Fundamentals of Critical Care Support: Ventilators

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Ventilatory Support

- Ventilators 101: The basics
- Indications for intubation
- ARDS and the ARDSNet data
- Ventilator weaning and extubation
Ventilator Basics

• Types of ventilators
  – Pressure-cycled
  – Volume-cycle

• Modes of ventilation
  – Assist-Control (Continuous Mandatory)
  – Synchronized Intermittent Mandatory Ventilation
  – Pressure-Controlled Ventilation
  – Pressure-Support Ventilation
What are all those knobs for?

- Mode
- Respiratory Rate
- Tidal Volume (or Peak Inspiratory Pressure)
- Pressure Support
- FiO₂
- Positive End-Expiratory Pressure
- I:E ratio
What do those numbers mean?

• Peak Pressure
• Plateau Pressure
• Pulse Oximetry
• Arterial Blood Gases (PaO$_2$, PaCO$_2$, pH)
Indications for Mechanical Ventilation

- Hypoxemia (oxygenation failure)
- Hypercapnia (ventilation failure)
- Inability to control airway
- Fatigue
- Shock
Criteria for Intubation

- Respiratory Rate > 30
- Vital Capacity < 15 mL/kg
- Minute Ventilation > 10 L/min
- \( \text{PaO}_2 < 55 \text{ mm Hg on supplemental O2} \)
- \( \text{PaCO}_2 > 50 \text{ mm Hg with pH < 7.25} \)
3 simple rules

Rule 1: The indication for intubation and mechanical ventilation is thinking of it.

Rule 2: Intubation is not an act of weakness.

Rule 3: Endotracheal tubes are not a disease, and ventilators are not an addiction.
When in doubt
ALI and ARDS

- Caused by direct and indirect lung injury
  - Direct: pneumonia, contusion, aspiration
  - Indirect: sepsis, shock, massive transfusion
- 150,000 patients per year in the US
- Mortality approaches 50%
- $5 billion in direct healthcare expenditures in the US
Lung-Protective Ventilation

• Landmark study by The ARDS Network: NEJM 2000; 342(18):1301-1308
• 861 patients with ALI/ARDS
  – Traditional ventilation: 12 ml/kg, plateau ≤ 50
  – Low $V_T$ ventilation: 6 ml/kg, plateau ≤ 30
• Mortality reduced by 22% in lower tidal volume group (39.8% vs. 31%)
• Greater ventilator-free days with lower $V_T$
What about PEEP?

• ARDS Network, NEJM 2004; 351(4): 327-336
• 549 patients on low-$V_T$ strategy
• Compared lower PEEP (8.3±3.2 cm H$_2$O) to higher PEEP (13.2±3.5 cm H$_2$O)
• No difference in mortality, ventilator-free days, ICU-free days, or organ-failure-free days
NIH ARDSNet Ventilator Protocol

• Set Tidal Volume based on IBW (6 ml/kg)
• Goals: SpO$_2$ 88%-95%, PaO$_2$ 55-80, pH 7.30-7.45, Plateau Pressure ≤ 30 cm H$_2$O
• PaO$_2$ takes precedence over SpO$_2$

| FIO$_2$ | .30 | .40 | .40 | .50 | .50 | .60 | .70 | .70 | .70 | .80 | .90 | .90 | .90 | 1.0 | 1.0 |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| PEEP   | 5   | 5   | 8   | 8   | 10  | 10  | 10  | 12  | 14  | 14  | 14  | 16  | 18  | 18  | 20-24 |
Ventilator Weaning: Criteria

- Underlying reason for intubation reversed
- Hemodynamically stable
- Minute ventilation < 20 L/min
- Fluid, electrolyte, and acid-base status appropriate
- FIO2 ≤ 0.50 and PEEP ≤ 8
- Patient without neuromuscular blockade
- Patient is triggering ventilation
Ventilator Weaning: SBT

- Place patient on FIO\textsubscript{2} of 0.50, Pressure Support 5, and PEEP 5
- Can titrate PS up to 10 to keep RR < 28
- Draw ABG after 30-120 minutes
- Consider extubation if SBT successful and:
  - Mental status appropriate
  - Secretions are minimal
  - SVP criteria are met