Physiologic challenges in COVID-19 airway management

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Objectives

• Review physiologic challenges in critically ill airway management
  – Hypoxemia
  – Hemodynamics

• Discuss how these physiologic challenges apply to COVID-19
Physiologic Challenges in Critically Ill Airway Management
ICU Intubations are Complicated

OR Intubation
Severe Complication Rate

ICU Intubation
Severe Complication Rate

Severe Complications = cardiac arrest, death, new SBP <65, new hypoxemia <80%

Mort, TC, et al. J of Cli Anes, 2004
Cook TM, et al. BJA, 2011
De Jong et al., Crit Care Med 2018
Heffner et al. Resuscitation 2013
Proportion of ≥ 1 Complication by Number of Attempts

Hypes et al. Intern Emerg Med 2017
Many factors that contribute to difficulty:

- Emergent, limited airway assessment
- Cardiopulmonary disease
- Hemodynamic instability
- Hypoxemia
- Full stomach
- Diverse clinical considerations
  - Increased ICP, myocardial ischemia
  - Obesity
- COVID-19
Physiologic challenges

<table>
<thead>
<tr>
<th>Factors</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hypoxemia / shunt physiology</strong></td>
<td>Rapid desaturation during intubation, which may result in hemodynamic instability, hypoxic brain injury and cardiopulmonary arrest</td>
</tr>
<tr>
<td><strong>Hypotension</strong> (shock index &gt; 0.8 predicts post-intubation hypotension)</td>
<td>Cardiopulmonary arrest (induction, positive pressure ventilation, loss of systemic vascular resistance, hypovolemia)</td>
</tr>
<tr>
<td><strong>Severe metabolic acidosis</strong></td>
<td>Brief apneic period can lead to precipitous drop in pH given loss of already inadequate respiratory compensation and hemodynamic deterioration</td>
</tr>
<tr>
<td><strong>Right ventricular failure</strong> (worsened by any process that increases RV afterload)</td>
<td>RV dilation, retrograde flow, decreased coronary perfusion, hypotension, CV collapse, extremely sensitive to intrathoracic pressure changes and worsened with positive pressure</td>
</tr>
</tbody>
</table>

Preoxygenation Goals

- Increase oxygen reservoir in FRC
- Denitrogenation
- Ultimately increase safe apnea time
<table>
<thead>
<tr>
<th>Gas</th>
<th>Percent of total composition</th>
<th>Partial pressure (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen (N₂)</td>
<td>74.9</td>
<td>569</td>
</tr>
<tr>
<td>Oxygen (O₂)</td>
<td>13.7</td>
<td>104</td>
</tr>
<tr>
<td>Water (H₂O)</td>
<td>6.2</td>
<td>40</td>
</tr>
<tr>
<td>Carbon dioxide (CO₂)</td>
<td>5.2</td>
<td>47</td>
</tr>
<tr>
<td><strong>Total composition/total alveolar pressure</strong></td>
<td><strong>100%</strong></td>
<td><strong>760.0</strong></td>
</tr>
</tbody>
</table>

**Diagram C**

- Healthy
- Obese

Legend:
- FRC
- RV
- ERV
- TLC
- IC
- VC

Source:
- Peters et al. CHEST 2018
- Biga et al. Anatomy and Physiology
Pre-Oxygenation in the Critically Ill

- Less time for intubation attempts

Mort TC. Crit Care Med 2005; 33:2672
SAFE APNEA TIME

\[
\text{SAFE APNEA TIME} = \left( \frac{F_{A\text{O}_2_{\text{End preoxygenation}}} - F_{A\text{O}_2_{\text{O}_2 \text{ saturation of 90\%}}}}{V\dot{O}_2} \right) \times \text{FRC}
\]

\[
= \left( \frac{F_{A\text{O}_2_{\text{End preoxygenation}}} - F_{A\text{O}_2_{\text{O}_2 \text{ saturation of 90\%}}}}{V\dot{O}_2} \right) \times \text{FRC} \times %\text{shunt}
\]
Hemodynamics

- Post intubation hypotension occurs in about \( \frac{1}{2} \) ICU intubations
- Cardiac arrest complicated about 4% of intubations
  - PEA most common presenting rhythm
  - 2/3 occurred within 10 minutes of pushing RSI drugs
- Increased odds of in hospital arrest (OR 14.8)

De Jong. CCM 2018
Heffner. Resuscitation 2013
Shock Index

Shock Index = HR / SBP : Should be < 0.8

>= 0.9  Higher hospital mortality (Trivedi 2015)

>= 1   Predicted post intubation arrest (Wardi 2017)

Other outcome data, esp post intubation hypotension:
Smischney. J Crit Care 2018
Smischney. JICM 2017

Courtesy of Viren Kaul, MD
HYpotension Prediction Score (HYPS) and (s)table HYpotension prediction score [(s)HYPS] and risk categorization

• Variables:
  – APACHE II score
  – Age, years
  – Sepsis diagnosis
  – Intubation setting (resp failure, MAP<65, cardiac arrest)
  – Diuretics in prior 24 hours
  – Catecholamine 60 minutes prior to intubation
  – Phenylephrine 60 minutes prior to intubation
  – Systolic blood pressure (mmHg)
  – Etomidate used for intubation

Smischney et al. PLoS ONE. 2020
<table>
<thead>
<tr>
<th>Risk Score</th>
<th>Expected Risk</th>
<th>N</th>
<th># (%)</th>
<th>OR</th>
<th>(95% C.I.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HYPS-score (Full Cohort)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 1.5</td>
<td>Low (≤ 19%)</td>
<td>101</td>
<td>12 (12%)</td>
<td>1.0</td>
<td>Reference</td>
</tr>
<tr>
<td>2 to 10.5</td>
<td>Moderate (20–39%)</td>
<td>526</td>
<td>140 (27%)</td>
<td>2.7</td>
<td>(1.4, 5.1)</td>
</tr>
<tr>
<td>11 to 18.5</td>
<td>High (40–59%)</td>
<td>211</td>
<td>123 (58%)</td>
<td>10.4</td>
<td>(5.3, 20.1)</td>
</tr>
<tr>
<td>≥ 19</td>
<td>Very High (≥ 60%)</td>
<td>96</td>
<td>69 (72%)</td>
<td>19.0</td>
<td>(9.0, 40.1)</td>
</tr>
<tr>
<td>(s) HYPS-score (Stable cohort)†</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤ 1</td>
<td>Low (≤ 19%)</td>
<td>81</td>
<td>9 (11%)</td>
<td>1.0</td>
<td>Reference</td>
</tr>
<tr>
<td>1.5 to 11.5</td>
<td>Moderate (20–39%)</td>
<td>579</td>
<td>161 (28%)</td>
<td>3.1</td>
<td>(1.5, 6.3)</td>
</tr>
<tr>
<td>≥ 12</td>
<td>High (≥ 40%)</td>
<td>69</td>
<td>46 (67%)</td>
<td>16.0</td>
<td>(6.8, 37.6)</td>
</tr>
</tbody>
</table>
Effect of a fluid bolus on cardiovascular collapse among critically ill adults undergoing tracheal intubation (PrePARE): a randomised controlled trial

David R Janz, Jonathan D Casey, Matthew W Semler, Derek W Russell, James Dargin, Derek J Vonderhaar, Kevin M Dischert, Jason R West, Susan Stempek, Joanne Wozniak, Nicholas Caputo, Brent E Heideman, Aline N Zouk, Swati Gulati, William S Stigler, Itay Bentov, Aaron M Joffe, Todd W Rice, for the PrePARE Investigators* and the Pragmatic Critical Care Research Group

![Bar chart showing cardiovascular collapse rates in fluid bolus vs no fluid bolus groups.](image)

*Figures 2: Cardiovascular collapse in the fluid bolus vs no fluid bolus groups. Horizontal bars represent the overall incidence of the primary outcome in each group. The p value represents the test for a difference between groups in the overall incidence of the primary outcome. Number (%) of patients is given above each bar. SBP = systolic blood pressure.*
**Preoxygenation**

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
<th>Refractory</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical Patient is intubated for airway protection without any airspace disease.</strong></td>
<td><strong>Typical Patient is intubated for respiratory failure in the presence of recruitable disease and minimal–moderate shunt.</strong></td>
<td><strong>Typical Patient is intubated for severe ARDS and refractory hypoxemia. PaO2 does not increase despite optimal preoxygenation.</strong></td>
</tr>
<tr>
<td><strong>Recommendations:</strong></td>
<td><strong>Recommendations:</strong></td>
<td><strong>Recommendations:</strong></td>
</tr>
</tbody>
</table>
| 1. Flush flow oxygen  
2. Upright positioning  
3. Apneic oxygenation  
4. Mask ventilation between induction and laryngoscopy | 1. NIPPV preoxygenation  
2. HFNO preoxygenation and apneic oxygenation  
2. Upright positioning  
3. Apneic oxygenation  
4. Mask ventilation between induction and laryngoscopy | 1. Maintain spontaneous respiration  
2. HFNO  
2. Upright positioning  
3. Consider inhaled vasodilators to improve ventilation:perfusion |

**Hemodynamics**

<table>
<thead>
<tr>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Typical Patient is normotensive with a normal or elevated shock index.</strong></td>
<td><strong>Typical Patient is hypotensive with elevated shock index.</strong></td>
</tr>
<tr>
<td><strong>Recommendations:</strong></td>
<td><strong>Recommendations:</strong></td>
</tr>
</tbody>
</table>
| 1. Fluid bolus if likely to be volume responsive  
2. Push-dose or continuous vasopressors immediately available | 1. Fluid resuscitation if likely to be volume responsive  
2. Inline continuous vasopressor  
3. Consider point-of-care ultrasound  
4. Hemodynamically neutral sedative agent (consider a reduced dose) |

**Risk of Decompensation**

**Figure 2.** Recommendations for reducing the risk of desaturation and cardiovascular collapse depending on preintubation risk. Future research is needed to characterize patients’ risk on the basis of preintubation hemodynamics and gas exchange and evaluate the interventions within each risk category. ARDS = acute respiratory distress syndrome; HFNO = high-flow nasal oxygen; NIPPV = noninvasive positive pressure ventilation; RV = right ventricle.
**TABLE 1**  Key considerations for airway management outside of a negative pressure room

<table>
<thead>
<tr>
<th>Airway management step</th>
<th>Recommendationa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oxygenation</td>
<td>Avoid high-flow pre-oxygenation. Use NIPPV with a tight-fitted mask for escalating preoxygenation. Avoid nasal cannula for apneic oxygenation.</td>
</tr>
<tr>
<td>Intubation</td>
<td>Avoid “closely intubating” with direct laryngoscopy. Use VL for indirect tracheal tube placement. Use RSI with the highest recommended dose of an NMBA.</td>
</tr>
<tr>
<td>Rescue techniques</td>
<td>SGA placement attached to closed ventilator circuit for rescue oxygenation in lieu of manual bagging. Use HEPA filters whenever PPV is performed.</td>
</tr>
<tr>
<td>Personal protective equipment</td>
<td>PAPR use preferred over N95, if available consider plastic face tent or hood.</td>
</tr>
</tbody>
</table>

Avoid aerosol-generating procedures, including high-flow nasal oxygen, non-invasive ventilation, bronchoscopy and tracheal suction without an in-line suction system in place.
Take Home Points

• Intubation of critically ill patients is high risk
• Key physiologic challenges include hypoxemia and hypotension, both of which can increase risk for cardiac arrest
• Preoxygenation is key to increase safe apnea time, which is dependent on size of FRC, denitrogenation of that FRC and oxygen consumption
• Adhere to core preexisting airway management principles with strict adherence to appropriate PPE in COVID-19 era