Care of the Patient with Mechanical Ventilation

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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

Why?

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

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

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
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

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?”
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
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

Causes of Respiratory Failure Type I

- Low levels of ambient oxygen -> high altitudes
- Alveolar hypoventilation
- Diffusion problems
- Cardiac Shunts
- Ventilation – perfusion mismatching
• Oxygen simply cannot enter the blood vessels due to a disease issue
• Classic issues include:
  – Pneumonia
  – Pulmonary Edema
  – ARDS
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

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)
Respiratory Failure reflected in ETCO2 monitoring

<table>
<thead>
<tr>
<th>Hypoxemic Respiratory Failure</th>
<th>Hypercapnic Respiratory Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Known as:</strong></td>
<td>Type I ARF, Pump Failure, Ventilatory Failure</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>The failure of the lungs to eliminate adequate CO₂</td>
</tr>
<tr>
<td><strong>Criteria:</strong></td>
<td>PaO₂ &lt; 60 mmHg on FiO₂ ≥ 50 or PaO₂ &lt; 40 mmHg on any FiO₂, SaO₂ &lt; 90</td>
</tr>
<tr>
<td><strong>Basic Causes:</strong></td>
<td>Pump failure (drive, muscles, WOB), ↑ CO₂ production, R L shunt, ↑ Deadspace</td>
</tr>
<tr>
<td><strong>Known as:</strong></td>
<td>Type II ARF, Lung Failure, Oxygenation Failure, Respiratory Insufficiency</td>
</tr>
<tr>
<td><strong>Definition:</strong></td>
<td>The failure of lungs and heart to provide adequate O₂ to meet metabolic needs</td>
</tr>
<tr>
<td><strong>Criteria:</strong></td>
<td>Acute ↑ in PaCO₂ &gt; 50 mmHg or Acutely above normal baseline in COPD with concurrent ↓ in pH &lt; 7.30</td>
</tr>
<tr>
<td><strong>Basic Causes:</strong></td>
<td>R L shunt, V/Q mismatch, Alveolar hypoventilation, Diffusion defect, Inadequate FiO₂</td>
</tr>
</tbody>
</table>
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

Central Chemoreceptors

- Medulla chemoreceptors are very CO2 sensitive
- Stimulate the medullary inspiratory neurons to increase alveolar ventilation as much as 2-3 liters for each mmHg rise in PaCO2 values (normal is 35-45mmHg)
- PaCO2 is the direct measurement of ventilation
- So an increase in respiratory rate, depth, will be reflected in patient presentation
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.

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
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

Need for Intubation and 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

Indications for Mechanical Ventilation
Those Ventilator Settings

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

Ventilator Settings to Understand
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

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
• 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
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
**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
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

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)
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

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
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

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
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)

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

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
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

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)
**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

**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
## RASS

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

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## Critical Care Pain Observation Tool

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

- BIS® Monitoring – Bispectral Index

<table>
<thead>
<tr>
<th>0 (flat line EEG)</th>
<th>100 (awake)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-80 (moderate sedation)</td>
<td></td>
</tr>
</tbody>
</table>

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**“Train-Of-Four” assessment**

<table>
<thead>
<tr>
<th>No. of twitches</th>
<th>Approximate percentage of receptors blocked</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>90</td>
</tr>
<tr>
<td>2</td>
<td>75-80</td>
</tr>
<tr>
<td>3</td>
<td>75</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

*Based on Foster et al.* and Vilby-Mogensen.20
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

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)
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)

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
**Issues that could impair weaning**

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

**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
**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

**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)
ARDS: Direct vs Indirect Injury

<table>
<thead>
<tr>
<th>Respiratory (direct)</th>
<th>Non-Respiratory (indirect)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aspiration</td>
<td>Blood transfusion reactions</td>
</tr>
<tr>
<td>Near-drowning</td>
<td>Burns (massive)</td>
</tr>
<tr>
<td>O₂ toxicity</td>
<td>DIC</td>
</tr>
<tr>
<td>Pneumonia (all types)</td>
<td>Drug abuse</td>
</tr>
<tr>
<td>Post-pneumonecstomy</td>
<td>Fat embolism</td>
</tr>
<tr>
<td>Raised ICP (head injury)</td>
<td>Pancreatitis (acute)</td>
</tr>
<tr>
<td>Smoke inhalation</td>
<td>Prolonged cardiopulmonary bypass</td>
</tr>
<tr>
<td>Thoracic Irradiation</td>
<td>Sepsis</td>
</tr>
<tr>
<td>Trauma (lung contusion/</td>
<td>Shock (severe and prolonged)</td>
</tr>
<tr>
<td>Injury)</td>
<td></td>
</tr>
<tr>
<td>Vasculitis</td>
<td></td>
</tr>
</tbody>
</table>

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
Treatment of ARDS

**INITIAL MANAGEMENT OF ARDS**

- **Initiate volume/pressure-limited ventilation**
  - **Goals and Limits:**
    - Tidal volume ≤ 6 ml/kg PBW
    - Plateau pressure ≤ 30 cmH₂O
    - RR ≤ 35 bpm
  - FIO₂ ≤ 0.6
  - PEEP ≤ 10 cmH₂O
  - SpO₂ 88 – 95%
  - pH ≥ 7.30
  - RR ≤ 135 bpm
  - MAP ≥ 65 mmHg
  - Avoid hypoperfusion

- **Oxygenate**
- **Minimize acidosis**
- **Diuretics**

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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 \( \rightarrow \) consult RT
- Prevent VAP
- Work as a team \( \rightarrow \) RN, RRT, MD, Dietician
- Weaning & Extubation is team work \( \rightarrow \) morning time
- Know your hospitals policies / procedures
- Who is your support staff?
Thank You For Joining Us

For additional questions for this webinar…
contact via email
questions@mededseminars.net

For support questions
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