Considerations for Mechanical Ventilation of Patients with COPD

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Outline

• **Pathophysiological Considerations of COPD**
• **COPD Exacerbation**
• **Guidelines for Mechanical Ventilation of COPD Patients**
• **Case Study**
Pathophysiological Considerations
COPD patients

90% Chronic Bronchitis

5% Emphysema

5% Chronic Bronchitis

5% Emphysema

100% COPD patients
# Pathophysiological Considerations of COPD

<table>
<thead>
<tr>
<th>Chronic Bronchitis</th>
<th>Emphysema</th>
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<tbody>
<tr>
<td>• Inflammation &amp; swelling of airways</td>
<td>• Destruction &amp; enlargement of peripheral airways</td>
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<tr>
<td>• Excessive production of mucus</td>
<td>• Destruction of pulmonary capillaries</td>
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<td>• Partial &amp; total mucous plugging</td>
<td>• Loss of elastic recoil</td>
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<tr>
<td>• Bronchial smooth muscle contraction</td>
<td>• Less surface area for gas exchange</td>
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<td>• Hyperinflation</td>
<td>• Hyperinflation</td>
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Pathophysiological Considerations of COPD

“Blue Bloater”       “Pink Puffer”
Pathophysiological Considerations of COPD

COPD patients have:

- Increased $R_{aw}$
- Increased $C_L$

- Expiratory airflow obstruction
- Lengthened ventilation time constant
- Air trapping
COPD Exacerbation
COPD Exacerbation Features

- Increased Exp. Raw
- Increased RR
- Intrinsic PEEP
- Alveolar hypoventilation
- Respiratory muscle work
- Increased O2 consumption
COPD Exacerbation

- More air trapping
- Hypoventilation
- Increased WOB
- Muscle fatigue
Acute-on-Chronic Respiratory Failure

Uncompensated respiratory acidosis superimposed on compensated respiratory acidosis
DEATH

No intervention

Respiratory failure

DEATH
O₂ Therapy

Bronchodilators

Conventional Therapy

Anti-inflammatory agents

NPPV

ANTIBIOTICS??
Antibiotics are given when:

1) Increased dyspnea
2) Increased sputum volume
3) Increased sputum purulence

1) Severe exacerbation
2) Mechanical ventilation (invasive or noninvasive)
Common bacteria recovered from lower airways during COPD exacerbation.

- Hemophilus influenzae
- Streptococcus pneumoniae
- Moraxella catarrhalis
COPD Exacerbation

Current Standard of Care

• Conventional Therapy: $O_2$ therapy, bronchodilators, anti-inflammatory agents

• NPPV:
  – Reduces WOB
  – Reduces inspiratory muscle activity
  – Reduces RR
  – Increases VT
  – Improves minute ventilation
  – Enables better gas exchange
  – Rests respiratory muscles
Guidelines for Mechanical Ventilation of COPD Patients
Guidelines for Mechanical Ventilation of COPD Patients

Associated Morbidity When Mechanically Ventilating COPD Patients

- Air trapping
- Nosocomial infections
- Barotrauma
- Cardiac problems (cor pulmonale)
- Aspiration
- Difficulty weaning
Guidelines for Mechanical Ventilation of COPD Patients

Goals for Mechanically Ventilating COPD Patients

• Maximize patient-ventilator synchrony
• Reduce WOB
• Alleviate patient anxiety
• Avoid problems associated with mechanical ventilation
Guidelines for Mechanical Ventilation of COPD Patients

Non-Invasive Positive Pressure Ventilation (NPPV)

1st Choice
NPPV

• Reduces inspiratory muscle activity
• Decreases respiratory rate
• Increases $V_T$
• Increases minute ventilation
• Improves alveolar ventilation
• Improves gas exchange
• Rests respiratory muscles
Physiological Goals of NPPV in ARF

- Increase alveolar ventilation
- Improve gas exchange

Both goals are accomplished by resting the muscles of respiration.
Guidelines for Mechanical Ventilation of COPD Patients

NPPV Selection Criteria

• **Determine need for ventilatory assistance**
  – Dyspnea (moderate to severe respiratory distress)
  – Excessive accessory muscle use/paradoxical breathing
  – pH < 7.35 and/or PaCO2 > 45 mm Hg
  – PaO2/FIO2 < 200
  – RR > 25 breaths/minute
  – Potential reversibility of the disease process

• **Exclusion criteria**
Guidelines for Mechanical Ventilation of COPD Patients

**NPPV Exclusion Criteria**

- Respiratory arrest
- Need for immediate ET intubation
- Hemodynamic instability
- Inability to protect airway (impaired cough)
- Excessive secretions
- Agitated & confused
- Uncooperative or unmotivated
- Facial deformities
- Brain injury/unstable respiratory drive
Guidelines for Mechanical Ventilation of COPD Patients

NPPV for Acute COPD Exacerbations

• Provides time for conventional therapy to take effect:
  – $O_2$ therapy
  – Bronchodilators
  – Anti-inflammatory agents
Guidelines for Mechanical Ventilation of COPD Patients

- **NPPV**: avoid hazards associated with ETT & invasive positive pressure ventilation (IPPV)
- Bilevel positive airway pressure (BiPAP)
- Continuously monitor: SpO₂ & HR
  - F₁O₂ to maintain SpO₂ at 90%-92%
- ABGs 2 hours into NPPV
- Improving pH and PaCO₂: positive signs
- Chronic hypercapnia: takes longer to improve
Guidelines for Mechanical Ventilation of COPD Patients

**Discontinue NPPV**

- **pH and PaCO₂:**
  - No improvement
  - Worsening
- Continued respiratory distress
- Deteriorating level of consciousness
- Hemodynamic instability
- Worsening oxygenation status
Guidelines for Mechanical Ventilation of COPD Patients

Initial Ventilator Settings for IPPV
Guidelines for Mechanical Ventilation of COPD Patients

**Initial Ventilator Settings (IPPV)**

- **Inspiratory flow**: meet patient’s demands (> 60 L/minute)
- **VT**: 6 to 8 ml/kg
- **RR**: 8 to 12 breaths/minute
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Initial Ventilator Settings (IPPV)

- I:E ratio with longest $T_E$ possible:
  - Decreasing $T_I$
  - Increasing $T_E$
  - Reducing RR and/or VT
- Permissive hypercapnia: $\text{PaCO}_2 >$ patient’s baseline
- PEEP: $\leq 5$ cm H$_2$O
- Minute ventilation: low as possible yet promote gas exchange (baseline ABGs)
Guidelines for Mechanical Ventilation of COPD Patients

Initial Ventilator Settings (IPPV)

- $\text{FiO}_2$: $< 0.50$ (with $\text{SpO}_2 > 90\%$)
- ABGs:
  - $\text{PaO}_2$ 55 to 75 mm Hg
  - $\text{PaCO}_2$ 50 to 60 mm Hg
  - $\text{pH}$ 7.30 to 7.35
- Monitor for & minimize dynamic hyperinflation
- $P_{\text{plateau}}$: $< 30$ cm H$_2$O
Guidelines for Mechanical Ventilation of COPD Patients

Considerations during Mechanical Ventilation

• Adequate hydration
• Pharmacologic therapy
  – Bronchodilators
  – Corticosteroids
  – Secretion mobilization
  – Antibiotics (if indicated)
• Nutritional support
  – Inadequate food intake
  – Hypermetabolism

To reverse airflow limitation
COPD Case Study
COPD Case Study

- 73-year-old male, 5’10” in ER
- 62 kg (IBW 75.5 kg)
- 40-pack-years
- Retired police officer
- Retired living at home with wife
COPD Case Study

Mental Status:

• Alert, oriented, but weak
• Speaks in halting sentences
• Catches breath between efforts to talk
Physical Appearance:
• Tall & thin
• Barrel chest
• Pale skin
• Prolonged expiration through pursed lips
• Labored breathing
• Sitting in tripod position
• Active sternocleidomastoids
COPD Case Study

Auscultation:
- Bilateral wheezing
- Inspiratory crackles

Percussion:
- Hyperresonance bilaterally

Cough:
- Weak
- Moderate secretions
- Yellow, thick mucus
COPD Case Study

- Room air SpO2 71%
- Now breathing 28% O₂ via air-entrainment mask
- Nebulized albuterol via SVN
- Unable to breath deeply & breath hold
- Complains of dyspnea
COPD Case Study

ABGs on 28% O2:

- pH 7.24
- PaCO₂ 97 mm Hg
- PaO₂ 38 mm Hg
- HCO₃ 41 mEq/L
ABG Interpretation:

- Acute-on-chronic respiratory failure with severe hypoxemia
- Uncompensated respiratory acidosis superimposed on compensated respiratory acidosis with severe hypoxemia
COPD Case Study

• CXR:
  – infiltrates in both lower lung fields
  – flattened diaphragms
  – widened rib spaces
• Sputum: thick, yellow
• Body temperature: normal
• Labs: C & S done
COPD Case Study

- NPPV initiated
  - to avoid auto-PEEP: low $V_T \times$ low RR
  - synchronize ventilator with patient
  - BiPAP S/T-D selected
  - RR: 8 breaths/minute
  - TCT: (60 sec/min divided by 8 bpm = 7.5 seconds)
  - $T_I$: 13% of TCT  $T_I$ 1 second
  - IPAP: 14 cm H$_2$O  $T_E$ 6.5 seconds
  - EPAP: 4 cm H$_2$O
  - $V_T$: 600 ml (8 ml/kg x 75.5 kg)
  - FIO$_2$: titrated to SpO$_2$ (> 90%) – FIO$_2$: 0.40
COPD Case Study

- Patient transferred to ICU
- NPPV for 2 hours
- Patient’s secretions increase
- Patient agitated (repeated attempts to remove mask)
COPD Case Study

- NPPV fails
- Patient given Ativan and succinylcholine
- Patient intubated with 8.5 mm I.D. ETT
- IPPV initiated
- Time-triggered, VC-SIMV with PSV instituted
  - Time-triggered, VC- or PC-CMV unloads respiratory muscles more than patient-triggered, VC- or PC-SIMV (increases risk of PEEP_{auto} & increased lung pressures).
COPD Case Study

IPPV STRATEGY

• Get patient under control.
• Sedate & short-duration paralytic.
• Establish patient-ventilator synchrony.
• Unload muscles of respiration (1 to 2 days).
• Patient likely will sleep because of fatigue.
• Anxiolytic & paralytic wear off.
• Ventilator accommodates patient’s ventilatory needs.
• Gradually reduce mandatory RR.
• Wean.
COPD Case Study

Settings for Time-Triggered, VC-SIMV with PSV

- $V_T$: 600 ml ($8 \text{ ml/kg} \times 75.5 \text{ kg}$)
- Mandatory RR: 10 breaths/minute
- Inspiratory flow: 40 L/minute
- Pressure support: 10 cm H$_2$O
- FiO$_2$: 0.40

Treat underlying cause during time on mechanical ventilator

- Irritants (bronchodilators & corticosteroids)
- Pneumonia (antibiotics)
COPD Case Study

Flow-Time Scalar: Mandatory Breath
COPD Case Study
Pressure-Time Scalar:
Time-Triggered Mandatory Breaths

![Diagram of Pressure-Time Scalar: Scooped Inspiratory Limb]
COPD Case Study

Pressure-Time Scalar: Time-Triggered Mandatory Breaths
COPD Case Study

Measures Taken To Reduce/Eliminate Auto-PEEP

- Increase inspiratory flow
- Shorten $T_I$
- Lengthen $T_E$
- Decrease I:E
- Decrease RR
- Decrease $V_T$
- Use larger I.D. ET
- Administer bronchodilator
- Institute PEEP (50% - 80% of auto-PEEP)
COPD Case Study

Action Taken To Correct for Auto-PEEP

• Inspiratory flow increased to 80 L/minute.
COPD Case Study

Flow-Time Scalar: No Auto-PEEP
COPD Case Study

Pressure-Time Scalar
COPD Case Study

**Final Disposition**

- Mandatory RR decreased over time
- SBT conducted successfully
- Weaning successful
- Patient extubated
- Eventual discharge home
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