Optimizing mechanical ventilation for COVID-19
Before thinking ECMO

Ehab Daoud MD, FACP, FCCP
Associate professor of medicine, University of Hawaii
To watch the lecture

copy and paste the link below in your browser

https://na01.safelinks.protection.outlook.com/?url=https%3A%2F%2Fdrive.google.com%2Ffile%2Fd%2F1WfNgys1kjcJW63yRAJY0cRqXqTZItHq6C%2Fview%3Fusp%3Dsharing&data=04%7C01%7C%7C263f485a21d74442045108d8aaca6499k7C84df9e7fe9f640fba435aaaaaaaaaaaa%7C1%7C0%7C637447133525636378%7CUnknown%7CTWFpbGZsb3d8eyJWIjoiMC4wLjAwMDAiLCJQIjoiV2luMzIiLCJBTiI6Ik1haWwiLCJXVCI6Mn0%3D%7C1000&sdata=lvLBdm3LZ6kXhA7uW2brt0YcjHaCHpq1Vm%2F2JAdzZB%3D&reserved=0
Objectives

- Review of Pathology
- Invasive mechanical ventilation for COVID-19
- Optimizing ventilatory support
- ECMO
COVID-19 Pathology

- Diffuse Alveolar Damage (DAD)
- Pulmonary vascular damage with macro/micro thrombosis

COVID-19 ARDS similar to the non COVID-19 ARDS ?????

- Different phenotypes: L & H?
- Higher respiratory compliance?
- Similar ARDS?


When to initiate Mechanical Ventilation

Early in course?

After failing HFNC/NIPPV

Clinically

O₂ saturation

As always, we should only intubate when necessary, but we must not leave it too late. Therefore, critical care needs highly trained, experienced clinicians involved in bedside care. It is also why we need more research.
When to initiate Mechanical Ventilation

Timing of invasive mechanic ventilation in critically ill patients with coronavirus disease 2019

Conclusion: Early initial intubation after NIV/HFNC might have a beneficial effect in reducing mortality for critically ill patients meeting IMV indication. Considering APACHE II and PSI scores might help physicians in decision making about timing of intubation for curbing subsequent mortality.


Timing of Intubation and Mortality Among Critically Ill Coronavirus Disease 2019 Patients: A Single-Center Cohort Study

Conclusions: In this cohort of critically ill patients with coronavirus disease 2019, neither time from ICU admission to intubation nor high-flow nasal cannula use were associated with increased mortality. This study provides evidence that coronavirus disease 2019 respiratory failure can be managed similarly to hypoxic respiratory failure of other etiologies. (Crit Care Med 2020; XX:00–00)

Invasive mechanical ventilation for COVID-19
Strategies

• Same strategy as non COVID-19 given the lack of understanding of how the pathology really differ

• Every mechanical ventilation strategy should be **INDIVIDUALIZED** to the patient not one-size-fit all strategy

• Avoid VILI, appropriate PEEP, lowest driving pressure, tidal volume

• Be patient: tolerate some hypoxia and hypercapnia and acidimia
Optimizing Mechanical Ventilation

**Ventilatory strategies**
- Optimal PEEP
  - Pressure-Volume curve
  - Trans-Pulmonary pressure
  - Electrical Impedance Tomography (EIT)
- APRV

**Non Ventilatory strategies**
- Prone Position
- Inhaled Pulmonary Vasodilators
- Steroids
Pressure-Volume curve (Best Compliance)

- Lower Inflection point (LIP)
- Point of Maximal Curvature (PMC)
- Hysteresis
Esophageal Balloon Manometry

- Measuring Trans-Pulmonary pressure to set Inspiratory pressure and PEEP
- Assess WOB during spontaneous breathing
- Aid in diagnosing Patient-Ventilator dys-synchrony
- Aid in assessing recruitability during recruitment maneuver
- Measuring Chest wall and lung elastance separately
- Aid in weaning off mechanical ventilation
- Transmural vascular pressure (i.e. the difference between intravascular and extramural pressure reflected by Pes)
Esophageal Balloon Manometry

- A physiologically based ventilator strategy should take the trans-pulmonary pressure into account

- Despite all those benefits, this tool remains confined to research

- Used in less than 1% of ARDS patients

Esophageal Balloon Manometry Beneficial?

**CONCLUSIONS**

As compared with the current standard of care, a ventilator strategy using esophageal pressures to estimate the transpulmonary pressure significantly improves oxygenation and compliance. Multicenter clinical trials are needed to determine whether this approach should be widely adopted. (ClinicalTrials.gov number, NCT00127491.)

**Effect of Titrating Positive End-Expiratory Pressure (PEEP) With an Esophageal Pressure-Guided Strategy vs an Empirical High PEEP-Fio2 Strategy on Death and Days Free From Mechanical Ventilation Among Patients With Acute Respiratory Distress Syndrome: A Randomized Clinical Trial**

**Conclusions and Relevance** Among patients with moderate to severe ARDS, PEEPG-guided PEEP, compared with empirical high PEEP-Fio2, resulted in no significant difference in death and days free from mechanical ventilation. These findings do not support Pees-guided PEEP titration in ARDS.


Trans-Pulmonary Pressure (PTP)

PTP = Palv – Ppl.

• Is the distending pressure of the alveoli

End Inspiratory P<sub>TP</sub>
Too high during inhalation: rupture (stress)

End Expiratory P<sub>TP</sub>
• Too low during exhalation: collapse (strain)
Trans-Pulmonary Measurement

Goal is to keep Inspiratory PL < 15-20 cmH₂O, to avoid lung stress (over distension, i.e. volu-trauma and barotrauma) i.e. Stress.

Goal to keep Expiratory PL > 0 (0-5) cmH₂O to avoid lung strain (repeated opening and closing of alveoli, i.e. atelectrauma) i.e. Strain.
Trans-Pulmonary Measurement

Electrical Impedance Tomography

Noninvasive, bedside monitoring technique that provides semicontinuous, real-time information about the regional distribution of changes in the electrical resistivity of lung tissue due to variations in ventilation.

APRV (Airway Pressure Release Ventilation)

- APRV was described more than 30 years ago (1987) by Stock and Downs as CPAP with intermittent release phase.
- APRV is classified as pressure controlled intermittent mandatory ventilation, and is typically applied using inverse inspiratory I:E ratios.
- There are both mandatory breaths (i.e. time-triggered and time-cycled), as well as spontaneous breaths (i.e. patient triggered and patient-cycled).
- Spontaneous breaths can occur both during and between mandatory breaths.

APRV setting

- P High: mandatory inspiratory pressure (Driving pressure)
- P Low: expiratory pressure (PEEP)
- T High: mandatory inspiratory time (I time)
- T Low: expiratory time
- Release rate: mandatory respiratory rate
APRV + Esophageal balloon

Prone Position
Prone Position Mechanisms

- Alteration of distribution of ventilation
- Redistribution of blood flow
- Improved matching of Ventilation & Perfusion (V/Q)
- Improved homogeneity of lung units
- Decreased alveolar Stress and Strain
- Recruitment maneuver
- Decrease VILI
- Relief of Left lower lung compression by the heart
- Relief dorsal lung compression by abdominal organs
- Enhanced secretion clearance
- Improved RV output and Pulmonary pressures
Improved mortality in ARDS


Prone position in ARDS 2ry to COVID-19

- Improves oxygenation
- Possible improved mortality
- Improves oxygenation and might prevent invasive mechanical ventilation in non intubated patients
- 75-80% of patients with COVID-19
Role of Perfusion

Abstract

There have been confusion and contradiction on how to best manage patients with acute respiratory failure secondary to Corona virus disease-2019 (COVID-19). Recent report suggested two different phenotypes of patho-physiology (type L and type H). Type L is characterized by low elastance and low ventilation-perfusion mismatch ratio (V/Q), while type H is more consistent with the classic acute respiratory distress syndrome (ARDS) characterized by high elastance, and increased right to left shunt. The role of perfusion deficits has been clearer with the discovery of micro and macro vascular thrombi in the lung vascular endothelium. Prone position has gained interest in research and guidelines as a maneuver capable of improving ventilation and perfusion. Airway pressure release ventilation (APRV) can theoretically improve hypoxemia due to ventilation/perfusion mismatch in patients with COVID-19 compared to other conventional strategies. From this perspective, we may have to consider perfusion as the major problem in the disease process more than just ventilation.

More studies are required to explore the role of perfusion and the different ventilatory strategies to best manage those patients.

Key Words: airway pressure release ventilation; APRV; prone position; COVID-19; SARS-CoV-2.

Inhaled Pulmonary Vasodilators

Fig. 1. Effects of systemic vasodilation (from intravenous, taneous, or oral administration) versus selective pulmonary dilation (from inhalation). Systemic vasodilation affects all beds, thereby decreasing mean arterial blood pressure and improving oxygenation by increasing blood flow to poorly ventilated alveoli, secondary to reversal of hypoxic pulmonary vasoconstriction. Inhaled vasodilators selectively dilate pulmonary vasculature adjacent to alveoli that are well ventilated, thus reducing pulmonary arterial pressure while improving ventilation-perfusion matching and oxygenation. However, spillover of long-acting drug into poorly ventilated alveoli and into the systemic circulation can worsen shunt fraction and systemic blood pressure. V = ventilation, HPV = hypoxic pulmonary vasoconstriction. (Adapted from Reference 1.)
Inhaled Vasodilators
Inhaled Pulmonary Vasodilators: do they work?

Makes sense but controversial

| No: Critical Care Explorations: October 2020 - Volume 2 - Issue 10 - p e0259 |
| No: BJA October 14, 2020 |
| Yes (50%): Journal of Intensive Care Medicine 2020 November 25 |
ECMO

- WHEN to start? when everything fails: PEEP, Recruitment, Prone, NMB, Pulmonary Vasodilators
- WHO gets it: unclear
- Mortality: unclear but NO
- For how long? Unclear
- Cost: 73,000 USD, for 14 days
- Side effects
- Ethics
### ECMO Indications & Contraindications

**Table 1** Proposed indications and contraindications to ECMO for ARDS

<table>
<thead>
<tr>
<th>Indications</th>
<th>Relative contraindications</th>
<th>Absolute contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>EOLIA entry criteriaa</td>
<td>Invasive mechanical ventilation for more than 7–10 days</td>
<td>Moribund state with established multiple organ failure</td>
</tr>
<tr>
<td>$\text{PaO}_2/\text{FiO}_2 &lt; 50 \text{ mmHg for &gt; 3 h}$</td>
<td>Contraindication to anticoagulation</td>
<td>Prolonged cardiac arrest</td>
</tr>
<tr>
<td>$\text{PaO}_2/\text{FiO}_2 &lt; 80 \text{ mmHg for &gt; 6 h}$</td>
<td>Severe coagulopathy</td>
<td>Severe anoxic brain injury</td>
</tr>
<tr>
<td>$\text{pH} &lt; 7.25$ with a $\text{PaCO}_2 \geq 60 \text{ mmHg for &gt; 6 h}$</td>
<td>Advanced age</td>
<td>Massive intracranial hemorrhage</td>
</tr>
<tr>
<td></td>
<td>Salvage ECMO (referred to as “rescue” in EOLIA) i.e., employing ECMO when severe right heart failure, or other severe decompensation occurs</td>
<td>Severe chronic respiratory failure with no possibility of lung transplantation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Metastatic malignancy or hematological disease with poor short-term prognosis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other advanced comorbidities with poor short-term prognosis</td>
</tr>
</tbody>
</table>

Weaning ECMO

MV during ECMO
- **VCV mode:** FiO₂: 0.3-0.5; PEEP ≥ 10 cmH₂O; VT lowered to obtain a P₅₋₁ ≤ 24 cmH₂O; RR 10-20/min
- **BIPAP/APRV:** FiO₂: 0.3-0.5; P₅₋₁ ≤ 24 cmH₂O; Pₖₓ ≥ 10 cmH₂O; RR 10-20/min

The pump outflow and FiO₂ adjusted for 65% PaO₂ ≥ 90 mm Hg or SaO₂ ≥ 90%. Sweep gas flow to get PaCO₂ ≤ 45 mm Hg.

Check Daily
- FiO₂ ≤ 60% and Sweep gas flow < 8 L/min and
- In VCV: VT ≥ 4.5 mL/kg PBW obtained with P₅₋₁ ≤ 24 cmH₂O or
- In BIPAP/APRV: VT ≥ 4.5 mL/kg PBW obtained with a driving pressure ≤ 14 cmH₂O

Prerequisites for ECMO weaning trial
- VT 6 mL/kg PBW; RR ≤ 28/min; PEEP 6-14 cmH₂O; FiO₂ ≤ 60%

- Resulting P₅₋₁ ≤ 28 cmH₂O?

ECMO weaning trial
- Turn off the sweep gas flow
- Maintain ECMO flow > 3 L/min

- SpO₂ ≥ 90% with FiO₂ ≤ 60%?

Withdrawal of ECMO

After 1 to 12-hour weaning trial:
- PaO₂ ≥ 60 mmHg, SaO₂ ≥ 90%, with FiO₂ ≤ 60%
- PCO₂ ≤ 50 mmHg or pH ≥ 7.36, with RR ≤ 28/min
- Pₖₓ ≤ 28 cmH₂O

and if no signs of acute cor pulmonale

Withdraw ECMO
Mortality in COVID-19

• >90%: early case studies and small cohorts


Thank You