

# Respiratory Care Pocket Reference

v1.1



Created by collaborators & support from:  
University of California San Francisco, Makerere University, USAID,  
Sustaining Technical & Analytic Resource (STAR) project & others

## Oxygen Sources & Delivery Devices

<b>Nasal Cannula</b> (NC)	<p><b>Pros:</b> Ubiquitous; commonly used up to 6LPM</p> <p><b>Cons:</b> Requires humidification if &gt;4LPM (risk of epistaxis); no work of breathing support</p> <p><b>O<sub>2</sub>:</b> works with any pressure source via flow meter; FiO<sub>2</sub> increases 2-4% per LPM; variable FiO<sub>2</sub> delivery based on patient's minute ventilation &amp; flow rate</p>
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<b>Non-Rebreather/Facemask</b> (NRB/FM)	<p><b>Pros:</b> ~High FiO<sub>2</sub>; can be more comfortable than NC</p> <p><b>Cons:</b> Limited FiO<sub>2</sub> if high respiratory drive; no work of breathing support</p> <p><b>O<sub>2</sub>:</b> works with any pressure source via flow meter; simple FM 5-10 LPM (~FiO<sub>2</sub> 35-50%); NRB 10-15 LPM (~FiO<sub>2</sub> 60-80%); enough flow to prevent bag collapse</p>
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<b>High Flow Nasal Cannulae</b> (HFNC)	<p><b>Pros:</b> Able to achieve high FiO<sub>2</sub> even with high minute ventilation; can titrate flow and FiO<sub>2</sub>; heated and humidified for comfort; may improve outcomes in acute hypoxemic respiratory failure compared to NIPPV or low-flow O<sub>2</sub>; small amount positive pressure assists with work of breathing</p> <p><b>Cons:</b> Requires special device; consumes massive amounts of oxygen</p> <p><b>O<sub>2</sub>:</b> Requires high pressure/flow source; ~ &gt;90% FiO<sub>2</sub> (variable with minute ventilation, entraining room air around cannulae) <b>3 types:</b> 1) With blender to mix compressed air + O<sub>2</sub>; 2) With port/Venturi effect to entrain room air and mix with compressed O<sub>2</sub>; or 3) Without blender.</p> <p><b>Initial Settings:</b> infant &lt;1 year = 8LPM; child 1-4 years = 10LPM; Child &gt; 4 years = 20LPM; adolescents/adults = 40LPM flow and 100% FiO<sub>2</sub>; can titrate flow and/or FiO<sub>2</sub> (max flow depends on cannula size; up to 60 LPM for adults and 100% FiO<sub>2</sub>) if tolerated and O<sub>2</sub> source adequate.</p>
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<b>Non-invasive Ventilation</b> (NIV) or <b>Positive Pressure Ventilation</b> (NIPPV)	<p><b>Pros:</b> May avoid intubation in some pts (COPD, cardiogenic pulmonary edema, upper airway obstruction) by decreasing work of breathing and adding PEEP</p> <p><b>Cons:</b> Risk of infectious aerosol generation (possibly less if helmet NIPPV); risk of aspiration if patient not alert / unable to protect airway or if inspiratory pressures &gt;20cm H<sub>2</sub>O; pt must be alert enough to remove mask if uncomfortable; skin breakdown with prolonged use; confusing terminology: IPAP (inspiratory pressure); EPAP (expiratory pressure = PEEP); PS of "5 over 5" is the same as PS delta 5 over 5, is the same as IPAP 10/EPAP 5</p> <p><b>O<sub>2</sub>:</b> requires high pressure/flow source to achieve high FiO<sub>2</sub></p> <p><b>Initial Settings:</b> PS (ΔP) 5/PEEP (EPAP) 5-10; titrate ΔP up to 15 to reduce inspiratory work; use higher initial IPAP with obese pts; higher pressures may require sedation in peds</p>
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<b>Continuous Positive Airway Pressure</b> (CPAP)	<p><b>Pros:</b> Delivered via face mask or multiple other potential interfaces to splint open the upper airway, increase lung volume &amp; intrathoracic pressure</p> <p><b>Cons:</b> Prolonged use is uncomfortable &amp; causes skin breakdown; limited unloading of inspiratory muscles or provide complete respiratory support</p> <p><b>O<sub>2</sub>:</b> requires high flow/pressure source to achieve high FiO<sub>2</sub></p> <p><b>Initial Settings (adults/peds):</b> CPAP or PEEP 5-10; adults: titrate as needed up to 15; peds ≤12; higher pressures may require sedation in peds</p>
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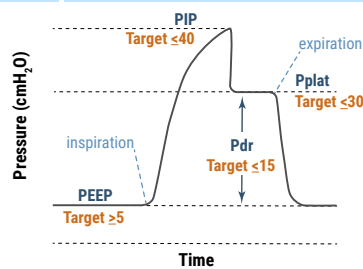
**Oxygen Delivery Device & Supply FAQ**

**Oxygen Supply & Demand Calculator**

**Disclaimer:** This card is intended to be educational in nature and is not a substitute for clinical decision making based on the medical condition presented. It is intended to serve as an introduction to terminology. It is the responsibility of the user to ensure all information contained herein is current and accurate by using published references. This card is a collaborative effort by representatives of multiple academic medical centers.

## Respiratory Mechanics

<b>Positive End Expiratory Pressure (PEEP)</b>	<ul style="list-style-type: none"> <li>Pressure within respiratory circuit at end of expiration</li> <li>Must be ≥5 cmH<sub>2</sub>O in IMV to prevent derecruitment of alveoli</li> <li>This value is <b>always</b> set by ventilator operator</li> </ul>
<b>Pressure<sub>Peak</sub> Inspiratory (PIP)</b>	<ul style="list-style-type: none"> <li>Reflects pressure generated by airway/ETT resistance and compliance</li> <li>Range 10-40cmH<sub>2</sub>O; <b>target &lt;40cmH<sub>2</sub>O</b></li> </ul>
<b>Pressure<sub>Plateau</sub> (Pplat)</b>	<ul style="list-style-type: none"> <li>Reflects pressure in alveoli only</li> <li>If in volume control, perform inspiratory pause (when there is no flow, there is no effect of resistance; Pplat=P at alveoli)</li> <li><b>Target &lt;30cmH<sub>2</sub>O (adults); &lt;28 (peds);</b> optimal ≤25 cmH<sub>2</sub>O</li> </ul>
<b>Pressure<sub>Driving</sub> (Pdr)</b>	<ul style="list-style-type: none"> <li>Pdr = Pplat - PEEP</li> <li>Tidal stress (lung injury and mortality risk) if elevated</li> <li><b>Target &lt;15cmH<sub>2</sub>O</b>; mortality risk if ≥20cmH<sub>2</sub>O</li> </ul>
<b>I:E and Inspiratory Time (T<sub>I</sub>)</b>	<ul style="list-style-type: none"> <li>I:E = ratio of Inspiration to Expiration</li> <li>Normal 1:2 or 1:3; 1:1 is only tolerated when paralyzed (and rarely indicated); 1:4 or 1:5 may be better in asthma or COPD</li> </ul>
<b>Minute Ventilation (MV)</b>	<ul style="list-style-type: none"> <li>MV = V<sub>T</sub> x RR; where V<sub>T</sub> is the <b>tidal volume</b> (i.e. volume of each breath) and RR is the <b>respiratory rate</b> (breaths per minute)</li> <li>Normal 4-6 LPM; ~lower if obtunded, hypothermic, deeply sedated; ~higher 8-14 LPM in hypoxemic respiratory failure</li> <li>Adjust for pCO<sub>2</sub> goal (e.g. permissive hypercarbia if ARDS); ~6-8 L/min in most intubated adults, may be ≥10-15 L/min in ARDS</li> </ul>
<b>Peak Flow</b>	<ul style="list-style-type: none"> <li>Highest flow delivered by ventilator during inspiration</li> <li>40-60 LPM common; ~50-80 LPM if patient triggered mode</li> <li>Sometimes increasing flow can improve patient-ventilator synchrony; <b>caution this may cause elevation in PIP</b></li> </ul>
<b>Compliance (C)</b>	<ul style="list-style-type: none"> <li>C = ΔV / ΔP = Tidal volume of breath / Pdr</li> <li><b>Dynamic compliance</b> (VT/PIP-PEEP) or <b>static compliance</b> (VT/Pplat-PEEP) measured at end inspiratory pause</li> <li>Range is 60-80mL/cmH<sub>2</sub>O in intubated patients; ARDS ≤40</li> </ul>
<b>Inspiratory Resistance (R)</b>	<ul style="list-style-type: none"> <li>R = PIP - Pplat/inspiratory flow</li> <li>Must be measured during constant flow</li> <li>Normal &lt;10cmH<sub>2</sub>O/L/sec; <b>concern if ≥15cmH<sub>2</sub>O/L/sec</b></li> </ul>



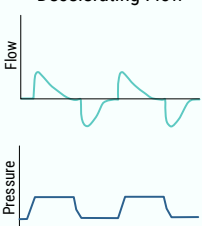
## Choosing a Ventilator Mode

- Assist Control (AC) Volume Mode** is *default* for non-spontaneous breathing patients or ARDS
- AC Pressure Mode & Dual Modes** can be used for non-spontaneous breathing patients or ARDS
- PSV** if spontaneous breathing and non-ARDS; **SIMV** and **APRV** have no data to support regular use

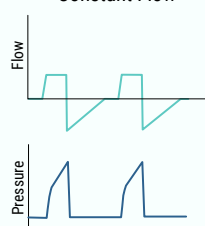
## Volume Control

<b>Other Names</b>	AC-VC; Assist Control Volume Control; VCV; ~CMV (controlled mandatory ventilation = all modes with RR and fixed T <sub>I</sub> ); (S)CMV
<b>Controlled Variables</b>	<b>RR, V<sub>T</sub>, PEEP, FiO<sub>2</sub>, Trigger level, Flow pattern, I:E</b> (either directly or via peak flow, T <sub>I</sub> settings)
<b>Initial Settings Adult &amp; Pediatric</b>	<ol style="list-style-type: none"> <li>Set V<sub>T</sub> at 6-8 mL/kg ideal body weight (IBW)</li> <li>Set RR: <b>Adults:</b> set at pt's most recent RR (do not exceed 35); <b>Peds:</b> set at most recent RR (do not exceed 60 bpm in <b>infants</b>, 40 bpm in <b>toddlers/preschoolers</b>, 35 bpm in <b>school-aged children or adolescents</b>)</li> <li>Set T<sub>I</sub>: <b>Adults</b> 0.70-1 sec; <b>Peds</b> based on RR to maintain a minimum ratio of 1:2</li> <li>Select FiO<sub>2</sub> and PEEP (use ARDSnet grid if applicable; see next page)</li> </ol>
<b>Flow</b>	Square wave/constant/fixed; or Variable/decreasing ramp ( <i>potentially</i> more physiologic); 40LPM healthy, 60LPM ARDS
<b>I:E</b>	<ul style="list-style-type: none"> <li>I:E of 1:2 or 1:3 is best for most patients; Normal Ti ~ 1-1.5s in non ARDS patients; Consider Ti 0.7-1 for ARDS</li> <li>I:E of 1:1 or &gt;1:1 associated with PEEP, decreased cardiac output (CO) and oxygen delivery</li> <li>Process for setting I:E may vary by ventilator make; commonly by changing Ti, inspiratory flow and flow pattern</li> </ul>
<b>Pros</b>	Guaranteed MV regardless of changing respiratory system mechanics; precise control of V <sub>T</sub> to limit volutrauma
<b>Cons</b>	Will overcome high resistance or compliance to deliver set V <sub>T</sub> (must set pressure limit & alarm); breath stacking (i.e. next breath delivered before exhalation of prior breath); fixed flow and T <sub>I</sub> can increase asynchrony when V <sub>T</sub> & flow demand > vent settings
<b>Breath Initiation</b>	Control: Time trigger (60s/set RR): fixed VE Assist: Pt effort triggers full breath at set T <sub>I</sub> , V <sub>T</sub> , and flow rate
<b>If No Patient Trigger</b>	Delivers full set V <sub>T</sub> at set rate (i.e. guaranteed VE)
<b>Breath Termination</b>	<b>Time cycled</b> = breath ends at set T <sub>I</sub> ; alarms if V <sub>T</sub> not achieved; flow is set, breath ends once V <sub>T</sub> delivered <b>Pressure cycled</b> = safety mechanism; breath termination by clinician set high-pressure limit (10-15cmH <sub>2</sub> O>avg PIP); "pop-off"
<b>Notes</b>	<ul style="list-style-type: none"> <li>Inspiratory pause (~0.3s) can be built into each breath, will increase mean airway pressure; can measure Pplat</li> <li>Alarms: high pressure 5-10 &gt; PIP, VE 50% above+below actual</li> <li>Trigger: 2-5 Lpm for flow; -2 cmH<sub>2</sub>O for pressure</li> </ul>

### Decelerating Flow



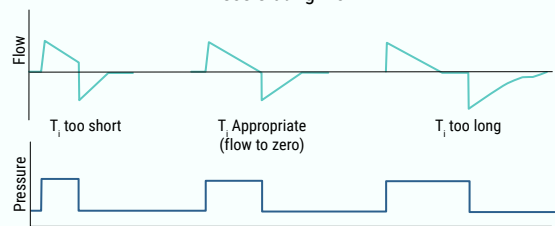
### Constant Flow



## Pressure Control

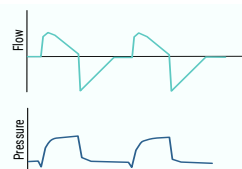
<b>Other Names</b>	AC-PC; Assist Control Pressure Control; ~CMV - PC
<b>Controlled Variables</b>	<b>RR, Pinsp (or PC level), PEEP, FiO<sub>2</sub>, Flow trigger, Rise time, I:E</b> (set directly or by Inspiratory time, T <sub>I</sub> )
<b>Initial Settings Adult &amp; Pediatric</b>	<ol style="list-style-type: none"> <li>Set inspiratory pressure (Pinsp) at 8-20cmH<sub>2</sub>O, or set equal to previous Pdr, Ppft or ~1/2 of PIP if transitioning from VC</li> <li>Set RR: <b>Adults:</b> set at pt's most recent RR (do not exceed 35); <b>Peds:</b> set at most recent RR (do not exceed 60 bpm in <b>infants</b>, 40 bpm in <b>toddlers/preschoolers</b>, 35 bpm in <b>school-aged children or adolescents</b>)</li> <li>Set T<sub>I</sub>: <b>Adults</b> 0.70-0.85 sec; <b>Peds</b> based on RR to maintain a minimum ratio of 1:2</li> <li>Select FiO<sub>2</sub> and PEEP (use ARDSnet grid if applicable; see next page)</li> </ol>
<b>Flow</b>	Variable/decreasing ramp ( <i>potentially</i> more physiologic)
<b>I:E</b>	<ul style="list-style-type: none"> <li>I:E of 1:2 or 1:3 is best for most patients; Ti 0.7-1s for ARDS</li> <li>I:E 1:1 or &gt;1:1 associated with PEEPI, decreased CO &amp; O<sub>2</sub> delivery</li> <li>Determined by set T<sub>I</sub> and RR (Volume and flow variable)</li> </ul>
<b>Pros</b>	<ul style="list-style-type: none"> <li>Avoids high PIPs</li> <li>Variable flow (↓ pt effort causes ↑ flow to maintain constant airway pressure = <i>potentially</i> better synchrony: ↓ pt effort → ↓ flow and ↓ V<sub>T</sub>)</li> <li>"Automated/active expiratory valves" (transiently opens expiratory valve to vent off pressure with coughing, asynchrony); ↑ comfort and ↓ barotrauma risk</li> </ul>
<b>Cons</b>	V <sub>T</sub> and MV not guaranteed; V <sub>T</sub> determined by C and R (might be bigger or smaller than is optimal)
<b>Breath Initiation</b>	Control: Time trigger - (60s/set RR) Assist: Pt trigger delivers Pinsp for inspiratory time cycle
<b>If No Patient Trigger</b>	Delivers Pinsp at set rate and T <sub>I</sub>
<b>Breath Termination</b>	Time cycled = I:E or T <sub>I</sub> set, breath ends at set time
<b>Notes</b>	<ul style="list-style-type: none"> <li>Pplat is the set inspiratory pressure</li> <li>Alarms: high pressure 5-10 &gt; PIP, VE 50% above+below actual</li> <li>Trigger: 2-5 Lpm for flow; -2 cmH<sub>2</sub>O for pressure</li> <li>Unlike in VC, in PC the ventilator cannot compensate for volume lost to circuit compliance (i.e. V<sub>T</sub> delivered may be less than V<sub>T</sub> measured and may be significant especially in pediatrics)</li> </ul>

### Decelerating Flow



## Pressure Support

<b>Other Names</b>	PS; PSV; Spontaneous
<b>Controlled Variables</b>	<b>Pinsp, PEEP, FiO<sub>2</sub>, Flow trigger, Rise time</b>
<b>Initial Settings Adult &amp; Pediatric</b>	Use for Spontaneous Breathing Trial (SBT): <ol style="list-style-type: none"> <li>Set Pinsp 5-10 cmH<sub>2</sub>O accounting for ETT size (3.0/3.5mm = 10 cmH<sub>2</sub>O; 4.0/4.5mm = 8 cmH<sub>2</sub>O; ≥5mm = 5 cmH<sub>2</sub>O</li> <li>Set PEEP 5-8 cmH<sub>2</sub>O</li> <li>FiO<sub>2</sub> ≤0.40 (<b>Peds</b>) or ≤0.50 (<b>Adults</b>) per SBT initiation criteria</li> </ol>
<b>Flow</b>	Decreasing ramp ( <i>potentially</i> more physiologic) Determined by 1) PS level; 2) R <sub>aw</sub> ; 3) Rise time (↑ Rise time → ↓ Peak flow) and 4) Pt effort
<b>I:E</b>	Determined by patient effort and flow termination ("E <sub>sense</sub> " - see below "Breath Termination")
<b>Pros</b>	↑ Synchrony: allows pt to determine peak flow, V <sub>T</sub> , and T <sub>I</sub>
<b>Cons</b>	No guaranteed MV; V <sub>T</sub> determined by pt (big or small); high PS and/or low E <sub>sense</sub> in COPD can incr air-trapping asynchrony; muscle weakness/fatigue: ↓ effort or ability to sustain effort → hypoventilation, ↑ fatigue
<b>Breath Initiation</b>	Pt flow or pressure triggered; Flow (3-5LPM) more sensitive than pressure trigger (~2cmH <sub>2</sub> O)
<b>If No Patient Trigger</b>	Apnea (Most vents will have backup rate; all have alarm)
<b>Breath Termination</b>	Flow cycled: Delivers Pinsp until flow drops to predetermined % of initial peak flow ~E <sub>sense</sub> (Standard setting ~25%; ~40-50% if obstructive pulmonary disease to prevent air trapping)
<b>Notes</b>	PS mode is not necessarily equivalent to a spontaneous breathing trial (SBT)



## Dual (Control) Mode

<b>Other Names &amp; Function</b>	<ul style="list-style-type: none"> <li>Pressure regulated volume control (PRVC); VC+, AutoFlow</li> <li>~PC with a target V<sub>T</sub> &amp; variable Pinsp (Δ1-3cmH<sub>2</sub>O per breath) to meet goal V<sub>T</sub> despite changing C and R;</li> </ul>
<b>Pros</b>	<ul style="list-style-type: none"> <li>↓ likelihood of hypo/hyperventilation associated with PC.</li> <li>If R or C changes, Pinsp automatically adjusts to keep target V<sub>T</sub></li> <li>Active expiratory valve (unlike AC-VC) promotes synchrony</li> </ul>
<b>Cons</b>	<ul style="list-style-type: none"> <li>C &amp; R can change significantly without notification</li> <li>Vent can't discern if V<sub>T</sub>&gt;target is due to ↑ pt effort or ↑C; vent response to both = ↑ Pinsp; Can lead to closed-loop "runaway" (↓Pinsp→ ↑ Pt Effort→ ↓ Pinsp)= ↑ Pt work; must carefully set alarms</li> </ul>

# Respiratory Care, Setup, & Monitoring

<b>Ventilator Setup (prior to connecting patients)</b>	<ul style="list-style-type: none"> <li>Inspect all equipment for <a href="#">cleanliness</a> or damage</li> <li>Review circuit orientation, filters, &amp; heat &amp; humidification system</li> <li>Ensure gas supply connected</li> <li>Perform machine self-test with new patient and per manufacture (ensure leak test included)</li> <li>Confirm initial settings and alarms</li> </ul>
<b>Ventilator Performance</b>	<ul style="list-style-type: none"> <li>Perform Full Status Check q4h: (PIP, Pplat, V<sub>T</sub>, FiO<sub>2</sub>, Alarms, SpO<sub>2</sub>, ETCO<sub>2</sub> in addition to routine ICU monitoring)</li> <li>Evaluate vent &amp; patient within ~1h of ventilator settings changes</li> <li>Wipe down ventilator with approved disinfection qShift</li> </ul>
<b>Pulmonary, Endotracheal Tube &amp; Circuit Hygiene</b>	<ul style="list-style-type: none"> <li>Check cuff pressure and auscultate q12h to avoid over-inflation/leak (&lt;25 cmH<sub>2</sub>O); consider 'minimal occluding volume' in peds</li> <li>Check inflation of pilot balloon to ensure it remains inflated</li> <li>Reposition &amp; secure endotracheal tube with skin checks q12h</li> <li>Check ventilator circuit qShift for moisture accumulation (drainage); change circuit only if damaged or gross contamination (<b>VAP PPx</b>)</li> <li>Head of bed 30 degrees elevated for pneumonia prophylaxis (<b>VAP PPx</b>)</li> <li>Oral hygiene with mouthwash &amp; suctioning TID (<b>VAP PPx</b>)</li> <li>Consider continuous subglottic suctioning or q12h oropharyngeal suctioning (<b>VAP PPx</b>)</li> </ul>
<b>Filters</b>	<ul style="list-style-type: none"> <li>All <b>external filters</b> should be inspected <u>daily</u> (and after nebs)</li> <li>Replace <b>viral filters</b> as frequently as supplies allow in accord with the manufacturer's recommendations or if damaged/soiled (may last &gt;1 week)</li> <li>For turbine and compressor ventilators, <b>external inlet filters</b> and <b>fan filters</b> must be cleaned at least monthly. For ventilators that allow, bacterial/viral filters should be placed proximal to external intake filters</li> </ul>
<b>Heat &amp; Humidification</b>	<ul style="list-style-type: none"> <li><b>Active system:</b> must use distilled or sterile water (~&gt;500mL daily) to avoid infectious risk and device damage; can be made on site or purchased; check H2O supply q12-24h</li> <li><b>Passive heat moisture exchanger (HME):</b> Only some HME include pathogen filter capability; Many manufacturers suggest change q24h, but studies show that an unsoiled HME in some circumstances can be used for several days. Nebs decrease lifespan (and must be given via bypass or with HME removed from circuit). Monitor for signs of an increased resistance (e.g. increase in PIP but no change in Pplat, or a prolonged exp flow)</li> </ul>
<b>Respiratory Specific Monitoring</b>	<ul style="list-style-type: none"> <li>Continuous pulse oximetry, if unable then spot check as frequently as possible</li> <li>Continuous capnography, if unable then spot check as frequently as possible, especially after major ventilator settings changes</li> <li>Auscultation performed routinely with checks</li> <li>Skin/Mucosal Assessments qShift</li> </ul>
<b>Contingency Planning</b>	<ul style="list-style-type: none"> <li>Ensure manual (i.e. bag valve resuscitator) ventilation device is operational and at bedside along with a facemask and PEEP valve</li> </ul>

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# Lung-Protective Ventilation (LPV)

<b>When to Use LPV?</b>	<p>All ARDS patients and most intubated non-ARDS patients will benefit from LPV, though there are some instances where departures from LPV are justified (i.e. mechanical ventilation ≤24h).</p> <p><b>ARDS Berlin Definition for Adult ARDS with Kigali Modification</b></p> <ol style="list-style-type: none"> <li>Acute (within 1 week of new symptoms or insult)</li> <li>Bilateral opacities on CXR or Chest CT or chest US</li> <li>P:F ≤300 or S:F &lt;315 with or without ≥5 cmH<sub>2</sub>O PEEP</li> <li>Not fully explained by cardiac failure or fluid overload on exam</li> </ol> <p><b>Pediatric ARDS (pARDS) Definition</b></p> <ol style="list-style-type: none"> <li>Acute (within 1 week of new symptoms or insult)</li> <li>Infiltrate(s) on chest imaging consistent with acute lung disease</li> <li><b>Non-Invasive Ventilation:</b> P:F ≤300 or S:F ≤264 with CPAP ≤5 cmH<sub>2</sub>O</li> <li><b>Invasive Ventilation:</b> Oxygen Index (OI) ≥4 or Oxygen Saturation Index (OSI) ≥5</li> <li>Not fully explained by cardiac failure or fluid overload on exam; exclude perinatal related lung disease</li> </ol>																																																																																				
<b>Acute Respiratory Distress Syndrome (ARDS)</b>	<table border="1"> <tr> <th colspan="2">Severity Grading of ARDS (Correct for altitude)</th> <th colspan="2">Peds: OI &amp; OSI</th> </tr> <tr> <th colspan="4">Adult: P:F (PaO2 ÷ FIO2)</th> </tr> <tr> <td>Mild</td> <td>P:F 200-300, ~27% mortality</td> <td>OI 4-73; OSI 5-74</td> <td></td> </tr> <tr> <td>Moderate</td> <td>P:F 100-200, ~32% mortality</td> <td>OI 8-15.9; OSI 7.5-12.2</td> <td></td> </tr> <tr> <td>Severe</td> <td>PF: &lt;100, ~45% mortality</td> <td>OI&gt;16; OSI&gt;12.3</td> <td></td> </tr> </table> <p>If P:F &lt;150 and worsening ARDS, consider adjunctive therapies</p>	Severity Grading of ARDS (Correct for altitude)		Peds: OI & OSI		Adult: P:F (PaO2 ÷ FIO2)				Mild	P:F 200-300, ~27% mortality	OI 4-73; OSI 5-74		Moderate	P:F 100-200, ~32% mortality	OI 8-15.9; OSI 7.5-12.2		Severe	PF: <100, ~45% mortality	OI>16; OSI>12.3																																																																	
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<b>Tidal Volume (V<sub>T</sub>)</b>	<ul style="list-style-type: none"> <li>Measure height &amp; calculate <b>predicted body weight</b> (PBW) (See table)</li> <li>Set initial <b>V<sub>T</sub> 6 mL/kg PBW</b> (AC-VC)</li> <li>Check V<sub>T</sub> at least every 4h (PC or if weaning PS mode)</li> <li>Titrate V<sub>T</sub> by pressure goals &amp; pH (below)</li> <li>If pH &lt; 7.15 consider increase V<sub>T</sub> toward 8mL/kg regardless of Pplat</li> </ul>																																																																																				
<b>Pressures</b>	<p><b>Check Pplat (0.5s inspiratory pause) &amp; Pdr (deltaP=Vt/C<sub>rs</sub> = Pplat-PEEP) ~q4-6h and after each change in PEEP or V<sub>T</sub></b></p> <ul style="list-style-type: none"> <li>If adult Pplat &gt;30 cmH<sub>2</sub>O (&gt;28 Pediatrics), optimize sedation (±paralysis) and decreasing V<sub>T</sub> by 0.5-1 cc/kg toward ~4 mL/kg</li> <li>If Pplat &lt;30 cmH<sub>2</sub>O and severe patient-ventilator dyssynchrony that cannot be addressed pharmacologically, consider increase V<sub>T</sub> in 1 mL/kg steps up to 8 mL/kg</li> <li>If Pplat &lt;25 cm H<sub>2</sub>O and V<sub>T</sub> &lt;6 mL/kg, increase V<sub>T</sub> to 6 mL/kg</li> <li>If PEEP ≥20 then use Pdr goal &lt;15 (rather than Pplat goal)</li> </ul>																																																																																				
<b>Respiratory Rate (RR) &amp; Inspiratory Time (Ti)</b>	<p><b>Set RR at -pre-intubation RR don't exceed ~35 breaths/minute (Adults)</b></p> <p><b>Set Ti 0.70-0.85 sec (may be longer if low RR) (avoid Ti &lt;0.70 sec)</b></p> <ul style="list-style-type: none"> <li>When changing V<sub>T</sub>, adjust RR to keep target VE by goal pH (~8-12 L/min in acute ARDS)</li> <li>Consider lower RR if evidence of obstructive ventilatory defect</li> <li>Increase RR if pH &lt;7.30 and decrease RR if pH &gt;7.45</li> <li>Keep duration of inspiration ≤ expiration</li> </ul>																																																																																				
<b>PEEP &amp; FiO2 (Goal to minimize)</b>	<ul style="list-style-type: none"> <li><b>Start at 5 cmH<sub>2</sub>O PEEP for 2min, if stable hemodynamics, then Select one of the following PEEP / FIO2 titration strategies for goal PaO<sub>2</sub> 55-80 mmHg or SpO<sub>2</sub> 88-95% (In ARDS, PEEP usually ~10-14 cmH<sub>2</sub>O).</b></li> <li>When ↑ PEEP; if Pplat ↑ more than a PEEP, think over-distension</li> </ul> <table border="1"> <tr> <th colspan="12">Lower PEEP/higher FIO<sub>2</sub> Strategy (*Default - May consider if low Pdr or pediatrics)</th> </tr> <tr> <th>FiO<sub>2</sub></th> <td>0.3</td> <td>0.4</td> <td>0.4</td> <td>0.5</td> <td>0.5</td> <td>0.6</td> <td>0.7</td> <td>0.7</td> <td>0.7</td> <td>0.8</td> <td>0.9</td> <td>0.9</td> <td>0.9</td> <td>1.0</td> </tr> <tr> <th>PEEP</th> <td>5</td> <td>5</td> <td>8</td> <td>8</td> <td>10</td> <td>10</td> <td>12</td> <td>14</td> <td>14</td> <td>14</td> <td>16</td> <td>18</td> <td>18</td> <td>24</td> </tr> </table> <table border="1"> <tr> <th colspan="12">Higher PEEP/lower FIO<sub>2</sub> Strategy (May consider if PaO2/FiO2 is &lt;100, high Pdr, BMI&gt;40)</th> </tr> <tr> <th>FiO<sub>2</sub></th> <td>0.3</td> <td>0.3</td> <td>0.3</td> <td>0.3</td> <td>0.3</td> <td>0.4</td> <td>0.4</td> <td>0.5</td> <td>0.5</td> <td>0.8</td> <td>0.8</td> <td>0.9</td> <td>1.0</td> <td>1.0</td> </tr> <tr> <th>PEEP</th> <td>5</td> <td>8</td> <td>8</td> <td>10</td> <td>12</td> <td>14</td> <td>16</td> <td>16</td> <td>18</td> <td>20</td> <td>22</td> <td>22</td> <td>22</td> <td>24</td> </tr> </table>	Lower PEEP/higher FIO <sub>2</sub> Strategy (*Default - May consider if low Pdr or pediatrics)												FiO <sub>2</sub>	0.3	0.4	0.4	0.5	0.5	0.6	0.7	0.7	0.7	0.8	0.9	0.9	0.9	1.0	PEEP	5	5	8	8	10	10	12	14	14	14	16	18	18	24	Higher PEEP/lower FIO <sub>2</sub> Strategy (May consider if PaO2/FiO2 is <100, high Pdr, BMI>40)												FiO <sub>2</sub>	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.8	0.8	0.9	1.0	1.0	PEEP	5	8	8	10	12	14	16	16	18	20	22	22	22	24
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# Adjunctive Therapies for ARDS Hypoxemia

<b>Fluid Management</b>	<ul style="list-style-type: none"> <li>Concentrate IV medications and consider diuresis once hemodynamically tolerated with goal of euvolemia</li> <li><b>FACTT Trial</b> of conservative vs. liberal fluid strategy showed conservative fluid strategy improved oxygenation, more ventilator-free &amp; ICU-free days, no increased shock. However, no mortality benefit.</li> </ul>
<b>Paralysis</b>	<ul style="list-style-type: none"> <li>Check <b>adequate sedation, then consider paralysis</b> no longer than needed</li> <li><b>Choice of agent</b> (each with pros &amp; cons, may vary by setting): cisatracurium, atracurium, rocuronium, pancuronium, or vecuronium</li> <li>Monitor degree of paralysis with serial train-of-four (TOF) &amp; wean as able</li> <li><b>ACURASYS Trial</b> showed mortality benefit; <b>ROSE Trial</b> did not</li> <li>Short term paralysis eliminates work of breathing and can be helpful to accurately assess respiratory mechanics</li> </ul>
<b>Prone Positioning</b>	<ul style="list-style-type: none"> <li><b>Prone patient for ~16h at a time</b>, continue proning until P:F &gt;150 with PEEP remaining &lt;10 cmH<sub>2</sub>O while patient is supine for &gt;4h</li> <li><b>Alternate with supine positioning</b> which allows for patient care</li> <li><b>Do not need special bed; manually proning requires a team</b></li> <li><b>If unable to prone</b>, could put less diseased lung down to improve V/Q match</li> <li><b>PROSEVA Trial</b> showed mortality benefit</li> </ul>
<b>Pulmonary Vasodilator Therapy</b>	<ul style="list-style-type: none"> <li>No data demonstrate mortality benefit with pulmonary vasodilators</li> <li><b>Inhaled Prostacyclin Initial Dose:</b> 50 ng/kg/min PBW (range 10-50 ng/kg/min); should be weaned (10 ng/kg/min increments q30min; once at 5ppm consider wean by 1ppm) to avoid hemodynamic compromise</li> <li><b>Inhaled Nitric Oxide (iNO) Initial Dose:</b> ~20ppm; should be weaned (5 ppm increments q30min) to avoid potential hemodynamic compromise</li> <li><b>Caution</b> if reduced left ventricular function, pulmonary hemorrhage,</li> </ul>

### Predicted Body Weight (kg)

Males = 50 + 2.3 [height (inches) - 60]  
Females = 45.5 + 2.3 [height (inches) - 60]

Height	PBW f/m	4mL/Kg f/m	5mL/Kg f/m	6mL/Kg f/m	7mL/Kg f/m	8mL/Kg f/m
58" (147cm)	40.9/45.4 kg	164/182	205/227	245/272	286/318	327/363
60" (152cm)	45.5/50 kg	182/200	228/250	273/300	319/350	364/400
62" (157cm)	50.1/54.6 kg	200/218	251/273	301/328	351/382	401/437
64" (163cm)	54.7/59.2 kg	219/237	274/296	328/355	383/414	438/474
66" (168cm)	59.3/63.8 kg	237/255	297/319	356/383	415/447	474/510
68" (173cm)	63.9/68.4 kg	256/274	320/342	383/410	447/479	511/547
70" (178cm)	68.5/73 kg	274/292	343/365	411/438	480/511	548/584

### Imputed Values for P:F Ratio

- Use when blood gas analysis unavailable ([Link to source data](#))

Measured SpO <sub>2</sub>	Imputed PaO <sub>2</sub>	FiO <sub>2</sub>	Imputed P:F
96%	82 mmHg	≥0.6	≤137
95%	76 mmHg	≥0.5	≤152
94%	71 mmHg	≥0.5	≤142
93%	67 mmHg	≥0.5	≤134
92%	64 mmHg	≥0.5	≤128
91%	61 mmHg	≥0.4	≤153
90%	59 mmHg	≥0.4	≤148
<89%	≤57 mmHg	≥0.4	≤150

# High Pressures, Desaturations & Dyssynchrony

<b>General Considerations</b>	<ul style="list-style-type: none"> <li>Is the ventilator set to FiO<sub>2</sub> 100% while you troubleshoot?</li> <li>Is the patient hemodynamically unstable? If so, consider pressors &amp; urgent evaluation for pneumothorax or severe auto-PEEP.</li> <li>Is the ventilator circuit connected &amp; set correctly?</li> <li>Are breath sounds bilateral? If unilateral, consider mainstem ETT, lobar collapse, and pneumothorax.</li> </ul>
<b>High Pressures</b>	<ul style="list-style-type: none"> <li>Is the patient agitated or asynchronous?</li> <li>Can a suction catheter pass easily through the endotracheal tube? If no, consider kinked tube, biting/bite block, secretions/suction, or replace ETT.</li> <li>What is the Pplat?</li> </ul>
<b>Diagrams</b>	
<b>Troubleshooting low compliance:</b>	<p>Decrease V<sub>T</sub>, &amp; evaluate for breath stacking (auto-PEEP). Consider ↓PEEP or adjunct therapies for hypoxemia if decrease in PEEP causes desaturations.</p>
<b>Troubleshooting high resistance:</b>	<p>Work outside (machine) to inside (alveoli); circuit problem, ETT kink/occlusion/biting, ETT obstructed/mainstem, large airway obstruction (mucous plug), small/medium airway obstruction (bronchospasm); auscultation &amp; passing a suction catheter can quickly eliminate many of these.</p>
<b>Desaturations</b>	<ul style="list-style-type: none"> <li>Is the endotracheal tube in good position? (consider CXR)</li> <li>Is the pulse oximetry waveform good quality?</li> <li>Is there acute hypotension? Evaluate for tension pneumothorax, air trapping and pulmonary embolism</li> <li>Is the source of oxygen faulty or is there an air leak? Check each connection/element sequentially from source of oxygen to the patient.</li> <li>Are there concomitant pressure elevations? If so, see "High Pressures" (next column)</li> <li>Is P:F &lt;150 in setting of worsening ARDS? If so, consider adjunct therapies (above).</li> <li>Are there signs of infection? Consider ventilator-associated pneumonia.</li> </ul>
<b>Patient-Ventilator Dyssynchrony</b>	<ul style="list-style-type: none"> <li>Detect signs of dyssynchrony: coughing, paradoxical breathing, ventilator alarms (low tidal volumes or high pressures), breath stacking.</li> <li>Treat underlying causes: 1) <i>Ineffective triggering</i> (patient or ventilator); 2) <i>Inappropriate triggering</i> (patient inspires while ventilator expires); 3) <i>Auto-triggering</i> (non-respiratory muscle movement triggers ventilator); 4) <i>Flow dyssynchrony</i> (too fast or too slow)</li> </ul> <p><b>General Approach</b></p> <ul style="list-style-type: none"> <li>Treat pain or anxiety if present</li> <li>If ineffective ventilator triggering change trigger sensitivity, decrease VT or pressure</li> <li>Increase V<sub>T</sub> to 8 mL/kg and increase flow rate if pressures allow. Consider change to decelerating flow delivery if setting available.</li> <li>If still dyssynchronous, paralyze patient (and sedate patient to RASS goal -5)</li> </ul>

# Discomfort & Delirium

<b>Discomfort (pain, agitation, anxiety) &amp; Delirium</b>	<ul style="list-style-type: none"> <li>Ensure appropriate <b>analgesia &amp; sedation</b> to minimize ICU/IMV duration &amp; risk of long-term neuropsychiatric impact.</li> <li><b>Reassess every &lt;4 hours using a standardized scale</b> <ul style="list-style-type: none"> <li>Goal RASS -4 to 0 in intubated patients</li> <li>If RASS -4 to -5 consider lightening sedation unless patient is paralyzed or dyssynchronous with ventilator.</li> <li>Target RASS -5 for paralyzed patients. <b>Never paralyze without sedation</b></li> </ul> </li> <li>Perform Daily Sedation Interruptions (DSIs) in non-paralyzed patients to reassess sedation &amp; analgesia needs, which can guide weaning these medications.</li> </ul>
<b>Delirium:</b> Prevention & treatment of delirium reduces mortality and ICU/IMV duration	<ul style="list-style-type: none"> <li>Screen every 12h using standardized tool (i.e. CAM-ICU)</li> <li>Treat delirium by addressing underlying causes (pain, agitation, anxiety, or physiologic derangements)</li> </ul>

# Ventilator Weaning & Extubation

<b>SBT Initiation Criteria</b>	<ul style="list-style-type: none"> <li>FiO<sub>2</sub> ≤ 0.50 and PEEP ≤8</li> <li>No ↑ in PEEP/FiO<sub>2</sub> requirements over past 24hrs</li> <li>pH &gt; 7.30. VE &lt; 15 L/min</li> <li>~MAP &gt; 60 mmHg (minimal pressors)</li> <li>ICP: non-labile and &lt; 20 mmHg w/ CPP &gt; 60 mmHg</li> <li>No MI in previous ~48hr</li> </ul>
<b>Weaning Strategies</b>	<ul style="list-style-type: none"> <li>Once daily SBT PS Pinsp 7-8/PEEP 5-8 cmH<sub>2</sub>O x 2hr (2nd daily trial permissible if failure was sedation-related or caused by some other transient issue)</li> <li>SBT x 30min ~probably as good as SBT x 2hr if &lt;48h intubated</li> <li>SBT x 2hr better predictor if intubated &gt;48h</li> <li>If <b>cardiogenic pulmonary edema risk</b>: Consider 15min T-piece (i.e. d/c PS &amp; PEEP)</li> <li>RSBI (rapid Shallow Breathing Index) = f/V<sub>T</sub>, is unreliable; &lt;80 goal for extubation; sensitive, not specific (if &gt; 105, good predictor of failure)</li> <li>Daily sedation interruption = faster extubation, shorter LOS</li> </ul>

<b>Extubation Criteria</b>	<ul style="list-style-type: none"> <li>Have you fixed the original problem and <b>no upcoming procedures</b>?</li> <li>Adequate <b>oxygenation</b>? (PaO<sub>2</sub> &gt; ~60 on PEEP&lt; 8 cmH<sub>2</sub>O, FiO<sub>2</sub> &lt;0.50)</li> <li>Adequate <b>ventilation</b> without excessive <b>work of breathing</b>? (ΔPaCO<sub>2</sub> of &lt; 10 mmHg with remaining pH &gt; 7.30 during SBT)</li> <li><b>Secretions?</b> (assess cough strength, suction frequency &amp; secretion volume)</li> <li><b>Airway protection?</b> (assess gag, sponit cough and GCS) <ul style="list-style-type: none"> <li>Assess <b>risk of post-extubation airway obstruction</b>: <ul style="list-style-type: none"> <li>Consider cuff leak test if: intubation &gt;6d, trauma, multiple intubations, prolonged prone, flat, volume overload, head/neck trauma, among others</li> <li><b>Cuff Leak Test: 1.</b> pt must be sedated (interaction with vent = incr PIP= incr leak = false reassurance); <b>2.</b> Suction oropharynx; <b>3.</b> Initiate AC-VC V<sub>T</sub> 8 mL/kg, RR 12, Ti: 1.5sec, Flow 50 LPM; <b>4.</b> Measure expired V<sub>T</sub>; <b>5.</b> Deflate cuff and wait 6 breaths; <b>5.</b> Measure expired V<sub>T</sub> expired V<sub>T</sub> (goal is   by &gt;110mL in measure expired V<sub>T</sub>); <b>6.</b> Reinflate cuff</li> <li>Decrease aspiration risk by holding tube feeds for safe interval (~6-8h)</li> <li>Extubation criteria/goals for neuro patients may be different (e.g. visual tracking, swallowing, GCS&gt;10, &lt;40yo)</li> </ul> </li> </ul> </li> <li><b>Hemodynamics</b> - re-intubation of an unstable patient can be lethal</li> </ul>
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