TITLE: Acute Respiratory Distress Syndrome (ARDS) Ventilator Management Protocol

PROCEDURE:
The Respiratory Therapist (RT) will adjust ventilator settings according to the criteria listed below. The Respiratory Therapist will place or change orders in PRISM to reflect the current ventilator settings.

The Berlin Definition of Acute Respiratory Distress Syndrome:
Timing      Within 1 week of a known clinical insult or new worsening respiratory symptoms
Chest Imaging Bilateral opacities—not fully explained by effusions, lobar/lung collapse, or nodules
Origin of edema  Respiratory failure not fully explained by cardiac failure or fluid overload
                              Need objective assessment (e.g. echocardiography) to exclude hydrostatic edema if no risk factor present
Oxygenation
Mild      200 mmHg < PaO2/FiO2 < 300 mmHg with PEEP ≥ 5 cmH2O
Moderate  100 mmHg < PaO2/FiO2 < 200 mmHg with PEEP ≥ 5 cmH2O
Severe    PaO2/FiO2 ≤ 100 mmHg with PEEP > 5 cmH2O

Ventilator Settings:
  * **Mode**: Assist Control
  * **Autoflow**: In severe ARDS, the priority of low tidal volume ventilation warrants a default of Autoflow OFF (in many of these cases, strong consideration should be given to deep sedation and neuromuscular blockade).

In less severe conditions or when moving toward extubation, where comfort and lower sedation may be of higher priority, special consideration can be given to leaving Autoflow ON.
  * Document Plateau Pressures (with Autoflow off) every 4 hours.
  * **FiO2**: Maintain PaO2 55 to 80 mmHg or SpO2 88% to 95% using FiO2/PEEP table below
  * Notify LIP (Licensed Independent Practitioner) of any single FiO2 change of 20% or greater
  * **PEEP (Positive End Expiratory Pressure) Escalation Options**
    1. Use FiO2/PEEP table* below to guide escalation of PEEP and FiO2, or
    2. Titrate PEEP to plateau pressure of ≤ or = 30 cmH2O
  * **Separate options for PEEP de-escalation (to be determined by the ICU team)**:
    1. Reduce FiO2 and PEEP in decrements guided by escalation table below, not to exceed > 30% PEEP reduction over 12 hours.
    2. OR - No reduction in PEEP until FiO2 < or = 0.5, then decrease PEEP by 2 cmH2O no more frequently than every 4 hours, and not to exceed > 30% PEEP reduction in 12 hours.
  * **Tidal Volume (VT)**: goal: 6ml/kg IBW
    If the VT is > than 6 ml/kg IBW, reduce VT to 6 ml/kg IBW
    1. RT or RN to document height
    2. Ideal Body Weight (IBW) Calculation:
        Males: IBW (kg) = (height in inches – 60) x 2.3 + 50
        Females: IBW (kg) = (height in inches – 60) x 2.3 + 45.5
    3. VT is NOT adjusted in response to pH unless:
        • pH is less than 7.20 and the patient is demonstrating instability as a result of the acidosis (i.e. hypotension or arrhythmia)
        • OR – the patient is demanding a VT larger than that programmed, AND a clinical decision has been made to not paralyze and/or increase sedation to mitigate patient efforts.
  * **Respiratory Rate (RR)**: Initial respiratory rate should be set to approximate the patient’s minute ventilation (MV).
    1. Set RR should not exceed 35 breaths per minute
    2. If pH is 7.15-7.30, increase RR until pH > 7.30 or PaCO2 is < 25

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3. If pH is <7.15, increase RR to 35
4. If pH is >7.45, decrease RR until pH is 7.30-7.45, or decrease VT to < 6cc/kg (if tolerated by patient).

*Maintain target ranges of PaO2 or SpO2 using the following table during uptitration/escalation of PEEP and FiO2:

<table>
<thead>
<tr>
<th>FiO2</th>
<th>0.3-0.4</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
<th>0.7</th>
<th>0.8</th>
<th>0.9</th>
<th>0.9</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>PEEP</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>14</td>
<td>16</td>
<td>18</td>
</tr>
</tbody>
</table>

Plateau Pressure: Goal: < 30 cm H2O

5. Autoflow on the Draeger ventilator must be off for an accurate plateau pressure measurement.
6. If plateau remains >30 cm H2O on 6 ml/kg, contact LIP about potential reduction of VT to as low as 4 ml/kg.
7. If plateau pressure remains >30 cm H2O on 4 ml/kg or acidosis does not permit tidal volume reduction, transfer to ECMO center may be considered (see Appendix B below)
8. If Autoflow is ordered, peak pressure should be <30

In the event of severe patient-ventilator dis-coordination, consider:
(These steps require an LIP’s order.)
Increasing sedation
Increasing RR and/or increasing inspiratory flow to allow more time for exhalation
Increasing VT by 1ml/kg up to 8ml/kg/IBW, provided P plat is ≤ 30
Neuromuscular blockade (NBM) for 48 hours (if within 24 hours of presentation) – MUST use NMB order set.

*With autoflow on, AC is not a strictly volume controlled setting

De-escalation of ARDS protocol
* In the event that patient is awakening and exhibiting signs of discomfort on ventilator settings designated by the ARDS protocol, consider de-escalation of protocol as needed to limit sedation needs and promote earlier weaning. Options might include:
1. Liberalize tidal volumes to 8 cc/kg IBW, provided plateau pressure remains < 30cm H2O
2. Consider turning Autoflow on, or off, depending on patient comfort
3. Transitioning to more patient synchronous modes, such as PC-PSV with volume guarantee
4. Wean and extubate to High Flow Nasal Canula

Refractory Hypoxemia
* In the event of refractory hypoxemia (cannot achieve O2 sat > 90% or PaO2> 60) or “severe” ARDS (as defined in relevant studies as P:F ratio ≤ 150), consider the following additional strategies in the following listed order of priority (as supported by current published evidence).
  • FIRST Priority Interventions:
    o Neuromuscular blockade for 48 hours (MUST use NMB order set AND brain monitoring device)
    o and Prone positioning (provided no contraindication – see Appendix A for guidelines).
  * In the event of NMB and prone positioning, the team should begin evaluation of candidacy for transfer to an ECMO center if not improving in response to these interventions (See Appendix B).
  • SECOND Priority Interventions Include (in no particular order of priority):
    o Liberalize tidal volume to 8 cc/kg IBW
    o Or alternative modes of mechanical ventilation such as APRV.
    o Or Inhaled/aerosolized Flolan (epoprostenol) (Note: cannot be used inline with vent circuit during HFOV).

REFERENCES:
Acute Respiratory Distress Syndrome: The Berlin Definition


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Appendix A
ICU Prone Positioning Guidelines

Background:
Prone positioning is associated with a significant reduction in mortality from severe ARDS (Guerin, et al., 2013). The prone position is typically used in an attempt to recruit collapsed or fluid filled lung when conventional strategies have not been successful in providing adequate oxygenation and ventilation. The prone position is believed to improve oxygenation by altering the distribution of pleural pressures and improved ventilation and perfusion matching within the lungs (AACN, 2011).

There is no data to suggest that prone positioning promotes a radically different approach to basic nursing care. The AACN Procedure Manual (6th Ed.) includes a comprehensive explanation of the proning procedure (including rationale) and should be referred to in tandem with the general guidelines presented in this document.

There is limited objective data to guide best nursing practice for the proning of patients for severe ARDS. These guidelines are meant to inform the decisions of the multidisciplinary team but are not absolute mandates. The safest approach to prone positioning for individual patients should be determined on an ongoing basis and communicated in the notes of the health record for ongoing reference by providers. Patient-specific troubleshooting should be informed by sound clinical judgment, expert opinion, and standard principles of staff safety. Ultimately, a balanced analysis of expected benefit and risk should be the key consideration. Proper preparation for prone positioning is important; defined roles and good communication among team members will reduce risks associated with proning.

Inclusion Criteria:
1. Severe ARDS, PaO2/FiO2 < 150 mmHg, FiO2 > 0.6, PEEP of > 5 cmH2O
2. Endotracheal Intubation
3. Tidal volume 6ml/kg IBW

Exclusion Considerations:
1. Elevated ICP > 30 mmHg or CPP < 60 mmHg
2. Massive hemoptysis
3. Tracheal Surgery or Sternotomy in the previous 15 days
4. Serious facial trauma or facial surgery in the previous 15 days.
5. Cardiac pacemaker insertion in the previous 2 days
6. Unstable spine, femur, or pelvic fracture
7. MAP < 65mmHg, severe hemodynamic instability despite aggressive use of vasopressors
8. Active pregnancy
9. Anterior chest tube with air leak
10. Abdominal surgery with open abdomen
11. Abdominal compartment syndrome
12. Restricted C-spine passive range of motion (tested during neuromuscular blockade)
13. Severely restricted shoulder range of motion
Duration:
- Maximum time prone 20 hours per day
- Ideal total time prone 18-20 hours per day, and a minimum of 16 hours per day.
- Total time supine: 4-6 hours per day between proning sessions
- If possible, the ideal time of day to initiate proning procedure is around 15:00. This will allow for maximum attendance by experience staff at time of proning, as well as at time of returning to the supine position about 18 hours later at around 9:00.
- Consider returning patients to the prone position early if hypoxic and clinically indicated

General Preparation:
- All patients receiving proning therapy should have a systemic skin assessment performed: upon admission, every 12 hours, immediately prior to proning, and within 1 hour of returning to the supine position
- Wound care consult should be ordered if not already following the patient
- If indicated, move to specialty surface, appropriate bed frame, or specialty bed
- Physical Therapy (PT) should be ordered if not already following and should evaluate patient prior to proning whenever possible. Request should be placed for a STAT consult with “PRONE Consult” in comments section of PT Evaluation order and the care team should call x 72450
- If patient condition warrants initiation of proning without physical therapy assessment prior to initiation, the ordering provider, with nursing staff, should assess cervical and shoulder range of motion (ROM) following initiation of neuromuscular blockade prior to initiating proning. If cervical ROM is restricted to less than 45° in either direction, or shoulder ROM is restricted to less than 90° of flexion or abduction, the ordering provider must make the decision to prone after weighing the risk of injury.
- Nutrition Consult if: Braden ‘NUTRITION’ subscale less than 3 and/or Albumin less than equal to 3.4 g/dl and/or Pre-albumin less than equal to 20 mg/dl and Braden score less than equal to 16
- Respiratory Therapy should evaluate the patient prior to proning to consider:
  - administration of respiratory treatments while supine
  - endotracheal tube (ETT) securement method (tape vs., “burn” holder vs., alternative)
  - waveform capnography
  - And review orders for treatments and vent settings.
- A urinary catheter is indicated unless anuric on renal replacement therapy
- Fecal containment device if indicated.
- Turn off tube feedings 1 hour prior to prone positioning (enteral feedings may be resumed once prone; place bed in reverse trendelenburg, post-pyloric feed tube is ideal)
- When indicated complete all procedures, imaging studies, ventral side hygiene, ventral dressing changes, and empty all pouches and drains prior to prone positioning
- Educate the patient (if possible) and the family of the planned procedure

Items Needed for Prone Positioning:
- At least two full sheets.
- Disposable draw pads
- Gel face pad from OR or Prone Kit
- Multiple Mepilex foam dressings and gauze dressings for skin protection
- Skin barrier cream
- L’Nard splints
- Multiple pillows
- Endotracheal securement device (if not already in place)
- Minimum of 5 skilled providers

Immediate Preparation:
- Provider orders pronation therapy for severe ARDS
● Ensure emergency equipment is available (Ambu bag w/ mask, intubation box, etc.)
● A provider, highly skilled in emergent intubation / difficult airways (attending and/or anesthesia), should be present in room. -At least, until the proning routine is well-established for the individual patient.
● Consider notifying anesthesia to have on-call in event of inadvertent extubation
● Gather proning team of 5 or more (minimum of 5) to the bedside (RN, RRT, required. PT, orderlies, recommended).
  - The MD/DO provider monitors overall condition and stability
  - RT is primarily responsible for airway
  - RN is primarily responsible for lines, devices, & team communication
  - PT (when available) is primarily responsible for patient position, body mechanics
  - Orderlies are to take specific direction from other team members
● Ensure adequate analgesia and/or sedation – this may at first require neuromuscular blockade with BiS monitoring
● Perform eye care, including lubrication. Tape eyelids closed in horizontal fashion if open.
● Invasive lines, drains, and tubes should be positioned to minimize device-related pressure.
● Apply barrier cream, containing Dimethicone, to boney prominences of face
● Remove hospital gown and plan for minimal linen beneath patient while prone.
● Ensure tongue is inside patients mouth, insert bite block if protruding.
● Remove anterior EKG leads. Prepare electrodes for dorsal placement once prone.
● Focus on essential lines and tubes. Minimize tubing, devices, cables, connected to patient.
● Bring lines & tubes toward head or feet while avoiding entanglement with the endotracheal tube.
● Place full-length flat sheet beneath the supine patient, if not already present

**Steps for proning:**
1. Place gel prone face pad below head and ETT
2. Ensure that a full sheet is centrally placed under the entire length of the patient (head to toe)
3. Pad all anterior bony prominences, e.g., bilateral shin; iliac crests, knees, shoulders, face etc. with Mepilex foam pad dressings (See Prone Kit); apply gauze dressing to nipples (male and female)
4. Place arms tightly extended alongside of patient with shoulders and elbows fully extended and with palms face up tucked securely below the buttocks
5. The RN will disconnect all unnecessary lines/tubes or ensure lines and tubes in correct position for Prone position
6. The RN will remove ALL anterior chest leads to be ready to replace POSTERIORLY when PRONE
7. Place a FULL sheet over the top of and entire length of patient, but pulled back just to expose head/neck and airway
8. **STOP!** At this point take a time out to review roles and processes
9. Roll the lower sheet with the upper sheet tightly along each side of the body to “cocoon” the patient
10. With the RT positioned at the HOB (with head board removed from bed), once the airway is secured, the RT will count and continue to control the head/neck and endotracheal tube as the patient is rotated
11. Using the top and bottom sheets, slide the patient as far as possible to side of bed away from the ventilator
12. Roll patient toward the ventilator fully onto side using the tightly wrapped sheets for handles
13. Those assisting from behind the patient should GRAB and hold the lower part of the top sheet from beneath the patient
14. **STOP AGAIN!** When RT is satisfied with the position of head and neck and confirms the airway is secured, the RT will approve rolling patient into prone position.
15. Turn the patient’s face toward the ventilator as the team pulls the top sheet from beneath the patient toward them
16. Once safely in PRONE, quarter turn the body up from prone on the side the ETT is facing
17. Support the pelvis by placing pillow under one hip (anterior iliac spine) and support the trunk with additional pillows.
18. Place into “Swimmers position”
   a. Carefully Rotate, abduct then flex the shoulder at no more than 90 degrees UP (shoulder height level) on the same side that the ETT and head are facing
   b. The opposite arm remains fully extended down alongside the body with palm upward or against the body
19. Place the bed in Reverse T–Berg position at ~ 30 degrees
20. Position shins / lower legs onto pillows to float feet off the bed and maintain a neutral ankle
21. Apply bilateral L’Nard splints only when in the SUPINE position, but consider single L’Nard splint on upturned side (when prone) to prevent foot drop

22. Keep in Prone for 18 to 20 hours (minimum of 16 hours)

Maintaining in Prone Position:
1. Continue all standard nursing care while prone, including oral care every 4 hours
2. Avoid hyperextension when prone; avoid use of pillows around arms, shoulders, and head. Maintain cervical alignment.
3. Ensure boney prominences are maximally protected from pressure
   a. Continue to moisturize skin daily and PRN
   b. Consider gel pad under face (but remember any contact constitutes some pressure)
   c. Consider small towel rolls to prop minimal adipose surfaces, especially around the face
   d. Head must be kept to side but consider redistributing weight of head frequently every hour; to offload ears, periorbital areas, zygomatic process, forehead, chin, etc.
4. Diligently monitor ridged devices where they might contact skin. (i.e. blue claves, a line linkages, venodyne connections, ETT holder, foley catheter, rectal tube, etc). Avoid contact pressure from these whenever possible.

5. **Every 2 Hours:**
   a. NOTE: RT must be present for any complete turn of head.
   b. Rotate Head/neck/ETT (with RT present at HOB) and arm positions
   c. Ensure that barrier cream is placed on upper face/head
   d. Place patient into full Prone position, upper arm is now placed extended down to side
   e. Place bed into flat position
   f. Using FULL sheet below patient, boost patient fully to top of bed to allow ETT clearance off end of bed as needed for turning, with RT protecting ETT.
   f. RT rotates head/neck/ETT to the opposite side

Repeat step 17-21 detailed in the section above

   g. Using FULL draw below patient, re-position patient back to central bed location if indicated with RT protecting/securing the airway/ETT

Maintenance of supine position:
1. RN will reassess skin once supine, documenting any change
2. Complete ROM
3. Complete oral hygiene care
4. Continue partial turns every 2 hours to redistribute weight
5. Apply bilateral L’Nard splints when supine

Indications for discontinuation of prone therapy:
1. Immediately discontinue for: severe cardiac instability, cardiac arrest, or loss of airway.
2. P/F ratio deterioration of > 20% relative to supine measurements before two consecutive prone sessions.
3. Improvement in oxygenation: PaO2/ FiO2 > 150mm Hg with PEEP < 10 and FiO2 < 0.6 -with patient in supine position ≥ 4 hours since last prone session.

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References:
University of Colorado Hospital (September, 2009). Nursing practice clinical care guideline, Prone positioning the acute respiratory distress syndrome patient
Appendix B

UVMMC VENOUSOUS EXTRACORPORAL MEMBRANE OXYGENATION (VV-ECCMO) GUIDELINES

Potential Indications / Thresholds for Consideration of VV ECMO:
1. In hypoxic respiratory failure due to any cause (primary or secondary) Extracorporeal Life Support (ECLS) should be considered when the risk of mortality is 50% or greater, and is indicated when the risk of mortality is 80% or greater:
   a. 50% mortality risk is associated with a PaO2/FiO2 < 150 on FiO2 > 90% and/or Murray score 2-3.
   b. 80% mortality risk is associated with a PaO2/FiO2 < 100 on FiO2 > 90% and/or Murray score 3-4 despite optimal care for 6 hours or more.
2. CO2 retention on mechanical ventilation (pH < 7.20-7.25) for 6-12 hrs despite optimized management
3. Plateau pressure > 30-32 cmH2O for 6-12 hrs despite optimized management
4. Severe air leak syndromes.
5. Need for intubation in a patient on the lung transplant list.
6. Immediate cardiac or respiratory collapse (PE, blocked airway, unresponsive to optimal care).
7. Early consideration could be considered for patients at less than 6 hrs with persistent severe hypoxia (SpO2<80%) or severe respiratory acidosis (pH <7.15) despite optimal management

Contraindications:
There are no absolute contraindications to ECLS, as each patient is considered individually with respect to risks and benefits. There are conditions, however, that are associated with a poor outcome despite ECLS, and can be considered relative contraindications.
1. Mechanical ventilation at high settings (FiO2 > 90%, Pplat > 30 cm H2O) for 5-7 days or more.
2. Major pharmacologic immunosuppression (absolute neutrophil count <400/mm3).
3. CNS hemorrhage that is recent or expanding.
4. Non recoverable comorbidity such as major CNS damage or terminal malignancy.
5. Advanced age: no specific age contraindication but risk of poor outcome increases with increasing age.
6. History of Heparin Induced Thrombocytopenia (unless non-heparin bonded circuit available) or other contraindication to anticoagulation.
7. Left ventricular ejection fraction < 35-40%
8. Poor neurologic status
9. Advanced respiratory disease at base line and poor candidacy for lung transplant
10. Low RESP Score (<= -6; < 20% approximate survival on ECMO)

General Sequence for ECMO consideration
1. Request consultation by cardiothoracic surgery for initial assessment for candidacy
2. If cardiothoracic surgery consultation results in a decision to offer VV-ECCMO, consulting CT surgery attending activates conference call via PAS to include: 1. Consulting UVM cardiothoracic surgery attending, 2. On call UVM cardiac critical care attending (Cardiac SICU Attending), 3. Primary UVM attending requesting consult (typically Medical or Surgical ICU attending), and 4. Montefiore cardiothoracic surgeon (as an accepting physician).
3. Activation of VV-ECCMO team: after conference call: If the decision is made to cannulate the patient; PAS will be notified to activate the full on call ECMO team, and the Transfer center will be contacted to initiate transfer to Montefiore

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References:
1. ELSO 2017: Guidelines for Adult Respiratory Failure