Products are shown for demonstration purposes only. The American Heart Association does not endorse or recommend any specific manufacturer or product.

To show skills clearly, the healthcare providers shown do not always use recommended personal protective equipment (such as gloves, masks, face shields).
GAP: Escalation to invasive ventilation

- **G: Gas exchange abnormality**
  - COVID-19 respiratory failure is usually hypoxemic, not hypercarbic
  - Worsening oxygenation: \( \text{PaO}_2/\text{FiO}_2 \) or \( \text{SpO}_2/\text{FiO}_2 < 150 \)
  - NIV with \( \text{FiO}_2 > 0.6 \) and can’t maintain \( \text{SpO}_2 > 90\% \)
  - Oxygenation unresponsive to HFNC therapy
  - Hypercapnia with acidosis, pH < 7.3
  - Increased work of breathing suggests deterioration of respiratory function

- **A: Airway protection**
  - Altered mental status attributed to respiratory failure
  - Neurological dysfunction

- **P: Pulmonary toilet**
  - Increased airway secretions
Initial settings

- Ventilator settings: Lung protective ventilation
  - Initial mode of ventilation: Assist control PRVC
  - Tidal volume: 6 mL/kg PBW (calculate this from height and gender)
    - Male patients: $50 + 2.3 \times (\text{height (inches)} - 60)$
    - Female patients: $45.5 + 2.3 \times (\text{height (inches)} - 60)$
  - PEEP 10 cm H$_2$O: Monitor hemodynamics with increasing PEEP
  - Respiratory rate: 20–25
    - Consider patients’ preintubation respiratory rate
- Goal: Limit overdistention of alveoli and ensure adequate oxygenation and ventilation. Overdistention causes inflammation, organ dysfunction, decreased venous return, and worsens ARDS.
Maintenance: Goals of therapy

**Oxygenation**
- \( \text{PaO}_2 > 60 / \text{SpO}_2 \ 88-98\%
- \( \text{FiO}_2 \) to maintain a \( \text{SpO}_2 \) of 88-98%
  - \( \text{FiO}_2 < 0.6 \)
  - Try to avoid 100% oxygen, which favors de-nitrogen atelectasis
  - Lower \( \text{FiO}_2 \) of 0.7-0.9 may not drastically change oxygenation due to high levels of shunt

**Ventilation**
- Tidal volumes of 4-8 mL/kg of PBW
- pH 7.25-7.42
- \( \text{PaCO}_2 \) 40-65 / end-tidal carbon dioxide (ETCO\(_2\)) 35-60 mm Hg

**Pulmonary Mechanics**
- Plateau pressures of \( \leq 30 \) cm H\(_2\)O (reflects respiratory system compliance)
- Peak inspiratory pressure <35 cm H\(_2\)O
Analgosedation

• A1 approach: Analgesia first, then add sedation
• Analgesia (fentanyl, hydromorphone, morphine): Titrate to respiratory rate, Richmond-Agitation Scale (RASS), or pain score
• Sedation (propofol, benzodiazepine, dexmedetomidine): Titrate to RASS
• Medications may need to be adjusted for ventilator synchrony
• All patients who received a neuromuscular blocker must also receive either propofol or a benzodiazepine for amnesia
When to troubleshoot

- Peak airway pressure greater than 35 cm H₂O
  - Evaluate the need for suctioning
  - Check plateau pressure
  - Check placement of ETT (deep?) and cuff pressure (do you hear a leak?)
  - Evaluate for pneumothorax: Chest x-ray, ultrasound

- Plateau pressure >30 cm H₂O
  - Requires an inspiratory hold maneuver
  - Reduce the tidal volume 1 mL/kg (minimum of 4 mL/kg)
  - Consider diuresis
  - Consider paralysis
  - Adjust respiratory rate lower (usually 2-6/min per change) to increase CO₂
When to troubleshoot (cont.)

• FIO₂ >0.6 with SpO₂ <88%
  • Increase PEEP to level indicated on chart: Monitor blood pressure with each PEEP increase
  • Consider positioning of patient (ie, proning)
  • Consider diuresis

• pH <7.25
  • Assess whether acidosis is respiratory or metabolic
  • Adjust respiratory rate higher (usually 2-6/min per change) to lower CO₂ (max 35/min)
    • If you go higher than a respiratory rate of 30, you will need to decrease the inspiratory time to 0.8 to avoid an inverse inspiratory-to-expiratory ratio
    • Monitor for auto-PEEP
  • Evaluate and treat metabolic abnormalities (check anion gap, lactate)

• pH >7.42
  • Adjust respiratory rate lower (usually 2-6/min per change) to increase CO₂
Refractory hypoxemia

• Call for help early
• Consider proning to improve V/Q ratio mismatch
• Assess cardiac function (myocarditis and cardiomyopathy are reported)
• Consider nitric oxide to improve V/Q ratio mismatch
• Consider paralysis
  • Patient must be sedated with a benzodiazepine or propofol; analgesics do not provide amnesia for paralysis
• Consider extracorporeal membrane oxygenation (ECMO)
Call for help

- SpO₂ less than 88% on an FIO₂ of 1.0 for more than 15 minutes despite troubleshooting
- pH less than 7.25 for more than 2 blood gases
- pH less than 7.10
- PaO₂ less than 40
- SpO₂/FIO₂ or PaO₂/FIO₂ ratio of less than 150 for 2 hours
- SpO₂/FIO₂ or PaO₂/FIO₂ ratio of less than 80
- High-priority alarms (red) you cannot resolve within 2 minute
  - Manually ventilate until help arrives
- Low-priority alarms (yellow) you cannot resolve within 15 minutes