COVID-19 Ventilator Sheet

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Pre-intubation Considerations
- Awake patient proning has some anecdotal evidence. Early intubation for clinical worsening or escalating oxygen requirements, especially once on NIPPV (non-invasive positive pressure ventilation).

ARDS = Acute Respiratory Distress Syndrome
- Diagnosis - acute hypoxia with bilateral infiltrates on imaging in setting of pO2 to FiO2 ratio <300 not fully explained by cardiac failure. Management focuses on oxygenating while reducing risks of ventilator induced lung injury (VILI) by minimizing tidal volumes, airway pressure, and FiO2 while using higher PEEP and deeper sedation or prone to maintain vent synchrony.

Ventilator Basics – Goal is to Oxygenate and Ventilate

Minute Volume (MV) = Respiratory Rate per minute (RR) x Tidal Volume (VT)
- This equation determines ventilation, and increasing MV will allow for more pCO2 clearance. In general, we target low TV, which require higher RR to maintain same MV.
- Monitoring blood gases 15-30 minutes after ventilator change can aid in management.
- Normal MV between 6-12 depending on clinical status.

Oxygenation
- Goal pulse ox >92%
- Oxygenation can be improved by increasing positive end expiratory pressure (PEEP) and FiO2 as needed. In setting of ARDS, would favor using a HIGH PEEP strategy, with increasing PEEP and FiO2 per ARDSnet protocol to obtain goal SaO2.
- Recruitment maneuvers – RT places patient on continuous pressure (often 30-40 cm H2O) for a set time (30-40 seconds) to recruit alveoli to improve oxygenation. Can be used on “backup” when ventilator parameters (VT or RR) is repeating then should move to other methods such as paralysing, proning, inhaled therapy or ECLS consideration.
- Increased risk of arrhythmia or hypotension during maneuver.

Ventilator Modes – In ARDS, control mode is recommended. In this institution, we generally avoid volume mode.
- Pressure-limited assist control (PC) – Set the minimum RR, PEEP, and target inspiratory pressure (= pressure over PEEP, ΔP, or “delta”).
- Vent will deliver set pressure and patient’s compliance will determine a dependent volume. Patient can breathe faster than set RR if needed. Need to be monitored for changing volumes (such as increasing TV as compliance improves in ARDS) that would require change in delta.
- Pressure support (PS) – Set the FI02, PEEP and ΔP, patient will determine their MV based on their compliance and RR.
- Best ventilator mode for lightly sedated patients requiring minimal support. Improves synchrony and comfort, however requires more patient effort.

Tidal Volume Goals – If ARDS, target TV of 6 cc/kg of ideal body weight (dependent on sex and whether actual weight or height, not actual weight) which is called low tidal volume ventilation (LTTV) and has proven mortality benefit.
- Lung compliance determines how much pressure is required to reach a certain TV. Vent dysynchrony can make this difficult, in which case would increase sedation and consider paralysis. Be careful to monitor plateaus (RT can check this, it is pressure at end inspiration without flow), which should be < 30 cm H2O and often limits our TV and MV.
- Once plateau pressures >30, decrease TV by 1 ml/kg IBW down to 4 ml/kg IBW if needed.

PEEP – This maintains pressure at alveolar level as patient exhales, which keeps recruited alveoli open. Favor higher PEEPs, up to 20-24 cm H2O in some cases, to maintain oxygenation in this population. Minimum PEEP is 5 cm H2O.

RR – Generally set at 12 to 16 breaths/minute initially unless significant hypoxia. If not breathing spontaneously, repeat blood gases will aid in ensuring adequate MV (be sure to note actual TV and RR when calculating MV, versus set RR). We tolerate pH >7.15 with hypercarbia at if target TV in LTV, using RR to adjust MVE. RR >30, inspiratory times will begin to decrease and can cause decruitment or patient auto-PEEPs.
- If E:ratio – generally 1:3 but can move to 1:1 to maintain recruited alveoli.

Sedation – Often treating pain, delirium and agitation with multiple agents. Managed as step-up therapy, goal to have calm and responsive patient but similarly need to ensure enough sedation for vent synchrony and to limit double-triggering (breath stacking).
- Assess pain first - fentanyl PRN (50 to 200 mcg per dose) mainstay. May cause hypotension. Avoid infusion. Consider longer acting agents or higher dosing if on chronic opiates and poor control.
- Agitation – favor propofol (5-50 mcg/kg/hr) or precede (0.2-0.7 mcg/kg/hr) infusions as first line for their short half lives. They do not treat pain. Propofol can cause hypotension and pancreatitis (11% and 3rd day lipoase/TGs monitored, >360 or >500 respectively then should be stopped). Precedes cause headache for hypotension and may not sedate some patients. Benzodiazepines are not generally recommended unless there is another indication such as seizure or alcohol withdrawal.
- ARDS patients on vent requiring paralytics MUST be on fentanyl infusion (100-300 mcg/hr) and versed infusion (0.02-0.1 mg/kg/hr) while paralyzed, by deep sedation.

Proning – Consider if FiO2 >0.6 to maintain sats >92%. Patient is prone placed (face down) in order to improve ventilation and perfusion (VQ) matching and potentially improve alveolar recruitment. Improved mortality in ARDS. Generally prone for 12-16 hours. Need to consider access and habits prior to proning, as well as contraindications. Often improve oxygenation within minutes to hours, if not reaching goals once prone for 6-8 hours then need to consider ECLS. Video example.

Neuromuscular Blockade (NMB) – Used to facilitate LTV, especially in setting of dysynchrony, proning, or high plateau pressures. Currently recommend tri-methylated (benzatracinum here), but then switch to continuous infusion if persistent need for NMB. In general once on continuous infusion, want 12 to 24 hours before determining if to wean back. Goal <48 consecutive hours paralyzed. Need “triumph of 4” ahead of which we test muscle contractions post-stimulus, with goal TOF count 1. Patient must be deeply sedated with fentanyl and versed infusions before paralytics.

Inhaled Pulmonary Vasodilators – Currently only inhaled epoprostenol recommended for COVID population, this is used to improve VQ matching. Started at 0.01-0.05 mcg/kg/min and increased in stepwise fashion based on efficacy and tolerability. Wean by decreasing 0.01 mcg/kg/min every 1-2 hours as tolerated.

COVID Specific Techniques
- Early high PEEP seems to be beneficial – would follow HIGH PEEP ARDSnet Table closely, would keep high and drop FiO2 if improving oxygenation.
- Early threshold to paralyze and/or prone if not meeting oxygenation goals with moderate PEEP and moderate FiO2.
- Conservative fluid strategy – patients should be actively diuresed early on as blood pressure and creatinine tolerate if not actively hypervolemic, regardless of classical findings for end organ damage (pitting edema, hospital acquired pneumonia).
- When to Consider Extubation – There is no hard-and-fast rule for when to extubate.
- In general, patient with improved underlying pathophysiology with spontaneous breathing efforts (not on inotrope, bronchodilator) and potentially hemodynamic support (on inotrope, bronchodilator) will favor for extubation. Generally should tolerate PS mode with SBT for between 30 to 120 minutes depending on clinical scenario, without significant desaturations, tachypnea, or hemodynamic instability. Daily SBT and Spontaneous Awakening Trials (SAT)
- These should be done daily and usually together, exceptions being those patients that are in severe ARDS, paralyzed, or require sedation for other purposes (like benzodiazepine for status epilepticus). SBT generally is PS with delta of 5 and PEEP of 5 (“over 5”) and FiO2 >50 with sedation turned off or minimized. Obese patients may require 8/8.
- Other things to consider – Are tracheal secretions manageable off vent? Is mental state improved enough to protect airway once extubated? Do they have a sufficient cough? Can they generate significant inspiratory force without positive pressure (check by asking them to take deep breath)?
- Is the airway itself safe for extubation (i.e. angioedema, etc)? Are they candidate for rescue therapy such as NIPPV or HMPC if they fail? Would patient want to be reintubated if fails extubation?

Important Orders for Ventilated Patients – name of order in parentheses.
- “General Adult Ventilator Management” – An order set which includes NPO, continuous pulse oximetry, telemetry monitoring, maintain head of bed >30 degrees, oral care, adult respiratory care protocol (used for RT to follow as closely as well as lab, imaging, and stress ulcer prophylaxis order set. Use this for every patient newly intubated.
- “Ventilator Management” – Input vent mode, FiO2, PEEP, and other required settings (such as TV, RR, delta). Be frequently change this order as needed. Would ensure direct communication with RT if making an important vent change. This order is called “Mechanical ventilation” when part of order set.
- “ICU MUCI Analgesia-Based Sedation & Delirium Protocol” – An order set, which include the CAM-ICU, CPOIT, and KASS assessments, non-pharm delirium interventions, and medication options for analgesia (fentanyl and fentanyl citrate), paralytics (vecuronium, pancuronium), and propofol if appropriate (along with propofol infus pump), as well as delirium medications which we general do not use up front.
- “Extrusion” – Would discuss with RT timing of extubation and plan for post-intubation oxygen support.
- “Epoprostenol (VELETRI) inhalation solution” – Inhaled pulmonary vasodilator
- “Keep prone” – A nursing order for proned patients, there is a “specialty bed (aka PRONE POSITION) order” but we do not have extra prone beds at this time.

Lifespan COVID-19 Provider Information
Airway Management Algorithm
Lifespan Algorithms to Assess for COVID
ARDSnet Protocol
Helpful Links
Surviving Sepsis Campaign COVID-19 Guidelines
Oxyhemoglobin
Therapeutic Management

Note: this document was created by the Division of Pulmonary, Critical Care, and Sleep Medicine at Brown University and may be modified or updated as the COVID-19 situation evolves. Last update 3/13/20.