Guideline Goal
Provide clinical guidance regarding the diagnosis of refractory hypoxemia (algorithm 1) and a stepwise approach to the treatment of refractory hypoxemia (algorithm 2).

Key Points
- When employing a higher PEEP strategy for refractory hypoxemia, it is recommended to wait at least 2 hours to determine adequacy of clinical response. This interval can be shortened if clinical situation necessitates.
- While a determination regarding the adequacy of clinical response is based on bedside judgment, a PaO$_2$ > 55 mmHg is recommended.
- Prone ventilation for 16 hours/day has demonstrated benefits for patients with Refractory Hypoxemia due to ARDS or other etiologies (Appendix B).
- Patients in prone ventilation require a supine position trial daily for routine care and assessment.

Algorithm 1. Usual Care and Escalation to Consideration for Refractory Hypoxemia Therapies

Suspected ARDS (PF ratio < 300 mmHg)

Tv set at ≤ 6 ml/kg

PaO$_2$ > 55 mmHg or Decreased perfusion

YES

Recommended Interventions:
- IVF
- Pressors

NO

Pplat < 30?

NO

Recommended Interventions:
- Airway clearance
- Reduce Tv by 1 ml/kg
- Evaluate need for sedation

YES

Pplat < 30?

NO

PF ratio > 150 mmHg?

NO

Refractory hypoxemia therapies should be considered

YES

FiO$_2$ > 0.8 & PEEP ≥ 14 (for at least 12 hours)?

NO

- Allow time for alveolar recruitment
- Wean per Appendix A

YES

Refractory hypoxemia therapies should be considered
Algorithm 2. Recommended Escalation of Treatment for Refractory Hypoxemia

Refractory Hypoxemia

Increase PEEP per Appendix A

Success

YES

Continue current therapy

NO

Consider bolus of paralytic

Inhaled epoprostenol can be readily administered and therefore could be considered concurrently with prone or other interventions. No RCT supports primary use of pulmonary vasodilators in favor of lung protective ventilation; however, it can be effective in allowing the time to implement prone or other approaches without added risk.

Success

YES

Consider continuous paralysis

NO

Consider stopping therapy

Continue current therapy

ECMO takes significant time and resources to initiate. Therefore, in patients with refractory hypoxemia who are likely to be non-responsive to other therapies, it is reasonable to initiate CT surgery consultation at any point after refractory hypoxemia is recognized. If ECMO is considered, immediate evaluation is required. Direct physician to physician communication is also required.

Eligible for prone ventilation (Appendix B)

Success

YES

Attempt prone ventilation (Appendix C)

NO

ECMO

OSUWMC ECMO guideline

YES

Consult Cardiothoracic Surgery STAT

NO

Consider APRV (Airway Pressure Release Ventilation) (Appendix D)

Success

YES

Continue therapy

NO

Continue current therapy

Inhaled epoprostenol can be readily administered and therefore could be considered concurrently with prone or other interventions. No RCT supports primary use of pulmonary vasodilators in favor of lung protective ventilation; however, it can be effective in allowing the time to implement prone or other approaches without added risk.

OSUWMC epoprostenol guideline

YES

Continue current therapy
Resources

- OSUWMC Extracorporeal Life Support (ECLS) – Adult Veno-Venous Extracorporeal Membrane Oxygenation (VV-ECMO) guideline
- OSUWMC Epoprostenol (Veletri®) Intravenous Solution for Inhalation
- OSUWMC Continuous Pharmacologic Neuromuscular Blockade of the Critically Ill Patient

References


Quality Measures

- Proportion of patients eligible for prone ventilation receiving a trial of prone ventilation by 24 hours
- Proportion of patients on iNO without prior trial of epoprostenol

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Guideline Approved


Disclaimer: Clinical practice guidelines and algorithms at The Ohio State University Wexner Medical Center (OSUWMC) are standards that are intended to provide general guidance to clinicians. Patient choice and clinician judgment must remain central to the selection of diagnostic tests and therapy. OSUWMC’s guidelines and algorithms are reviewed periodically for consistency with new evidence; however, new developments may not be represented.

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Appendix A. PEEP/FiO₂ Table

<table>
<thead>
<tr>
<th>FiO₂</th>
<th>0.21-0.40</th>
<th>0.40-0.50</th>
<th>0.50-0.70</th>
<th>0.70-1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEEP</td>
<td>6</td>
<td>8</td>
<td>10-12</td>
<td>14-20</td>
</tr>
</tbody>
</table>

Appendix B. Relative and Absolute Contraindications for Selected Refractory Hypoxemia

<table>
<thead>
<tr>
<th>Intervention or Procedure</th>
<th>Relative Contraindications</th>
<th>Absolute Contraindications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prone Ventilation*</td>
<td>• Cardiovascular instability including shock</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Femoral venous or arterial catheter in use</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Intracranial pressure &gt; 30 mmHg or cerebral perfusion pressure &lt; 60 mmHg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Massive hemothysis requiring an immediate surgical or interventional radiology procedure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Tracheal surgery or sternotomy during the previous 15 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Serious facial trauma or facial surgery during the previous 15 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Deep venous thrombosis treated for less than 2 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Cardiac pacemaker inserted in the last 2 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Unstable spine, femur, pelvic or skull fractures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Mean arterial pressure lower than 65 mmHg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Pregnant women</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Single anterior chest tube with air leaks</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sternotomy within the last 30 days</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Burns on more than 20% of the body surface</td>
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<tr>
<td></td>
<td>• Chronic respiratory failure requiring oxygen therapy or non-invasive ventilation (NIV)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• End-of-life decision before inclusion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Intra-aortic balloon pump</td>
<td></td>
</tr>
<tr>
<td>Inhaled Vasodilators</td>
<td>Cardiovascular instability including shock</td>
<td></td>
</tr>
<tr>
<td>ECMO (see OSUWMC Extracorporeal Life Support guideline in reference section for further details)</td>
<td>• Inadequate cardiopulmonary resuscitation o CPR &gt; 5 minutes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Evidence of neurologic insult or compromised neurologic status prior to acute illness/shock</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Intracranial hemorrhage</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• BMI &gt;40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Life expectancy &lt; 1 year before onset of acute respiratory failure</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Primary or idiopathic pulmonary hypertension, end-stage cardiopulmonary disease, and home oxygen requirement and not a transplant candidate.</td>
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</tr>
<tr>
<td></td>
<td>• Neuromuscular blockade infusion &gt; 48 hours</td>
<td></td>
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<tr>
<td></td>
<td>• History of coagulopathy or thrombophilia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Ungrafted severe burns</td>
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<tr>
<td></td>
<td>• Profound metabolic acidosis with pH &lt; 7.1</td>
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<tr>
<td></td>
<td>• Requirement of prolonged high-dose vasoactive drugs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Severe immunocompromised state o ANC &lt;400/mm3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Open neck, chest or abdominal wounds</td>
<td></td>
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<tr>
<td></td>
<td>• Advanced age (&gt;75 years)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Prolonged ventilation for &gt; 7</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Established multi-organ system failure – SOFA Score &gt; 15</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Contraindication to systemic anticoagulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Refusal to receive blood products</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Quadriplegia</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Bone marrow transplant recipients</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• DNR/DNI status o Only relevant in patients who are full code prior to evaluation</td>
<td></td>
</tr>
</tbody>
</table>


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Appendix C. Usual Prone Ventilation Procedures

Figure A. Initial Prone Ventilation Trial, Daily Supine Positioning Trials, and Determining Need for Specialty Bed

- Patient > 200 kg
  - YES: Consider safety of manual prone trial and modify based on need
  - NO: Do not prone patient on a low air mattress.

- Manually prone patient
  - YES: Patient failed prone trial - return patient to supine position
  - NO: Maintain prone position

- Hemodynamic/respiratory instability experienced
  - YES: Patient failed prone trial - return patient to supine position
  - NO: Maintain prone position

- FiO₂ < 1.0 and SpO₂ > 92% or PaO₂ > 70%
  - YES: Perform SPT for up to 6 hours to allow for pt. care/evaluation
    - SPT tolerated? (SpO₂ > 92% ≥6h)
      - YES: Evaluate for discontinuation (page 7, figure C)
      - NO: Return to prone positioning

- Is patient 91-159 kg & 4'6"-6'6"
  - YES: In special situations, consider Rotoprone® bed with a critical care CNS consult
  - NO: Manually prone patient

- In special situations, consider Rotoprone® ordered/deliver, place patient on bed with next SPT

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Appendix C. Usual Prone Ventilation Procedures

Figure B. Daily assessments for prone ventilation need and general care (Daily supine positioning trial)

Prone ventilation in use for at least 16 hours with plans to continue

Is FiO₂ < 1.0 ?

NO → Continue prone ventilation and usual care

YES →

Is SpO₂ > 92% or PaO₂ > 70 ?

NO → Continue prone ventilation and usual care

YES →

Place patient in supine position

SpO₂ > 90% and Clinically stable

NO → Place in prone position and initiate prone ventilation for at least 16 hours

YES →

Tolerates supine position. See Appendix C, Figure C.
Figure C. Terminating Prone Ventilation

Patient placed in **supine** position
(Decision: See Figure B)

- Patient tolerates turn?
  - YES
    - While supine, titrate FiO$_2$ ≤ 0.6
      - PEEP ≤ 10 to maintain SpO$_2$ > 92%
      - Refer to Appendix C, Figure B
  - NO
    - Pt. tolerates
    - YES
      - Consider discontinuing daily **prone** ventilation
    - NO
      - Refer to Appendix C, Figure B

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