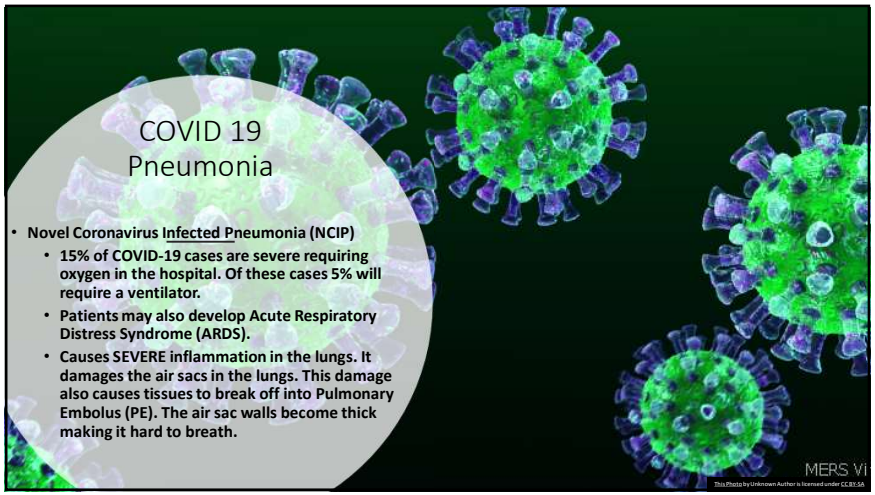
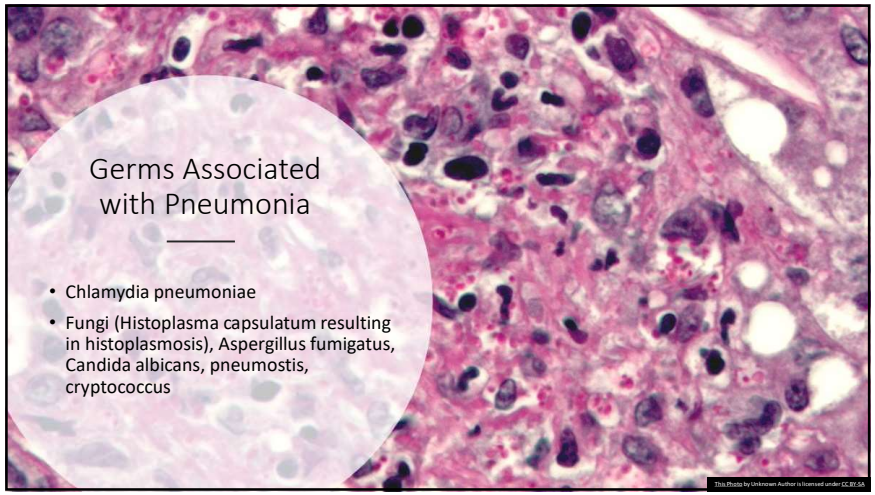

Germs Associated with Pneumonia
• Viruses
• Influenza A
• Most common causes in adults
• Cytomegalovirus (CMV), Respiratory syncytial virus (RSV) or herpes simplex virus (HSV)
• Seen more commonly in immunocompromised
• Others include adenoviruses and coxsackievirus, Coronavirus
MERS Vi

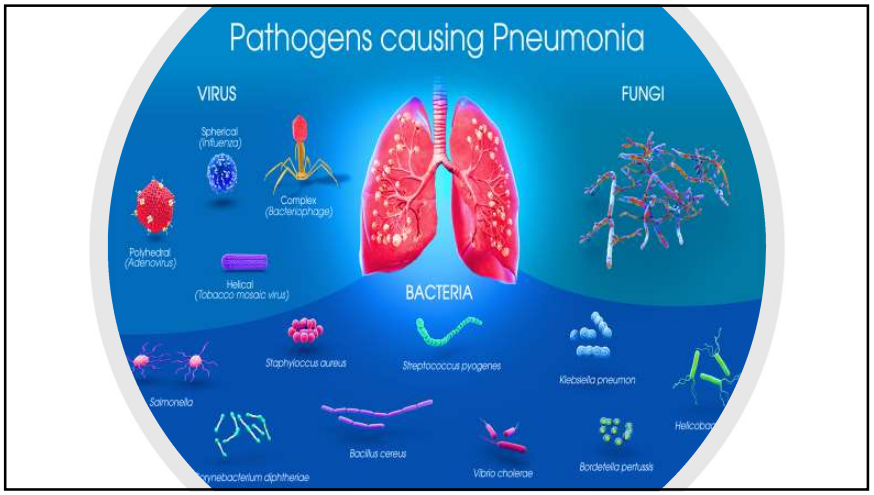
13


COVID 19 Pneumonia
• Novel Coronavirus Infected Pneumonia (NCIP)
• 15% of COVID-19 cases are severe requiring oxygen in the hospital. Of these cases 5% will require a ventilator.
• Patients may also develop Acute Respiratory Distress Syndrome (ARDS).
• Causes SEVERE inflammation in the lungs. It damages the air sacs in the lungs. This damage also causes tissues to break off into Pulmonary Embolus (PE). The air sac walls become thick making it hard to breath.
MERS Vi

14


Germs Associated with Pneumonia
• Chlamydia pneumoniae
• Fungi (Histoplasma capsulatum resulting in histoplasmosis), Aspergillus fumigatus, Candida albicans, pneumostis, cryptococcus

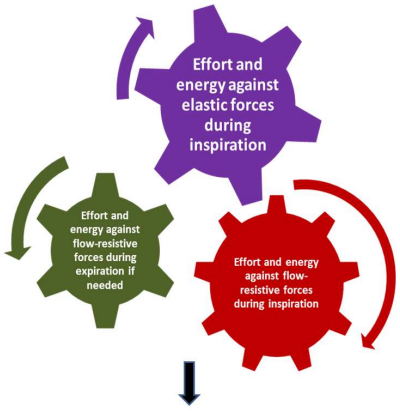
15


Pathogens causing Pneumonia
VIRUS
FUNGI
BACTERIA
Spherical (Influenza)
Complex (Bacteriophage)
Polyhedral (Adenovirus)
Helical (Tobacco mosaic virus)
Staphylococcus aureus
Streptococcus pyogenes
Klebsiella pneumon
Salmonella
Bacillus cereus
Vibrio cholerae
Bordetella pertussis

16

Clinical Manifestations

Common Symptoms
- Fever, productive cough, chills
- Flu like symptoms
- Hypoxemia
- Increased work of breathing
- Impaired alveolar breathing
- Impaired gas exchange



17

Assessment

- Cold or flu-like symptoms initially (frequent finding)
- Productive cough with sputum
- Dyspnea
- Crackles, rhonchi, or diminished breath sounds
- Wheezes
- Increased mucous production
- Chills
- Weakness
- Chest pain

18

Assessment

- Tachycardia
- Tachypnea
- Fever (elderly may be hypothermic)
- Use of accessory muscles
- Confusion (especially in the elderly)
- Cyanosis
- Elevated WBC (normal if viral)
- Decreased PaO2 on ABG
- Positive blood cultures

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Clinical Manifestations- Assessment

- Dullness to percussion – fluid in a lung or collapse of part of the lung
- Crackles/rales on auscultation – made by movement of fluid in the alveoli
- Bronchial breath sounds - wheezing
- Tactile fremitus - vibration
- Egophony- "E" – Pneumonia may cause the "E" to sound like the letter "A" when heard through a stethoscope

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Clinical Manifestations

- Chief complaint varies depending on the organism
  - *Pneumococcal pneumonia*: abrupt shaking chills or rigor, fever, dyspnea, pleuritic pain, and productive cough or rusty sputum

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Clinical Manifestations

- *Mycoplasma (walking pneumonia)*: fever, myalgias, headache, minimally productive cough, and non-pleuritic chest pain
- *H. Influenzae*: fever, chills, and cough purulent sputum
- *Klebsiella*: sudden onset, blood-tinged sputum, and tachypnea

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Diagnostic Findings

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Sputum

- Myeloperoxidase (MPO) – enzyme found in neutrophils that when released undergoes a reaction which results in the GREEN color of sputum.

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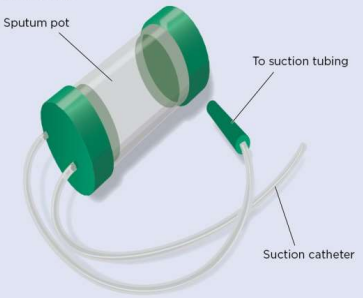
Cultures & Counts

- Blood and Sputum
  - Done before antibiotic administration
- Leukocyte counts
  - Often elevated in lobar pneumonia
  - Normal or reduced in
    - Elderly
    - Immunocompromised
    - Overwhelming infections
    - Viral infections

Fig 1. **Sputum trap**



A sputum trap is connected to the suction catheter to collect the sputum using oropharyngeal or endotracheal suctioning

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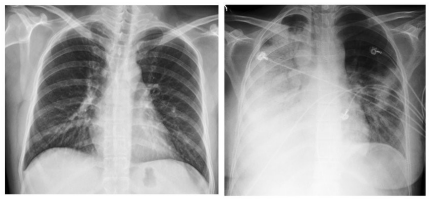
Other Diagnostics

- Arterial blood gas analysis
  - May indicate hypoxemia & hypocapnia
- Chest X-ray
  - Lobar consolidation
  - Infiltrates
  - Helpful in detecting effusions & abscesses
- Thoracentesis
  - May be indicated with pleural effusion is present



https://www.researchgate.net/figure/a-Normal-chest-X-ray-showing-the-lungs-clearly-b-Abnormal-CXR-with-high-opacity-where_fig1_343858424

26

Pneumonia Severity Index

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Pneumonia Severity Index

The Pneumonia Severity Index, or PSI, is a validated risk stratification instrument which can help in identifying CAP patients who can safely be treated with outpatient antibiotics.

Point values are given for a variety of clinical and laboratory parameters.

The PSI involves calculating a score, which places a given patient into one of 5 risk classes.

Classes I, II, and III are at low risk for death, and may be considered for outpatient treatment. Risk classes IV and V should usually be hospitalized.

Patient Characteristics	Points
Demographics	
Age(years): Male: age	—
Female: age	—
Nursing home resident	+10
Co-morbidities	
Neoplastic disease	+30
Liver disease	+20
Congestive heart failure	+10
Cerebrovascular disease	+10
Renal disease	+10
Examination findings	
Altered mental status	+20
Respiratory rate ³30/minute	+20
Systolic blood pressure <90 mmHg	+20
Temperature <35°C or ³40°C	+15
Pulse ³125/minute	+10
Laboratory findings	
pH <7.35 (do ABG only if hypoxic or COPD)	+30
BUN >10.7 mmol/ L	+20
Sodium <130 mEq/L	+20
Glucose ³13.9 mmol/L	+10
Hematocrit <0.30	+10
PaO_2 <60mmHg or oxygen saturation <90%	+10
Pleural effusion	+30

Risk	Class	Score
Low	I	<51
Low	II	51 - 70
Low	III	71 - 90
Medium	IV	90 - 130
High	V	>130

Hospitalisation is recommended for class IV and V. Class III is based on clinical judgement

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Criteria for Severe Pneumonia

MINOR CRITERIA

MAJOR CRITERIA

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Treatment

Based on physical examination findings, lab results, and patient characteristics

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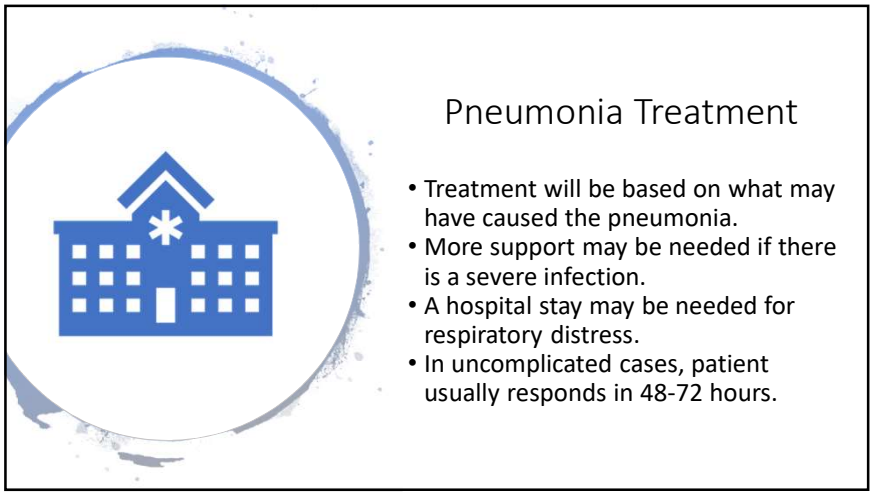
Management

- Positioning
- Skin Care
- Oral Care
- Pain Management – Pleuritic Pain
- Nutrition
- Infection Control
- Respiratory Treatments

32


Pneumonia Treatment
• Treatment will be based on what may have caused the pneumonia.
• More support may be needed if there is a severe infection.
• A hospital stay may be needed for respiratory distress.
• In uncomplicated cases, patient usually responds in 48-72 hours.

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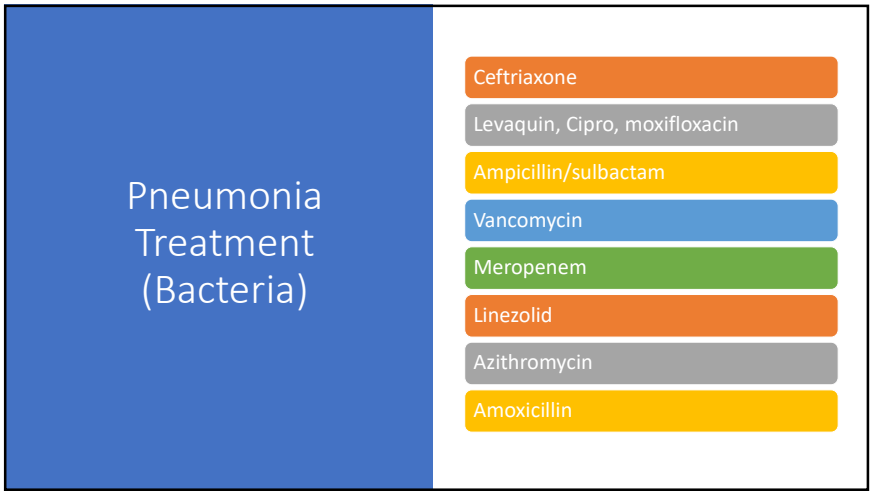
Pneumonia Treatment (Bacteria)
Ceftriaxone
Levaquin, Cipro, moxifloxacin
Ampicillin/sulbactam
Vancomycin
Meropenem
Linezolid
Azithromycin
Amoxicillin

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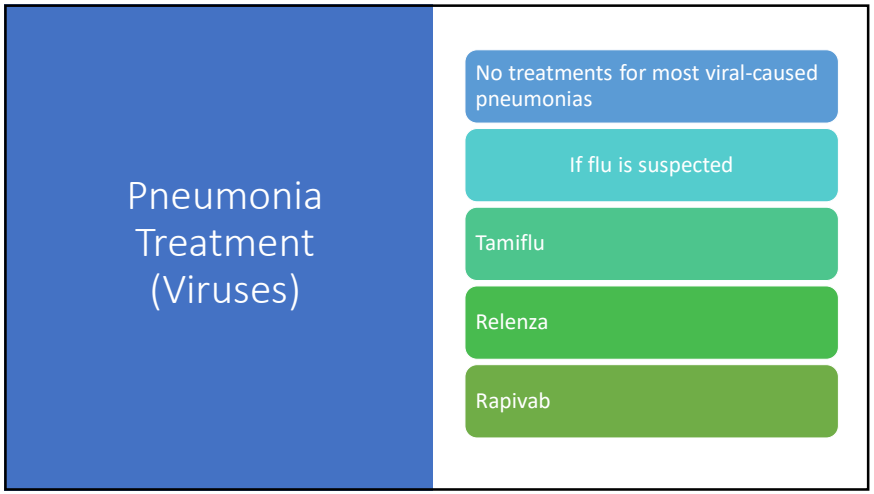
Pneumonia Treatment (Viruses)
No treatments for most viral-caused pneumonias
If flu is suspected
Tamiflu
Relenza
Rapivab

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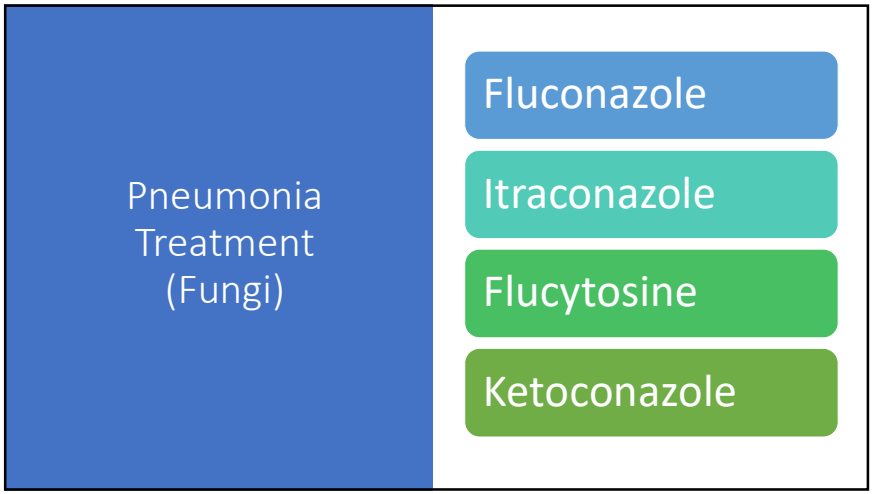
Pneumonia Treatment (Fungi)
Fluconazole
Itraconazole
Flucytosine
Ketoconazole

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Prevention and Vaccines

- Pneumococcal
- Haemophilus influenzae type b (Hib)
- Pertussis (whooping cough)
- Varicella (chickenpox)
- Measles
- Influenza (flu)

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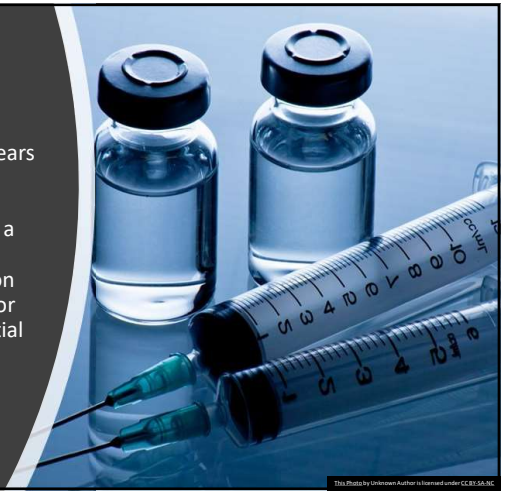
Pneumonia Vaccine

Recommended for:

- All adults who are aged 65 years or older.
- Adults of any age who are at high risk of infection or have a suppressed immune system.
- A one-time repeat vaccination in 5 years is recommended for those who received their initial vaccination prior to age 65.



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Pneumonia Complications

- Acute Respiratory Failure
- Septic Shock
- Hypoxemia
- ARDS

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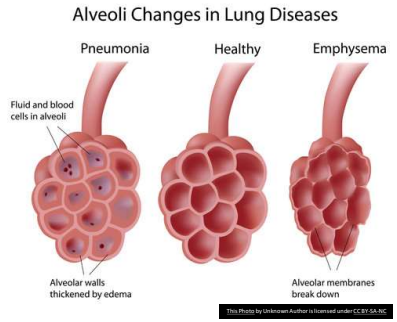

Additional Types of Pneumonia

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Community-acquired

- Infection is picked up outside of a hospital setting; most common type
- Usually caused by *Streptococcus pneumoniae*
- Antibiotics should be started within 4 hours of arrival to hospital

Hospital-acquired pneumonia

- Infection is picked up while in a hospital
- Develops after 48 hours of hospitalization
- Also referred to as nosocomial pneumonia
- Pneumonia is responsible for approximately 75% of all hospital acquired infections

Types of Pneumonia

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Types of Pneumonia

Aspiration

Happens when something such as food, liquid, saliva, or vomit is sucked into the lungs

Ventilator-associated pneumonia

Refers to pneumonia that develops more than 48 hours after endotracheal intubation

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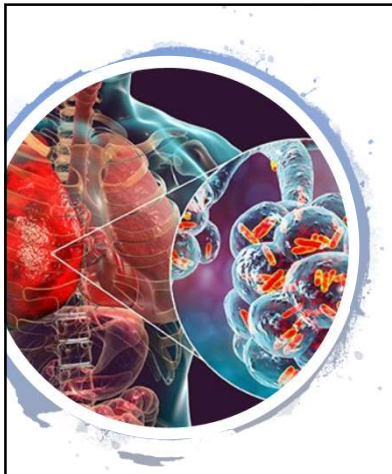

Types of Pneumonia

- **Bacterial Pneumonia**
- **Viral Pneumonia**
- **Mycoplasma Pneumonia**
- **Other Types of Pneumonia**
  - Pneumocystic Pneumonia
  - Aspiration Pneumonia

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Hospital Acquired Pneumonia (HAP) (Nosocomial)

- DEVELOPS IN A NON-INTUBATED PATIENT ≥ 48 HOURS AFTER HOSPITALIZATION
- 2ND MOST COMMON NOSOCOMIAL INFECTION AND IS MOST PREVALENT IN MEDICAL AND SURGICAL ICUS
- USUALLY BACTERIAL IN ORIGIN
- SIGNS AND SYMPTOMS ARE SAME AS COMMUNITY ACQUIRED PNEUMONIA

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Hospital Acquired Pneumonia (HAP)

- Etiology:
  - Microaspiration of bacteria that colonize in the oropharynx and upper airways
- Risk Factors:
  - Previous antibiotic treatment
  - High gastric pH
  - Age > 70
  - Abdominal/thoracic surgery

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Hospital Acquired Pneumonia (HAP)

- American Thoracic Society subdivides nosocomial pneumonia into early onset and late onset.
- Mortality due to gram-negative infection is about 25-50%.

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Common bacterial organism in ICU pneumonia:

Pseudomonas aeruginosa
Escherichia coli
Acinetobacter
Klebsiella
Staphylococcus aureus

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Distribution of common organisms responsible for HCAP and VAP

Non-ventilator associated HCAP	VAP
MRSA (20%)	MRSA (18%)
MSSA (13%)	MSSA (9%)
Pseudomona saeruginosa (9%)	*Pseudomonas aeruginosa* (18%)
Stenotrophomonas maltophilia (1%)	*Stenotrophomonas maltophilia* (7%)
Acinetobacter (3%)	*Acinetobacter* (8%)
Other organisms (18%)	Other organisms (9%)

*Pseudomonas aeruginosa is perhaps the most common MDR gram-negative bacterial pathogen causing HAP/VAP

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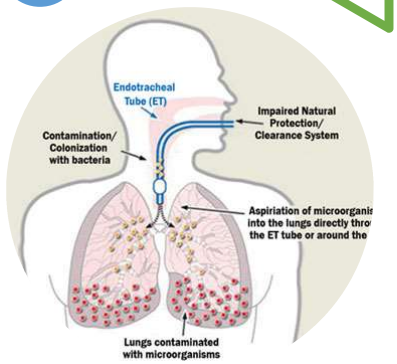

Ventilator-Associated Pneumonia (VAP)

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VAP Pathophysiology and Etiology/Risk Factors

- It's the primary cause of HCAP (Healthcare Acquired Pneumonia).
- It can add between $29,000 and $40,000 to a patient's hospital bill.
- It's tracked by the NNIS from the CDC.
- Trauma ICU's have the highest.

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VAP Clinical Manifestations

- Chest x-ray showing new or persistent infiltrate, consolidation, cavitation, or pleural infusion that persists for more than 48 hours.
- Temperature > 38.5 C.
- White Blood Cells > 10,000k/cm^3
- Purulent tracheal secretions or change in sputum.
- Positive blood or sputum cultures in conjunction with other clinical symptoms of pneumonia.

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VAP Physical Examination

Patient may present with rigors

Hypotension may occur in cases of dehydration/hypovolemia, but it should also suggest sepsis and impending circulatory collapse

Tachycardia may occur as a result of fever, hypovolemia, hypoxemia, or sepsis with impending circulatory failure

Tachypnea (respiratory rate greater than 20 breaths per minute in adults) may be present; severe tachypnea (i. e., rate greater than 30 breaths per minute in adults) may indicate impending respiratory failure

Dullness on percussion may be elicited over areas of consolidation or associated pleural effusion

On auscultation, rales may be heard, especially in the affected lobe
- Tubular breath sounds and rhonchi are often prominent
- Fremitus may be detected with dense consolidation

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Ventilator Associated Pneumonia (VAP) Prevention

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What role does handwashing play in nosocomial pneumonias?

- Wash hands before and after suctioning, touching ventilator equipment, and/or coming into contact with respiratory secretions.

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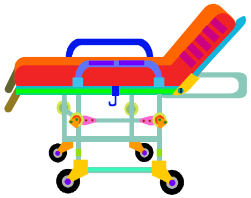
Head of Bed Elevation

"Patients should be kept in the semi recumbent position (30-45 degrees) rather than supine to prevent aspiration, especially when receiving enteral feeding."



Guidelines for the Management of Adults with Hospital-Acquired, Ventilator-Associated, and Healthcare-Associated Pneumonia. American Thoracic Society Oct. 2004. Am J Respir Crit Care Med 2005; 171:388-416

55

Contraindications

Head of Bed Elevation

- Prone positioning
- Marked hypotension
- Physiologic Instability
- Low cardiac index
- Medical/nursing procedure where HOB elevation would be inappropriate

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Oral Care

- Oral Care not only includes swabbing the mouth and brushing the teeth, but it also includes routine oral assessments and suctioning of the mouth as well as the endotracheal tube.

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Oral Care - Yankauer

PROPER STORAGE

KEEP YANKAUER COVERED WHEN NOT IN USE

ASSISTS IN DECREASING THE RISK OF ENVIRONMENTAL CONTAMINATION

REPLACE EVERY 24 HOURS AND PRN

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Core Measures

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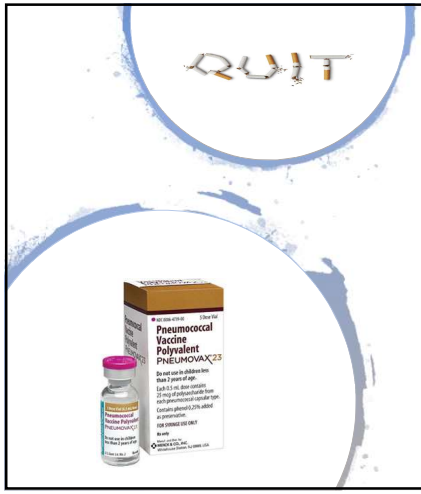

Core Measures

- Smoking Cessation
- Vaccination Status
- Antibiotics
- Blood Cultures

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Core Measures

- "Patient history of smoking anytime within the previous year must receive smoking cessation advice/counseling before discharge."

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References

- Bell, L. (2018). AACN Core Curriculum for High Acuity, Progressive, and Critical Care Nursing.

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Questions?

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Critical Care Nutrition

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Veterans Health Education Coordinator
Central Arkansas Veterans Healthcare System

1

Topics

- Role of a Registered Dietitian
- Basic Nutrition Review
- Types of Critical Care Patients
  - PO Diet
  - Enteral Nutrition (EN)
  - Parenteral Nutrition (PN)

2

Role of a Dietitian (RD)

- Assess nutritional status and degree of malnutrition
- Assess and calculate macro- and micronutrient needs
- Manage oral diet and supplementations based on medical hx/dx
  - Work closely with SLP
- Manage and monitor patients receiving nutrition support
- Provide diet education as appropriate

3

Nutrition Assessment

- Malnutrition Screening Tool
  - JACHO requirement to complete within 24 hours of admission
  - Questions wt loss PTA and poor appetite
  - If screened at risk, RD assesses pt within 24-48 hours
- Direct Consults from MD/RN
  - Nutrition Assessment/Education
  - Nutrition Support
- Pressure Injuries/ Ventilated pts

4

RD Assessment

RD will gather nutrition hx

- Wt changes, UBW
- Chewing/swallowing problems
- GI difficulties/concerns
- Allergies
- Changes in appetite/ overall intake

Nutrition Focused Physical Exams

- Able to identify degree of malnutrition using physical exam and nutrition hx
- Nutrition-focused physical findings assessment (often referred to as clinical assessment): Assessed findings from evaluation of body systems, muscle and subcutaneous fat wasting, oral health, hair, skin and nails, signs of edema, suck/swallow/breath ability, appetite and affect.

5

Basic Nutrition

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Basic Nutrition

- Carbohydrates
  - 4 kcal/g
  - Major energy source, providing 45-65% of daily energy
- Fat (lipids)
  - 9 kcal/g
  - Most concentrated energy source
  - Recommendations of 20-35% of daily energy
    - At least 7% needed to prevent Essential Fatty Acid Deficiency
- Protein
  - 4 kcal/g
  - Promote Nitrogen Retention and Support Metabolic Functions
    - Negative nitrogen balance in critically-ill patients
  - Preservation of Lean Body Mass
  - Regulate Fluid and Acid Balance

7

The Critically Ill Patient

Overfeeding associated with metabolic complications

- Hepatic steatosis
- Hyperglycemia
- Pulmonary compromise and vent weaning difficulties

Underfeeding Risks

- Poor wound healing
- Impaired organ function
- Altered immunological status

Critically Ill obese

- Permissive underfeeding

8

Oral/PO Diet

- Type of diet
  - Dependent on PMH, labs, nutrition status
- Diet Consistency
  - Eating ability/ SLP recommendations
- Oral Nutrition Supplements
  - Ensure, Boost, Glucerna, Nepro
  - Ordered based on clinical status, PMH, etc.
- Recommendations for appetite stimulants

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Nutrition Support: Enteral

- Ventilated, unsafe to swallow, too lethargic to eat
- Functioning GI Tract
- Preferred method of nutrition support

Advantages:

- Preserves gut integrity
- Decreases bacterial translocation
- Reduces rate of infectious complication
- Reduces risk of surgical interventions
- Reduces hospital costs
- Early EN reduces length of stay in ICU setting and overall hospital admission

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Delivery of EN

- Continuous
  - Administered over several hours via pump
  - Most common in critical care setting
  - Lower aspiration risk
- Intermittent
  - Set volumes of formula delivered at intervals throughout the day
- Bolus
  - Delivers large volume feeds over a shorter period of time
  - Common in more mobile patients or home TF
  - Higher risk of aspiration
  - **cannot bolus feed using a PEJ/NJ**

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Routes of EN

Nasogastric/Orogastric (NGT/OGT)
- Normal GI function, intact gag reflux
- Most common short-term use

Nasoduodenal/Nasojejunal (post-pyloric)
- Indicated if delayed gastric emptying, N/V, increased aspiration risk
- More difficult to place

Percutaneous Endoscopic Gastrostomy (PEG)
- Long-term enteral feeding
- Requires functioning gut

Jejunostomy
- Long-term aspiration risk
- Medical need to bypass stomach (ex pancreatic CA, severe gastroparesis)

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Enteral Nutrition: Formulas

- Nutritionally complete
  - Typically suitable for lactose intolerant
- Chosen based on estimated nutrition needs, PMH/Dx, labs, height/weight
- Types:
  - Standard/High Fiber: Jevity, Fibersource
  - Standard/Low-Residue: Osmolite, Isosource
  - Volume-Restricted: TwoCal HN, Nepro, Nutren 2.0
  - Renal: Nepro, Novasource Renal
  - Hyperglycemia: Glucerna, Diabetasource
  - Semi-Elemental: Peptamen AF, Vital 1.2
  - High Protein/ "Bariatric": Vital High Protein, Peptamen Bariatrick

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EN Initiation and Monitoring

- Goal to initiate within 24-48 hours of ICU admission
- Hemodynamic stability
- Abdomen is soft/non-distended
- **Hypoactive bowel sounds is NOT contraindication for EN**
- Changes in GI function
  - Ostomy/stool frequency
  - Nausea or Vomiting
  - Presence of or increasing abdominal distention
  - Loss of bowel sounds with EN infusing
- Laboratory Data
- Aspiration Risk
  - Ensure HOB elevated >30-45 degrees

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Gastric Residual Volume (GRV) Monitoring

- Normal Output of 3000-4000mL per day
  - Saliva and gastric output
- Recommended to not routinely monitor GRV
  - If hospital policy, do not hold EN for GRV <500mL without any further s/s of intolerance
- Increased GRV not associated with increased PNA risk

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EN Complications

- Continual High GRV
- Potential Factors:
  - Constipation/ Lack of BM
  - Medications
    - Propofol, narcotics, vasopressors
- Treatment
  - Prokinetic agent: Reglan, erythromycin
  - Add or adjust existing bowel management regimen
  - Post-pyloric feeding access
- Diarrhea
- TF formula is NOT always the cause (but can be)
  - TF formula with high osmolality, high fat content
  - High volume water flushes
- Medications
  - Antibiotics, sorbitol, electrolyte supplements, lactulose
- Prolonged Gut Rest
- C. diff

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Diarrhea Tx

- Stool for C. diff
- Anti-diarrheal medications
- TF Modular Products
  - Bulking agent to Tube Feeding (soluble fiber)
  - Ex. Banatrol (prebiotic)
- Probiotic
- Alter TF regimen to low-residue formula

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EN Complications

Constipation

- Prolonged bed rest
- Sedation, other medications
- Recommend early initiation of bowel regimen in ICU
  - Can start with "mild" regimen: docusate, Senna
  - Use of MiraLax, MOM, enema

Refeeding Syndrome

- At Risk: malnutrition, underweight, EtOH abuse, prolonged starvation
- Occurs with the initiation of nutrition, but also IV dextrose solutions
- Consists of low K, Mg, Phos and increased intravascular volume
- Can lead to arrhythmias, respiratory/cardiac failure, aspiration

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Contraindications to EN Initiation

- Mechanical bowel obstruction
- Bowel ischemia
- Therapeutic hypothermia
- Hemodynamic instability
  - Increasing pressor requirements
- Severe GIB
- High output fistula

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Parenteral Nutrition

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Central Parenteral Nutrition (TPN)

- Central Access Only
- Suitable for long-term nutrition support
- Formulation patient-specific
  - Can be calculated to meet 100% of nutrition requirements
- Composed of Dextrose, Amino Acids, Lipids, MVI, Trace elements, Insulin, etc.
  - Protein: 8.5%, 10%, 15% Amino Acid solutions
  - Dextrose: 10-70%
  - Lipids: 10%, 20%, 30%

21

PN Monitoring

- Glucose
  - Hyperglycemia common complication
  - Dextrose initially restricted: 150-200g/day
  - BG Goal (140-180)
- Triglycerides
  - Acceptable TG concentrations <400mg/dL
- Electrolytes
  - Concern for refeeding syndrome

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Potential PN Complications

- Electrolyte imbalances
- Over-feeding or under-feeding
  - Refeeding syndrome
- Increased permeability to bacteria
- Higher rates of infection
- Elevated Liver enzymes
- Hyperglycemia
- Azotemia

23

Peripheral Parenteral Nutrition (PPN)

- Peripheral access
- Limited to 900mOsm/L to avoid vein irritation
- Fixed formulations
  - Lower nutrient concentrations to allow peripheral venous administration
  - Ex. Procalamine: 3% Amino Acids with 3% Glycerin injection
    - 245 kcal, 29g Pro per liter bottle

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Peripheral Parenteral Nutrition (PPN)

- Advantages
  - Use as a bridge to EN initiation (short-term PN use)
  - Does not require PICC or central access, lower risk of infection
- Disadvantages
  - Difficult to meet 100% estimated nutrient needs
  - Often not suitable for volume-restricted patients

25

PN Contradictions

- Functional and accessible GI tract
- PO/TF to start <7-14 days
- Risks exceed benefit
  - Ex. Increased risk of infection

26

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- Carly Stanley MS, RD, LD, CNSC

- Further reading:

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2. American Society for Parenteral and Enteral Nutrition (ASPEN)
   - www.nutritioncare.org

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