Key Aspects of Care:

- Usual measures should be in place for at least long enough to determine adequacy of clinical response. Since a higher PEEP strategy takes several hours to reach its maximal effect, waiting at least 2 hours is recommended. However, if the clinical situation necessitates, the interval of observation can be longer or shorter.

- Determining the adequacy of clinical response is also generally defined clinically by bedside judgment and the overall condition of the patient. However, generally achieving a PaO₂ of at least 55 mmHg is advisable.

- This is considered a guidance document only. Clinical decisions can lead to a determination to immediately escalate therapy in a way that is dictated by patient response. Implementing the algorithm as outlined has the highest likelihood of eliminating refractory hypoxemia most efficiently.

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

Suspected ARDS (PF ratio < 200 mmHg)

- Shock adequately addressed?
  - PaO₂ > 55 mmHg and no evidence of on going lactic acidosis
  - Clinical judgment

  Possible Interventions: IVF, Pressors

- Pplat < 30?
  - NO → Reduce Tv by 1ml/kg
  - YES → Refractory hypoxemia therapies should be considered

- Oxygen acceptable?
  - NO → Refractory hypoxemia therapies should be considered
  - YES → FiO₂ > 0.8 and PEEP > 14 for at least 12 hours?
    - NO → Refractory hypoxemia therapies SHOULD NOT be considered
    - YES → Refractory hypoxemia therapies should be considered
Algorithm 2. Recommended Escalation of Treatment for Refractory Hypoxemia

*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. See OSUWMC ECMO guideline. If ECMO is considered, immediate evaluation is required. Direct physician to physician communication is also required:

a. Consult to Cardiothoracic Surgery STAT
   b. Consult to Anesthesia Critical Care STAT

**See PEEP/FiO$_2$ table from OSU ventilator management guideline, Appendix A.

***Rerfractory hypoxemia may result from other etiologies beyond ARDS. Therefore, the use of prone ventilation should be made on an individualized basis. See Appendix B for contraindications for prone ventilation.

†Inhaled epoprostenol can be readily administered and therefore could be considered concurrently with Prone or other interventions. No RCT support 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. Epoprostenol has not been studied against Prone ventilation so this concurrent use should not be construed as equivalence.

‡APRV (Airway Pressure Release ventilation); IRV (inverse ratio ventilation)
References


Guideline Authors

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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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Resources

- OSUWMC Extracorporeal Life Support (ECLS) — Adult Veno-Venous Extracorporeal Membrane Oxygenation (VV-ECMO) guideline

Quality Measures

- Proportion of patients 24 hours after start of mechanical ventilation requiring FiO₂ > 0.8 or PEEP >14 who are assessed for prone eligibility by 24 hours
- 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
- Proportions of patients requiring FiO₂ > 0.8 or PEEP > 14 at 48 hours after start of ventilation who receive an ECMO consult
- Proportion of patients who remain free of pressure ulcers while in prone position
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>• Open neck, chest or abdominal wounds</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 hemoptysis 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>
<td></td>
</tr>
<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></td>
<td>• Patients currently using HFOV can only receive iNO as an inhaled pulmonary vasodilator</td>
<td></td>
</tr>
<tr>
<td>HFOV</td>
<td>• Cardiovascular instability including shock</td>
<td></td>
</tr>
<tr>
<td>ECMO</td>
<td>• Prolonged and inadequate cardiopulmonary</td>
<td>• Prolonged ventilation for &gt; 10 days or with a high airway pressure and/or high FiO2 &gt; 7 days</td>
</tr>
<tr>
<td></td>
<td>• Resuscitation &gt; 5-30 minutes</td>
<td>• Established multi-organ system failure – SOFA Score &gt; 13</td>
</tr>
<tr>
<td></td>
<td>• Profound metabolic acidosis with pH &lt; 7.1</td>
<td>• Contraindication to anticoagulation</td>
</tr>
<tr>
<td></td>
<td>• Requirement of prolonged neuromuscular blockade infusion</td>
<td>• Intracranial hemorrhage</td>
</tr>
<tr>
<td></td>
<td>• Primary/Idiopathic pulmonary hypertension</td>
<td>• Refusal to receive blood products</td>
</tr>
<tr>
<td></td>
<td>• End stage cardiovascular disease – not a transplant candidate</td>
<td>• Ungrafted severe burns</td>
</tr>
<tr>
<td></td>
<td>• Evidence of neurologic insult</td>
<td>• Quadriplegia</td>
</tr>
<tr>
<td></td>
<td>• Home oxygen requirement (Non-fatal comorbidities may be a relative contraindication and will be evaluated on an individual basis.)</td>
<td>• Bone marrow transplant recipients</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Severe immunosuppressed state (ANC &lt; 200/mm³)</td>
</tr>
</tbody>
</table>

Appendix C. Usual Prone Ventilation Procedures

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

Does patient weigh > 200 kg

YES

Consider safety of manual prone trial and modify based on need

NO

Manually prone patient*

Does patient experience hemodynamic or respiratory instability?

YES

Patient failed prone trial - return patient to supine position

NO

Maintain prone position

• Eligible for SPT?**
  - FiO₂ < 1.0 and
  - SpO₂ > 92%?

YES

Perform SPT** between 0800-1000

SPT** tolerated? (SpO₂ > 92%)?

YES

Evaluate for discontinuation (page 7, figure C)

NO

Return to prone positioning

• Eligible for Rotoprone®?***
  - Weight 91-159 kg and
  - Height 4’6”-6’6”

YES

• Consider Rotoprone® bed and consider critical care CNS consult
• Rotoprone® ordered/deliver, place patient on bed with next SPT

NO

Manually prone the patient

*Do not manually prone patient on a low air loss mattress

**SPT Considerations: A daily Supine Positioning Trial (SPT) should be instituted to facilitate oral care, skin care, examination and other routine practices unless indicated by the treating team.
  - SPT Eligibility (applied at 0800-1000)
    - FiO₂ < 1.0
    - SpO₂ > 92% or PaO₂ > 70 (at least one)
  - If present, proceed with SPT
  - SPT Procedure:
    - By 1000 if patient is placed in the supine position
    - If SpO₂ remains ≥ 90% on any FiO₂, the patient remains supine up to 6 hours
    - If SpO₂ falls < 90% for greater than 10 minutes or 6 hours has passed, the patient should be returned to prone position

***Rotoprone® beds are not necessary to prone all patients and should only be used in specialized situations. A video demonstration of the process for manually placing patient in the prone position is provided through OSUWMC Critical Care. A video demonstration of the process for manually placing the patient in the prone position is also available through NEJM. Always consider using available ergonomic equipment to help assist with turning.
**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 > 16-24 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

- Patient tolerates turn?*
  - NO → Place in prone position and initiate prone ventilation for > 16-24 hours
  - YES → Complete physical assessments, skin care, planned tests/procedures (*planned care*), and review O₂ requirements

- Planned care complete or supine 6 hours?
  - NO → Complete planned care or ensure patient has been supine 6 hours
  - YES → Place in prone position and initiate prone ventilation for > 16-24 hours

*An overall clinical assessment should determine whether a patient tolerates the supine position, but at a minimum this should consist of a SpO₂ > 89%.

**NOTE:** In order to facilitate routine patient care needs, those patients who have less than maximal support requirements should undergo a trial of returning to the supine position on a daily basis. This is designed to prevent anterior skin morbidity, facilitate patient mobilization/reanimation, and assessment for termination of prone ventilation procedures.

**Associated Procedures While Receiving Prone Ventilation**

- Sedatives and analgesics should be used to facilitate deep sedation (RASS -3 or lower)
- Interventions to prevent anterior and facial dermal pressure injury should be instituted (ET consult may be necessary)
- Prone ventilation should be implemented for > 16 hours per day (minimum)
- A daily Supine Positioning Trial (SPT) should be instituted to facilitate oral care, skin care, examination and other routine practices unless indicated by the treating team
  - SPT Eligibility (applied at 0800-1000)
    - FiO₂ < 1.0
    - SpO₂ > 92% or PaO₂ > 70 (at least one)
    - If present, proceed with SPT
- SPT Procedure
  - By 1000 if patient is placed in the supine position
  - If SpO₂ remains ≥ 90% on any FiO₂, the patient remains supine up to 6 hours
  - If SpO₂ falls < 90% for greater than 10 minutes, the patient should be returned to prone position
Appendix C. Usual Prone Ventilation Procedures

Figure C. Terminating Prone Ventilation

*The decision to turn the patient supine is described above.

NOTE: The ultimate decision to discontinue prone ventilation is made through integrating the entire clinical picture. However, in the absence of other contraindications, the clinical values in this grid can be used to determine the end of prone ventilation.

Further Considerations for Terminating Prone Ventilation

- Patients must undergo a daily assessment for termination of prone ventilation
  - This is best facilitated by a daily SPT
- When the patient is able to tolerate SPT with SpO₂ > 92% on moderate settings the patient can be considered for discontinuation of prone ventilation
- Relative indication for discontinuation of prone ventilation
  - FIO₂ ≤ 0.5 while on prone ventilation
  - Tolerance (SpO₂ > 90%) of FIO₂ ≤ 0.6 and PEEP ≤ 10 while supine (SPT)
- Absolute indication for discontinuation of prone ventilation
  - PF ratio > 150 while supine with FIO₂ ≤ 0.6 and PEEP ≤ 10