Introduction to Mechanical Ventilation for COVID-19 Surge Plan

Pulmonary Critical Care Division
March 2020
Objectives

• Review criteria for airway management for COVID-19 at Lifespan
• Review of ARDS and introduction to ARDS physiology
• Describe mechanical ventilation protocol and rationale
Hypoxic Respiratory Failure

• COVID-19 often causes asymptomatic hypoxia
• Patients may acutely deteriorate several days into illness requiring high level oxygen delivery HFNC, NIPPV, MV
• There is exposure in treating COVID-19 patients, especially in performing aerosolizing procedures
  - N95 and eye protection for all aerosolizing procedures
AIRWAY MANAGEMENT FOR ADULT PATIENTS, CONFIRMED COVID-19 POSITIVE AND PUIs

COVID-19+ or PUI screened in the Emergency Department

- Transport using NC O2 is preferred. If additional O2 is needed (> 6L/min), NIV with an expiratory filter can be used provided that there is minimal/no leak around the mask. If NIV is ineffective, consider intubation prior to transport.

Place in negative pressure room (if available)
- If unavailable, place a portable HEPA filter in the room and keep the door closed.

Use supplemental NC O2, up to 6L/min, to maintain O2 sat ≥ 92%

MDI treatments ONLY
- NO nebulized bronchodilators

N95/face shield MUST be worn for the following:
- Intubation, extubation, use of bag mask valve ventilation, NIV, HFNC O2 > 6L/min
  * If a CAPR is available, it may be used as a substitute for N95/face shield.

HFNC O2 can be used. If unable to maintain target O2 sat with 15L/min flow or significant work of breathing, a trial of NIV may be considered, otherwise low threshold to intubate.

Multidisciplinary collaboration for all imminent intubations. Anesthesia will perform ALL intubations. In emergent situations, the next most skilled provider should intubate.

O2 sat < 92%

Exhale masks and face tents will NOT be used post-extubation.

Extubate to NC O2 or HFNC

Increased O2 demand, work of breathing

If unable to maintain target O2 sat with 15L/min HFNC O2 or significant work of breathing, a trial of NIV may be considered, otherwise low threshold to re-intubate.

Extubation

Intubate using RSI

Place patient on a ventilator with a closed filtered circuit

LTV 1200 (PALL filter)
- Trilogy (PALL filter)
- NIV with filtered circuit may be considered.

Essential travel
Airway Management Protocol

**LUNG PROTECTIVE VENTILATION**
- Target SaO2 of 92-96%, PaO2 > 60mmHg
- Goal tidal volume 6 ml/kg ideal body weight
- Plateau Pressure < 30 and Driving pressure (Pplat-PEEP) < 15
  - ARDSnet High PEEP strategy, monitor for barotrauma

**CONSERVATIVE FLUID STRATEGY**
- Avoid maintenance fluids, LR bolus if needed for fluid resuscitation
- Diuresis as hemodynamics and creatinine tolerate
- Hgb transfusion goal of 6 to 6.5, depending on comorbidities

**PARALYTICS**
- Trial of bolus NMBA, but continuous NMBA recommended if significant vent dyssynchrony, proning, high plateau pressures, or need for continuous deep sedation

**PRONE POSITIONING**
- Suggested for moderate to severe ARDS with hypoxemia, for a trial of 12-16 hours

**INHALED THERAPIES**
- Consider trial of inhaled epoprostenol if not meeting oxygenation goals, wean off if ineffective. Do not trial inhaled nitric oxide

**ECLS Consult**
When failing above therapies, at discretion of MICU attending

**Ventilator Liberation**
When passing SAT/SBT and can be extubated to ≤ 6 LPM NC

- We recommend using a pressure control mode
- Pressure control is
  - Cycled by time (inspiration switches to expiration based on time)
  - Pressure targeted (reach a pressure limit and breath held there until cycled to expiration)
Most Vent Screens

<table>
<thead>
<tr>
<th>Mode</th>
<th>What you set</th>
<th>What patient determines</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>Fio2, RR, PS or delta PEEP</td>
<td>TV, RR, MVE</td>
</tr>
<tr>
<td>RR</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>I: E</td>
<td>1:3</td>
<td></td>
</tr>
<tr>
<td>MVE</td>
<td>8.0</td>
<td></td>
</tr>
<tr>
<td>TV</td>
<td>600</td>
<td></td>
</tr>
</tbody>
</table>

- **P peak**: 35
- **Flow wave**: PS, PEEP
- **Pressure wave**: PS, PEEP
- **Volume wave**: PS, PEEP

**Parameters**:
- **PC FiO2**: 60
- **PEEP**: 5
- **RR**: 15
- **PS**: 30
Airway Management Protocol

• What determines oxygenation?
  - FiO2
  - PEEP, mean airway pressure

• What determines CO2?
  - minute ventilation which depends on TV and RR
  - on PCV TV determined by the driving pressure
### Table 3. The Berlin Definition of Acute Respiratory Distress Syndrome

<table>
<thead>
<tr>
<th>Timing</th>
<th>Within 1 week of a known clinical insult or new or worsening respiratory symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chest imaging^a</td>
<td>Bilateral opacities—not fully explained by effusions, lobar/lung collapse, or nodules</td>
</tr>
<tr>
<td>Origin of edema</td>
<td>Respiratory failure not fully explained by cardiac failure or fluid overload. Need objective assessment (eg, echocardiography) to exclude hydrostatic edema if no risk factor present</td>
</tr>
<tr>
<td>Oxygenation^b</td>
<td>Mild: $200 \text{ mm Hg} &lt; \text{PaO}_2/\text{FiO}_2 \leq 300 \text{ mm Hg}$ with PEEP or CPAP $\geq 5 \text{ cm H}_2\text{O}$</td>
</tr>
<tr>
<td></td>
<td>Moderate: $100 \text{ mm Hg} &lt; \text{PaO}_2/\text{FiO}_2 \leq 200 \text{ mm Hg}$ with PEEP $\geq 5 \text{ cm H}_2\text{O}$</td>
</tr>
<tr>
<td></td>
<td>Severe: $\text{PaO}_2/\text{FiO}_2 \leq 100 \text{ mm Hg}$ with PEEP $\geq 5 \text{ cm H}_2\text{O}$</td>
</tr>
</tbody>
</table>

ARDS
PEEP in ARDS

- The PEEP helps keep the alveolus “open” to allow for more gas diffusion at the alveolar/capillary interface.
Compliance Curve

- Optimal compliance between inflection points (red arrows)
- ARDS normal lung compliance curve is flattened - more pressure required to achieve a certain volume
- More PEEP required for alveolar recruitment and more driving pressure needed to achieve a certain volume.
- Barotrauma and volutrauma can happen at the higher inflection point and atelectrauma below lower inflection.
Management of ARDS in COVID-19

- Lung protective strategy is to minimize ventilator induced lung injury (VILI)
- Goal saturations ≥92%
- Target a driving pressure (delta P or PS) that will achieve a TV of ~6cc/kg of IBW to minimize volutrauma
  - Note, limiting TV and therefore MVE can cause hypercapnia. We allow permissive hypercapnia if pH>7.15
- Attempt to keep plateau pressures <30cmH20 and driving pressure <15cm H20 to achieve this volume to minimize barotrauma
- Use the ARDSnet *high PEEP* strategy to titrate PEEP to achieve oxygenation goals; note that COVID-19 patients have been found to be *very PEEP* responsive

<table>
<thead>
<tr>
<th>Higher PEEP/low FiO2</th>
<th>0.3</th>
<th>0.3</th>
<th>0.3</th>
<th>0.3</th>
<th>0.3</th>
<th>0.4</th>
<th>0.4</th>
<th>0.5</th>
</tr>
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<tbody>
<tr>
<td>FiO2</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>PEEP</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
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<table>
<thead>
<tr>
<th>FiO2</th>
<th>0.5</th>
<th>0.5-0.8</th>
<th>0.8</th>
<th>0.9</th>
<th>1.0</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEEP</td>
<td>18</td>
<td>20</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>24</td>
</tr>
</tbody>
</table>
Recruitment Maneuver

- Consider *early recruitment*
- Leave PEEP at least 2cmH2O higher than where you began
- Watch for hypotension (decreased venous return)
- Allows for increased alveolar recruitment
- No proven mortality benefit in ARDS

- Oxygenation is ~ to AUC
- Done with your RT
- Hold PEEP to 30 or 40 for 30 or 40s
  - ("30x30" or "40x40")
Paralytics and Proning

- Trial of bolus paralytics and continuous infusion if necessary for vent dyssynchrony, proning, high Pplat
- Supine ventilation causes atelectasis and intrapulmonary shunting in gravity dependent areas
- Proning:
  - Opens compressed lung in dorsum
  - Offsets compression of alveoli from heart
  - Mobilizes secretions
  - Reduces VILI by decreasing volutrauma

Consider proning if FiO2 > 0.6 needed to maintain saturation > 92%.
- There is some experience to support proning “awake” COVID patients who are not yet on invasive mechanical ventilation

Guerin, NEJM 2013; 368(23)
Rev Bras Ter Intensiva. 2017 Apr-Jun; 29(2)
Prone Ventilation

- Blood flow remains high in dorsum so V/Q mismatch improved due to improved ventilation of dorsal spaces
- Prone patients for at least 16 hours and place back in supine for rest of 24 hour cycle, repeat
- COVID patients are responsive to proning. *There will be a “proning team” at RIH consisting of MICU team with appropriate PPE to safely prone patients throughout RIH.*

Inhaled Epoprostenol and ECLS

- Inhaled epoprostenol helps to vasodilate pulmonary vasculature
  - to improve V/Q mismatch by offsetting any reflexive hypoxic vasoconstriction
  - there is an inhaled epoprostenol protocol (pharmacy, RT)

- If the above measures don’t improve oxygenation or pH is low despite liberalizing TV, consider ECLS

- **Initiating ECLS**
  Requires ECMO/MICU Attending consult
  COVID19 ECLS Patients will be cared for in the MICU
  For reference ECLS criteria are listed on the next slide
ECLS Criteria

• Absence of life-limiting comorbidity, including chronic cardiac or respiratory condition, active or recent malignancy, chronic liver disease, chronic kidney disease requiring hemodialysis, as assessed by the MICU/ECMO attending on call
• No prior cardiac arrest/CPR for > 30 minutes
• Normal neurologic exam, imaging (if available) and date last available
• If significant shock as assessed by the MICU/ECMO attending on call, transthoracic echocardiogram excluding poor cardiac function
• Absence of morbid obesity (BMI < 40)
• Absence of multisystem organ failure and/or moribund status as assessed by the MICU/ECMO attending on call
• Mechanical ventilation duration between 72 hrs and 7 days

Refractory respiratory failure as defined:

• PaO₂/FiO₂ < 50, FiO₂ ≥ 0.8, > 3 hrs despite low tidal volume ventilation for > 6 hrs OR
• PaO₂/FiO₂ < 80, FiO₂ ≥ 0.8, > 6 hrs despite low tidal volume ventilation OR
• pH < 7.25 with a PaCO₂ ≥ 60, > 6 hrs despite RR 35, Pplat < 33

• AND
• PEEP > 10
• Trial of neuromuscular blockade
• Failed trial or contraindication to proning OR failed trial of pulmonary vasodilator (iNO, epoprostenol)
Extubation

- Centers in NY reporting it is taking several days to wean
- **Switch to high level PSV (maintaining high PEEP strategy as oxygenation improves and FiO2 is weaned)**
- Requires an SAT and an SBT
- Ask RN to hold sedation before the RT performs an SBT
- Usually an SBT can be done on PSV mode with low settings such as PS of 5, PEEP of 5
- No accurate and accepted criteria for extubation but patient should:
  - Not be tachypneic
  - Maintain good TV on low settings
  - Saturation > 92% on <50% Fio2
  - Not be tachycardic/ have any arrhythmias
  - Ideally have a good cough reflex/manageable secretion burden
  - adequate muscle strength

- For COVID-19 patients, **extubate only if you think they will require nasal cannula supplementation alone**
- If the patient is unable to be extubated and it’s approaching 2 weeks, consider tracheostomy
- Note, anecdotal reports around the country say there have been cases of cardiac arrest after extubation
Conclusion

• “The ventilator is a means of support, and not a cure for any condition” – William Owens
Abbreviations

• ARDS= acute respiratory distress syndrome
• HFNC= high flow nasal cannula
• NIPPV= non invasive positive pressure ventilation
• MV= mechanical ventilation
• PPE = personal protective equipment
• PCV= pressure control ventilation
• CAPR= Controlled Air Purifying Respirator
• Pplat= plateau pressure
• Fio2 = fraction of inspired oxygen
• RR = respiratory rate
• PEEP = positive end expiratory pressure
• MVE= minute ventilation
• PS= pressure support = delta = driving pressure = pressure above PEEP
• SAT = spontaneous awakening trial
• SBT= spontaneous breathing trial
• TV= tidal volume