Care of the Patient with Mechanical Ventilation

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Faculty Disclosure:

No Conflicts of Interest.
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Objectives

- Define the two major types of respiratory failure
- State two indications for intubation and mechanical ventilation
- State two criteria to wean from mechanical ventilation
- States three assessment that should be performed on the patient requiring mechanical ventilation
- State the three criteria for a diagnosis of ARDS

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Why?

"The nurse plays a crucial role in providing patient-centered care to ensure adequate oxygenation, ventilation, breathing comfort and patient-ventilator synchrony"

Chaln, L., Tracy, M., & Grossback, I. (December 2011) Achieving quality patient ventilator management: Advancing evidence-based nursing care. Critical Care Nurse, 6, pg. 46-50

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So what is a ventilator?

- Neil MacIntryre, MD stated that “a ventilator is simply a machine, a system, set at a predetermined manner to perform useful work”
- Irwin & Rippe, MD defined it as “a method to mechanically assist or replace spontaneous breathing when a patient can not do so on their own”
- Therefore: a ventilator is a way to support the respiratory system until the underlying cause of respiratory failure has been resolved

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Oxygenation vs. Ventilation

- Oxygenation:
  - The process of adding oxygen to the body
  - Occurs at the cellular level
  - Process occurs at the Alveolar / Capillary bed
  - Oxygen binds to hemoglobin -> dissolves in plasma -> body
- Ventilation:
  - A separate physiological process
  - Simply -> air moves in and out of the lungs
  - Can be spontaneous or artificial
  - Occurs from the nose/ mouth -> alveoli
  - Active vs. Passive phase of breathing

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Arterial Blood Gases

- **pH** – acid / base status 7.35 – 7.45
- **PaCO2** – direct measurement of ventilation – 35-45mmHg
- **PaO2** – assessment of the oxygenation status – 80-100mmHg
- **HCO3** – bicarb status – compensation of the kidneys in correcting the acid-base imbalance occurring 22-26Meq/l

- ***The primary issue*** *we see requiring intubation and ventilation is Respiratory Acidosis w/ Hypoxemia*
- *i.e. 7.29 – 88 – 54 - 24*

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The process or respiration / ventilation

- Transfer of oxygen across the alveoli
- Transport of oxygen to the tissues
- Adequate removal of carbon dioxide from the blood via the alveoli then out of the body

- The question now is “how well is my patient oxygenating and ventilating?

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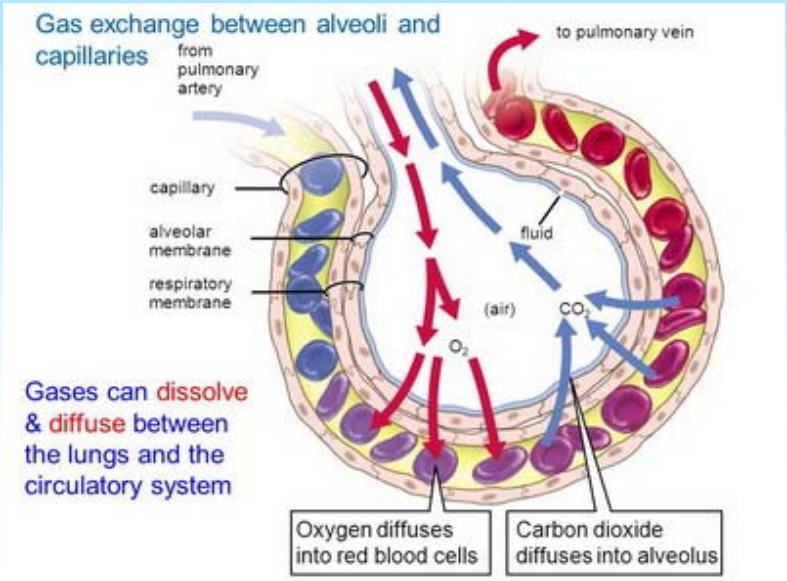

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Respiratory Failure

- Is a syndrome in which the respiratory system fails in either or both of its gas exchange functions
- Inadequate gas exchange by the respiratory system
- The body fails to keep the oxygen and / or carbon dioxide within the normal levels
- Four (4) types of respiratory failure

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Respiratory Failure Type I

- Also known as Hypoxemic Respiratory Failure
- Low levels of oxygen in the blood (hypoxemia) without an increase of carbon dioxide
- Oxygenation is the primary issue in this case
- Patients demonstrate:
  - Increase in respiratory rate
  - Increased work of breathing
  - Position themselves to aid in improved oxygenation
  - Arterial Blood Gases -> PaO2 levels

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Causes of Respiratory Failure Type I

- Low levels of ambient oxygen -> high altitudes
- Alveolar hypoventilation
- Diffusion problems
- Cardiac Shunts
- Ventilation – perfusion mismatching

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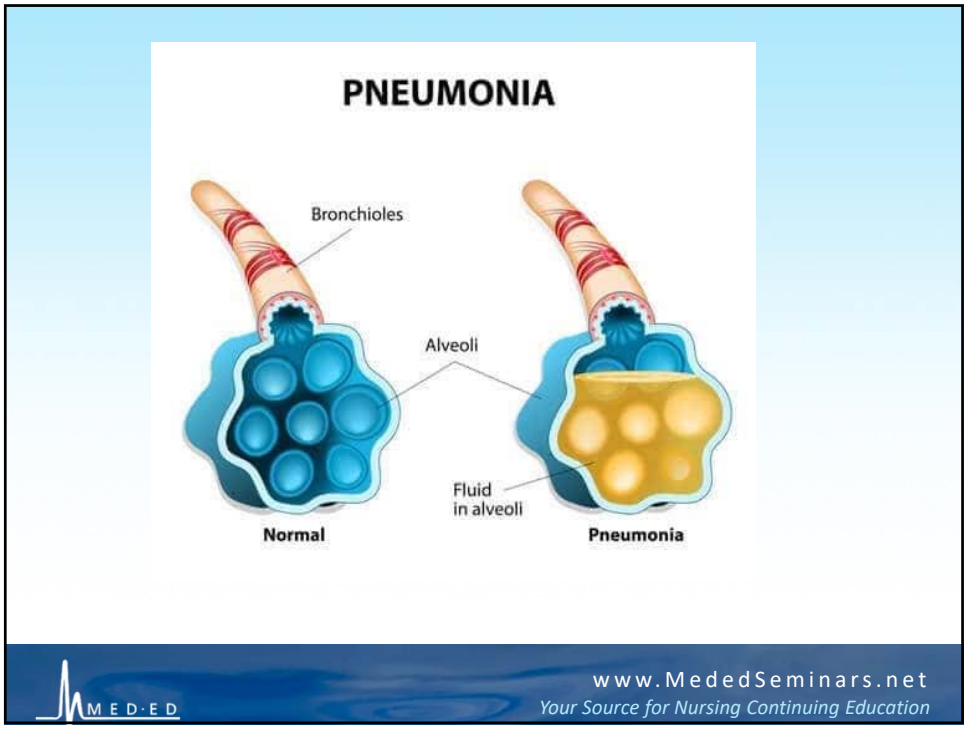
PNEUMONIA
Bronchioles
Alveoli
Fluid
in alveoli
Normal
Pneumonia
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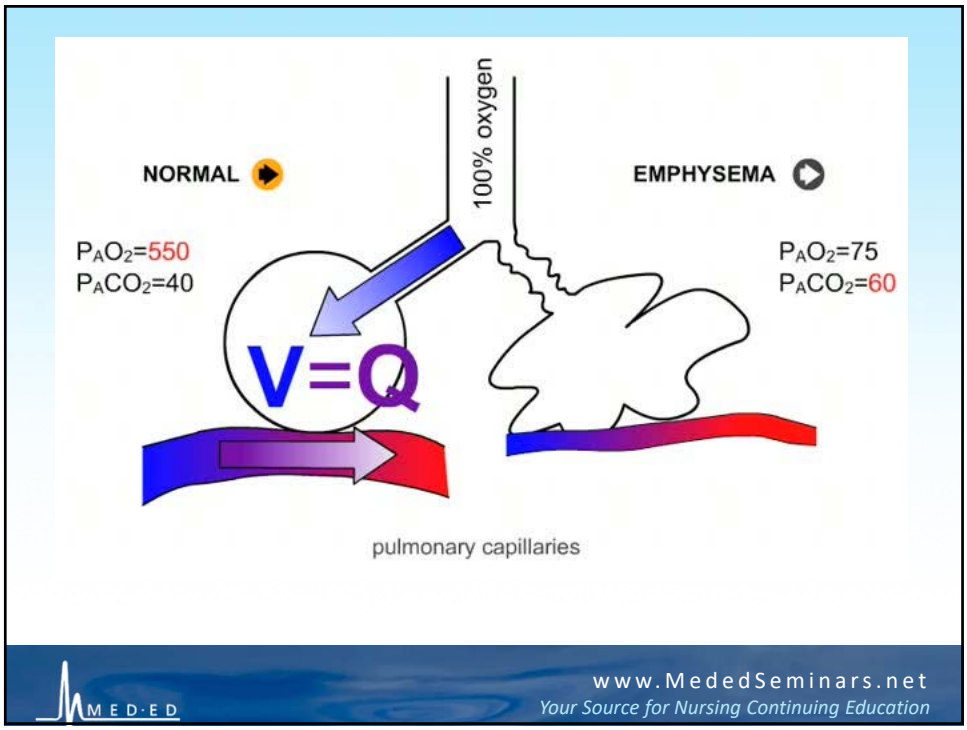
NORMAL
100% oxygen
EMPHYSEMA
P_AO_2=550
P_ACO_2=40
P_AO_2=75
P_ACO_2=60
V=Q
pulmonary capillaries
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Diffusion Problems

- Oxygen simply cannot enter the blood vessels due to a disease issue
- Classic issues include:
  - Pneumonia
  - Pulmonary Edema
  - ARDS

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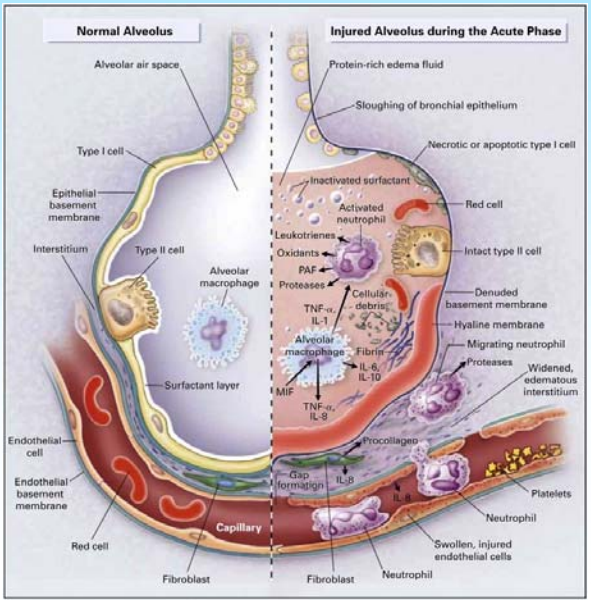

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Respiratory Failure Type II

- Hypoxemia with Hypercapnia
- Inadequate alveolar ventilation is occurring
- Have increased levels of carbon dioxide with low levels of oxygen
- Criteria:
  - PaO2 < 60mmHg
  - PaCO2 > 50mmHg
  - pH decreased <7.35

-> ABG's reflect Respiratory Acidosis with hypoxemia

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Causes of Respiratory Failure Type II

- Increased airway resistance (Asthma, COPD, airway obstruction)
- Reduced breathing effort (brain issues, opioids, benzodiazepines, morbid obesity)
- Neuromuscular diseases (Guillain-Barre' Syndrome)
- Chest deformities (Kyphoscoliosis, Pectus Excavatum)
- Reduced respiratory muscle activity (diaphragm issues)

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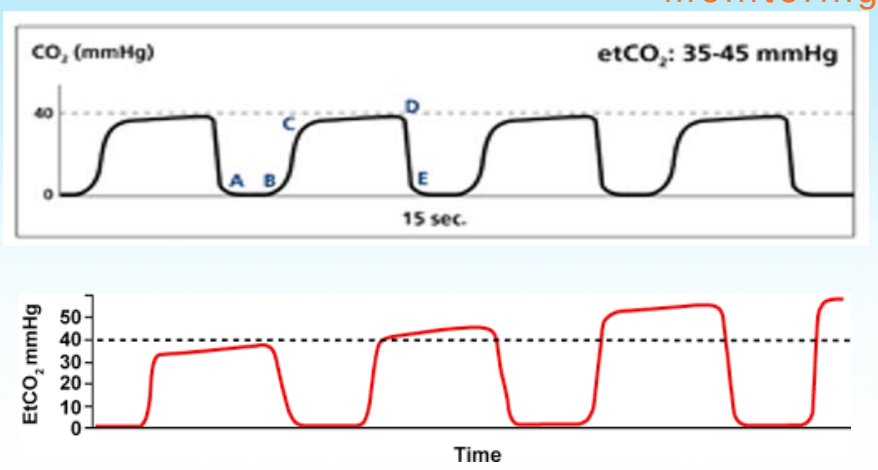
Respiratory Failure reflected in ETCO2 monitoring



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Hypoxemic Respiratory Failure	Hypercapnic Respiratory Failure
Known as: Type I ARF, Lung Failure, Oxygenation Failure, Respiratory Insufficiency	***Known as:*** Type II ARF, Pump Failure, Ventilatory Failure
Definition: The failure of lungs and heart to provide adequate O_2 to meet metabolic needs	***Definition:*** The failure of the lungs to eliminate adequate CO_2
Criteria: PaO_2 < 60 mmHg on FiO_2 ≥.50 or PaO_2 < 40 mmHg on any FiO_2 SaO_2 < 90	***Criteria:*** Acute ↑ in $PaCO_2$ > 50 mmHg or Acutely above normal baseline in COPD with concurrent ↓ in pH < 7.30
Basic Causes: R-L shunt V/Q mismatch Alveolar hypoventilation Diffusion defect Inadequate FIO_2	***Basic Causes:*** Pump failure (drive, muscles, WOB) ↑ CO_2 production R-L shunt ↑ Deadspace

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Body's Response to Respiratory Failure

- Chemoreceptors
  - Located in the carotids, aortic arch and brain
  - Sensory receptor cells
  - Sensitive to changes in carbon dioxide levels
  - More sensitive to changes in pH
  - Affect the heart rate -> SNS -> increase in contractility and rate

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Central Chemoreceptors

- Medulla chemoreceptors are very CO_2 sensitive
- Stimulate the medullary inspiratory neurons to increase alveolar ventilation as much as 2-3 liters for each mmHg rise in $PaCO_2$ values (normal is 35-45mmHg)
- $PaCO_2$ is the direct measurement of ventilation
- So an increase in respiratory rate, depth, will be reflected in patient presentation

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Respiratory Failure Types III & IV

Types of Respiratory Failure

Type 1 (Hypoxemic): * PO2 < 60 mmHg on room air.
Type 2 (Hypercapnic / Ventilatory): *PCO2 > 50 mmHg
Type 3 (Peri-operative): *This is generally a subset of type 1 failure but is sometimes considered separately because it is so common.
Type 4 (Shock): * secondary to cardiovascular instability.

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So can we use CPAP or BiPAP?

CPAP

- Continuous Positive Airway Pressure
- "E" setting
- Like having PEEP, but not intubated
- Primarily for oxygenation

BiPAP

- BiLevel Positive Airway Pressure
- aka: NIPPV
- "I & E" setting
- Aids in ventilation issues
- Minimal ventilation assistance
- Must have spontaneous breaths
- Able to tolerate the device
- Able to follow commands

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Need for Intubation and Mechanical Ventilation

- The goals of mechanical ventilation:
  - Intubation to protect the airway
  - Facilitate oxygenation and ventilation
  - Provide adequate oxygenation
  - Provide improved ventilation
  - Correct respiratory acidosis
  - Decrease the work of breathing
  - Protect from further insult

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Indications for Mechanical Ventilation

- Respiratory rate sustained > 30/min
- pH less than 7.25
- Altered LOC
- PaO2 <45mmHg despite supplemental oxygen
- Periods of apnea
- Hemodynamically unstable
- RR < 6/min
- Spontaneous Vt is less than 5ml/kg (IBW)
- Accessory muscle use (NIF < -20cmH20)
- Respiratory Failure Type I and / or II

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Those Ventilator Settings

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Ventilator Settings to Understand

- Mode of ventilation (AC, CMV, PRVC etc.)
- Tidal volume
- Respiratory rate / frequency
- Oxygen level or FiO2
- PEEP
- Pressure Support

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Mode of Ventilation

- Describes how the breaths from the ventilator will be delivered to the patient
- Mode is often decided upon on the patients condition / issue currently occurring (assist the patient or be in full control)
- Can often be determined by protocols based on the patients status
- Either be a ***Volume*** or ***Pressure*** delivery

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SIMV

- One of the oldest modes of ventilation, very seldom seen in the clinical area in todays practice
- Synchronized Intermittent Mechanical Ventilation
- Set tidal volume and rate on the ventilator
- Volume ventilation is occurring in this mode
- Allows the patient to have spontaneous breaths between the set delivered ventilation breaths
- Aids in resting the respiratory muscles, decreases the work of breathing
- Weaning mode of ventilation
- Can be often used for short term needs

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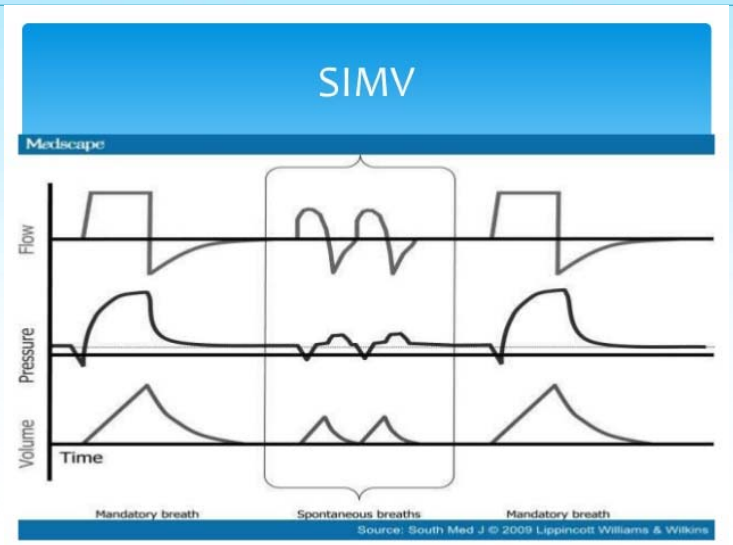
SIMV



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PRVC

- Pressure Regulated Volume Control
- One of the most frequent modes of ventilation utilized in practice today
- Utilizes pressure regulation to ventilate the patient
- Ventilator still has a preset tidal volume and rate
- Ventilator adjust the pressure for each breath delivered to achieve the set volume
- Breath by breath adjustment -> compliance
- Decreases barotrauma / lung injury

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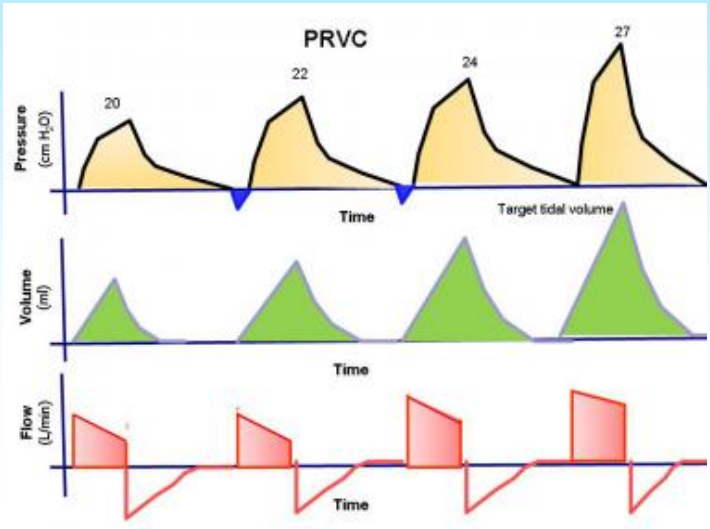
PRVC



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Tidal Volume

- TV or Vt
- Amount of air delivered with each preset breath
- Can be dictated or calculated by IBW or Height
- Range from 4ml to 8ml/ Kg of ideal body weight
- Adjusted at times to affect carbon dioxide, disease process, lung compliance, weaning status

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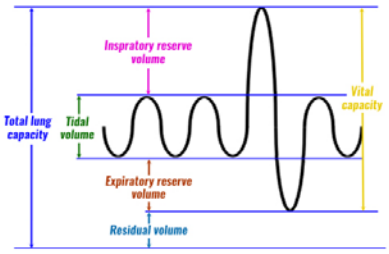
MALE QUICK REFERENCE FOR TIDAL VOLUME

HEIGHT	INCHES	PBW	8 mL/KG	6 mL/KG	4 mL/KG
4'6"	54	36.2	290	220	150
4'7"	55	38.5	310	230	160
4'8"	56	40.8	330	250	170
4'9"	57	43.1	350	260	170
4'10"	58	45.4	370	270	180
4'11"	59	47.7	380	290	190
5'0"	60	50.0	400	300	200
5'1"	61	52.3	420	320	210
5'2"	62	54.6	440	330	220
5'3"	63	56.9	460	340	230
5'4"	64	59.2	480	360	240
5'5"	65	61.5	490	370	250
5'6"	66	63.8	510	390	260
5'7"	67	66.1	530	400	270
5'8"	68	68.4	550	410	280
5'9"	69	70.7	570	430	290
5'10"	70	73.0	590	440	290
5'11"	71	75.3	600	450	300
6'0"	72	77.6	620	470	310
6'1"	73	79.9	640	480	320
6'2"	74	82.2	660	500	330
6'3"	75	84.5	680	510	340
6'4"	76	86.8	700	520	350

KG = kilogram; mL = milliliter; PBW = predicted body weight



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Respiratory Rate setting

- RR or f
- Respiratory rate or frequency
- The number of breaths the ventilator is to deliver each minute
- This setting is based often on the patients work of breathing and or the PaCO2 results from the ABGs
- Also can be adjusted based on the patients' ETCO2

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Oxygen setting

- FiO2 – fraction of inspired oxygen
- How much oxygen are we going to deliver to the patient
- .21 to 1.0 or 21% to 100%
- Based on the patients immediate physiological needs
- Setting is based on to maintain a PaO2 60-100mmHg
- Titrated based on ABG or POX readings

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PEEP

- Positive End Expiratory Pressure
- Recruits alveoli to aid in oxygenation
- Typical setting is begun at 5cmH20 pressure
- Treatment for refractory hypoxemia
- Based on the oxygenation status of the client, PaO2 of the arterial blood gas (or even on POX readings)

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PEEP continued...

- PEEP increases oxygenation by preventing collapse of the alveoli
- PEEP maximized the number of alveoli for gas exchange
- Therefore -> FRC improves -> resulting in improved oxygenation
- PEEP allow for less use of oxygen
- Does result in an increase in Intrathoracic Pressure

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PSV

- Pressure Support Ventilation
- A setting in which the patient's spontaneous breath is augmented by positive pressure
- It assist with the active phase of ventilation
- Decreases the work of breathing
- Aids in overcoming the ventilator circuit resistance
- Utilized in weaning the client from the ventilator
- Setting for PSV is often based on the desired spontaneous tidal volumes needed

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Making Ventilator Setting Changes

- Changes of the settings are based on multiple factors
  - Arterial Blood Gas Results
  - Chest X-ray
  - Patient presentation
  - Disease Process
  - Needs of the patient
  - Sedation status
  - Hemodynamic status

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Changes that affect ventilation

- Based on the ETCO2 readings or PaCO2 of ABG's:
  - Respiratory rate (primary change that will be made)
  - Tidal volume settings
  - Mode of ventilation
  - Pressure support settings

All will affect how the patient ventilates -> reflected in the ABG -> PaCO2 or noted on the ETCO2 values

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Ventilator Changes continued...

- Changes that will affect the oxygenation of the patient
- Will note the PaO2 on the arterial blood gases
- Also may adjust on the POX values
- Changes to the ventilator that affect oxygenation:
  - FiO2
  - PEEP
  - I – Time (inspiratory time)

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Ventilator Alarms

- Low Pressure Alarm:
  - Disconnect
  - Loose tubing
  - ETT issues
- High Pressure Alarm:
  - Obstruction
  - Secretions
  - Bronchospasms
  - Dysynchrony
  - Agitation

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Endotracheal Tube Issues

- Can become dislodged
- Displaced at or above the vocal cords
- Right main stem intubation
- Cuff leak
- Unplanned extubation
- Intolerance of the tube itself

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Patient Care & Assessment

- Vital signs
- Breath sounds
- ABG's, ETCO2, POX values
- Secretions
- Ventilator settings
- Cardiac assessment
- ETT evaluation/ assessment
- Chest x-ray
- Patient comfort
- Skin care / mouthcare
- VAP prevention

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Keep It Simple Assessment

- A –
  - Airway type, where intubated, size of tube, markings at teeth, which side of the mouth
- B-
  - Breathing pattern, ventilator settings
- C-
  - Hemodynamics, POX, ETCO2, urine output, capillary refill
- D-
  - Neurological status, RASS score, GCS value, AVPU

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Patient Sedation

- Reduction in anxiety
- Amnesia effects
- Aids in improving hemodynamics
- Decrease the level of the stress hormones
- Compliance with the ventilator
- Tolerance of the ETT
- Tolerance of the ventilator mode (AC, CMV, HFOV)

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Effects of poor sedation / analgesia

- **Respiratory**: tachypnea, asynchrony, increase in oxygen demand, intolerance of the ETT
- **Cardiovascular**: tachycardia, bradycardia, hypertensive, myocardial ischemia
- **Gastrointestinal**: delay in gastric emptying, effect on bowel motility
- **Neurological**: agitation, grimacing, sweating, anxiety
- **Psychological**: sleep deprivation, depression, anxious, anger

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Sedation / Pain Assessment

- Utilize the scales
  - CPOT – Critical Care Pain Observation Tool
  - RASS – Richmond Agitation and Sedation Scale
  - Vital signs
  - BIS monitoring may be utilized

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RASS

Score	Descriptor	Characteristics
+4	Combative	Combative, violent, immediate danger to staff
+3	Very agitated	Pulls or removes tube(s) or catheter(s); aggressive
+2	Agitated	Frequent nonpurposeful movement, fights ventilator
+1	Restless	Anxious, apprehensive but movements not aggressive or vigorous
0	Alert and calm	
-1	Drowsy	Not fully alert, but has sustained awakening to voice (eye opening and contact >10 seconds)
-2	Light sedation	Briefly awakens to voice (eye opening and contact <10 seconds)
-3		
-4	Moderate sedation	Movement or eye opening to voice (but no eye contact)
	Deep sedation	No response to voice, but movement or eye opening to physical stimulation
-5	Unarousable	No response to voice or physical stimulation

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Critical Care Pain Observation Tool

Indicator	Description	Score	
Facial expression	No muscular tension observed	Relaxed, neutral	0
	Presence of frowning, brow lowering, orbit tightening, and levator contraction	Tense	1
	All of the above facial movements plus eyelid tightly closed	Grimacing	2
Body movements	Does not move at all (does not necessarily mean absence of pain)	Absence of movements	0
	Slow, cautious movements, touching or rubbing the pain site, seeking attention through movements	Protection	1
	Pulling tube, attempting to sit up, moving limbs/ thrashing, not following commands, striking at staff, trying to climb out of bed	Restlessness	2
Muscle tension Evaluation by passive flexion and extension of upper extremities	No resistance to passive movements	Relaxed	0
	Resistance to passive movements	Tense, rigid	1
	Strong resistance to passive movements, inability to complete them	Very tense or rigid	2
Compliance with the ventilator (intubated patients)	Alarms not activated, easy ventilation	Tolerating ventilator or movement	0
	Alarms stop spontaneously	Coughing but tolerating	1
	Asynchrony: blocking ventilation, alarms frequently activated	Fighting ventilator	2
OR			
Vocalization (extubated patients)	Talking in normal tone or no sound	Talking in normal tone or no sound	0
	Sighing, moaning	Sighing, moaning	1
	Crying out, sobbing	Crying out, sobbing	2

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BIS Monitoring

- BIS® Monitoring – Bispectral Index

0 (flat line EEG) 100 (awake)

70-80 (moderate sedation)

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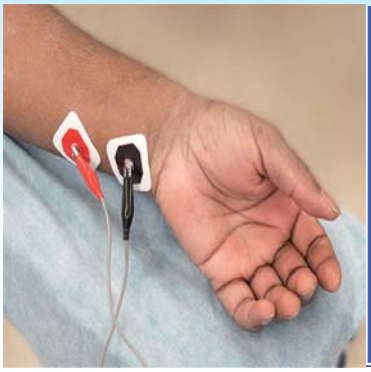
"Train-Of-Four" assessment



with train-of-four testing[a]

No. of twitches	Approximate percentage of receptors blocked
0	100
1	90
2	75-80
3	75
4	0

[a] Based on Foster et al[3] and Viby-Mogensen.[26]

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Weaning and Extubation

- Weaning from mechanical ventilation is the process of assisting the patient to breathe unassisted or the transition from ventilator support to spontaneous breathing
- Weaning and extubation are two separate processes
- Weaning and extubation is a team approach
- Weaning should only be considered once the underlying issues requiring mechanical ventilation have been resolved

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General Requirements for Weaning

- Lung issue is stable or resolved
- Medical condition is stable
- Hemodynamically stable patient
- Spontaneous breaths can be noted
- Good neuromuscular function
- Low FiO2 (40%)
- Low PEEP settings (5cmH20)

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Additional Requirements for weaning

- What was the initial indication for intubation / mechanical ventilation?
- Sedation levels
- NMBA agents? TOF?
- BIS monitoring
- Psychological readiness
- “Wake Up” Assessment met
- Spontaneous Breathing Trials (ventilator provides minimal support)

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Respiratory Weaning Parameters

- Respiratory rate <25/ minute
- Negative Inspiratory Force > -20cmH20
- Spontaneous Tidal Volume 5ml/kg
- Minute Ventilation 5-6 liters/ min
- Ventilator settings / mode ?
- PaO2 > 60mmHg on FiO2 40% or less

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Issues that could impair weaning

- Infection / disease issues
- Sleep deprivation
- Pain
- Abdominal distention
- Poor nutritional status
- Continued need for sedation
- Mental status ready

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Criteria To Stop Weaning

- RR < 8/min or > 30/min
- Agitation / labored
- Use of accessory muscles
- Spontaneous volumes are less 5ml / kg (IBW)
- Abnormal breathing pattern / use of accessory muscles
- HR increases by 20%
- Cardiac ectopy
- ST Segment Elevation
- Altered level of consciousness

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Are you ready to Extubate?

- Aspiration risk not present
- Airway edema not noted
- Patient can control secretions
- Cough present
- Intact gag reflex
- Sedation level is acceptable
- Adequate oxygenation
- POX & ETCO2 evaluation

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Brief word about ARDS

- Respiratory failure issues are present -> Respiratory Failure Type I
- Refractory Hypoxemia
- Type II Alveolar Cells are affected
- Direct vs Indirect lung injury has occurred
- Critical Care Criteria:
  - Refractory Hypoxemia
  - Bilateral Infiltrates on CXR (“Ground Glass Appearance” noted on radiology report)
  - P/F ratio < 200 (<100 if intubated/ ventilated)

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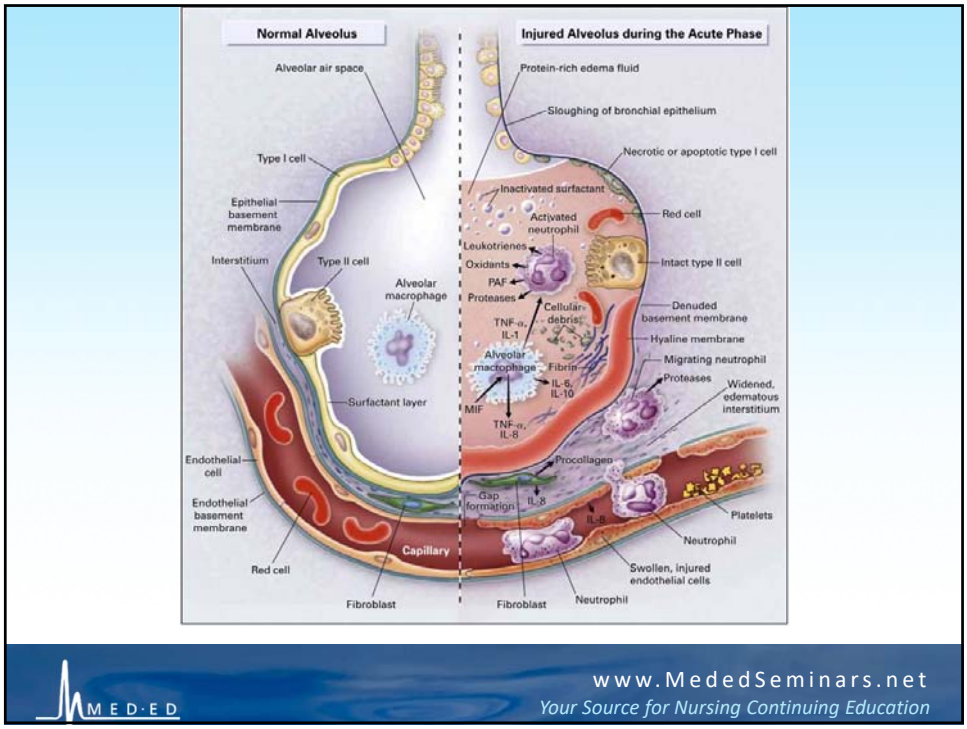

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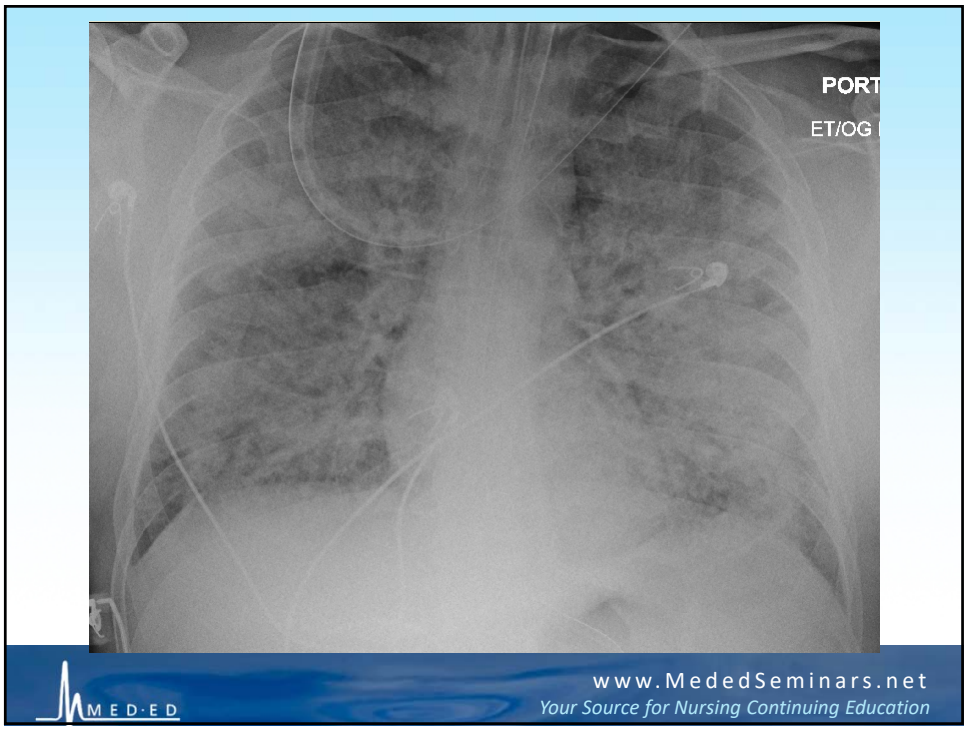

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ARDS: Direct vs Indirect Injury

Respiratory (direct)	Non-Respiratory (indirect)
Aspiration	Blood transfusion reactions
Near-drowning	Burns (massive)
O_2 toxicity	DIC
Pneumonia (all types)	Drug abuse
Post-pneumonectomy	Fat embolism
Raised ICP (head injury)	Pancreatitis (acute)
Smoke inhalation	Prolonged cardiopulmonary bypass
Thoracic irradiation	Sepsis
Trauma (lung contusion/ injury)	Shock (severe and prolonged)
Vasculitis	

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ARDS Effects...

- Increase in capillary permeability
- Damage to the capillary endothelium occurs
- Alveoli endothelium damage occurs
- Fluid leaks into the interstitial/ alveolar spaces
- Intrapulmonary shunting occurs
- Damage to Type II alveolar cells occurs -> surfactant production is poor

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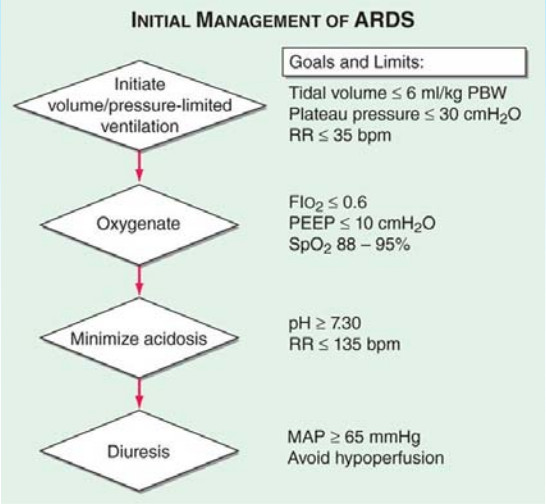
Treatment of ARDS



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When a patient is on mechanical ventilation

- Optimize oxygenation and ventilation
- Maintain acceptable hemodynamic status
- Provide patient comfort
- Know your patient's ventilator settings -> consult RT
- Prevent VAP
- Work as a team -> RN, RRT, MD, Dietician
- Weaning & Extubation is team work -> morning time
- Know your hospitals policies / procedures
- Who is your support staff?

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