



Respiratory Care Escalation, Non-Invasive Positive Pressure Ventilation (NPPV), and ICU Management

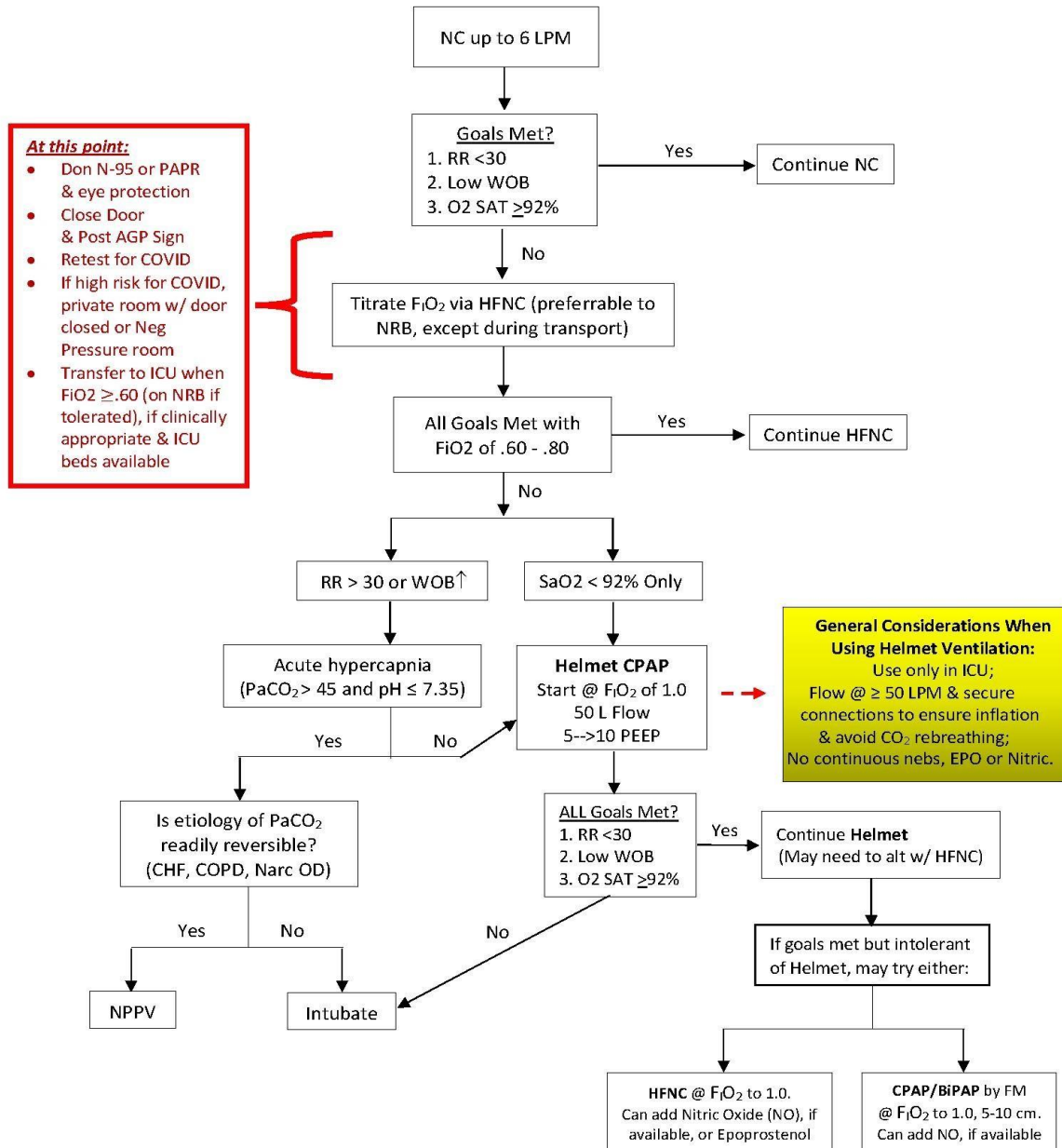
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Guideline Summary:

This guideline provides recommendations on how to care for hypoxemic/ and or hypercapnic respiratory failure in adult patients with, or at risk for, COVID-19 infections. It includes recommendations on how to select a respiratory support device, the settings to prescribe, and the infection control practices that should be followed.



Algorithm for Recommended Oxygen Escalation and Use of NPPV in Patients with, and Those at Risk for, COVID-19





Guidelines for Treatment of Hypoxemia

Acute Hypoxemia

1. If $\text{SaO}_2 < 94\%$ or increased work of breathing, despite supplemental oxygen up to 6 LPM NC, high flow nasal cannula (HFNC) is the preferred option for further oxygen escalation given its association with improved patient outcomes compared to use of a non-rebreather (NRB) mask:
 - **High Flow Nasal Cannula (HFNC):** Up to FiO_2 of .80 (1.0 for transient, emergent treatment) with flows of 10-60 LPM. Place surgical face mask over nose and mouth in all patients. Recommend setting up a NRB mask in room as back up.
 - **If HFNC is not available, use NRB mask:** Up to FiO_2 of .80 (1.0 for transient, emergent treatment) using flows from 10-15 LPM. Place surgical face mask covering holes in mask.
 - **When and how to transfer to ICU:**
 - Consider transfer at an FiO_2 of $\sim .60$ and, if on HFNC, a flow rate of 50 LPM, if clinically appropriate.
 - **Note:** If ICU beds are limited consider a higher FiO_2 threshold for transfer, particularly if work of breathing (WOB) is not increased.
 - To preserve O_2 supply during transport use a NRB at FiO_2 of 1.0, providing SaO_2 at goal and WOB not excessive. If these goals are not met on NRB, other transport options include Helmet, HFNC, or BiPAP, however, these all require high oxygen flows that may deplete O_2 supply. See page 10 of this document for how to ensure safe patient transport.
2. If $\text{SaO}_2 < 94\%$ **despite** HFNC or NRB at FiO_2 from .06-.80 in the absence of a high RR (>30) and/or increased work of breathing:
 - **Helmet Continuous Positive Airway Pressure (CPAP)** should be considered using the following settings: Start at FiO_2 of 1.0 and titrate down, flow rate ≥ 50 LPM, and PEEP 5-10 cmH₂O (See [Helmet CPAP Quick Guide](#) and [StarMed Helmet Operational Guide](#))
Note: Compared to HFNC or NRB mask, as well as CPAP via facemask, use of Helmet CPAP may reduce the need for intubation by improving both oxygenation and work of breathing. However, if the Helmet is considered for use only after a patient fails to respond to maximal HFNC (or NRB) settings (FiO_2 1.0/60 LPM) this may unsafely delay intubation. Thus, switching to
Helmet CPAP should be considered when the FiO_2 on HFNC (or NRB) is from .60 to .80
 - For *comfort/oral access* provide breaks with intervening HFNC or NRB use prn during the day and qHS.



- If *intolerant* of Helmet, there are 2 other options to consider:
 - **Option #1: HFNC** to an FiO₂ of 1.0
 - a. If still not meeting SaO₂ goals, at HUP may consider adding inhaled Nitric Oxide (NO @ 20 PPM; preferred choice for inhaled vasodilator) or inhaled Epoprostenol (EPO @ 50 ng/kg/min) through aerogen nebulizer. See inhaled vasodilator section on page 5 for details.
 - **Option #2: CPAP/NPPV** via full facemask with 5-10 cm H₂O; start with an FiO₂ of 1.0 and titrate downward to SaO₂ goal
 - a. If still not meeting SaO₂ goals, at HUP may consider adding NO during NPPV with a mechanical ventilator and dual limb circuit only.
- Patients on NPPV (Helmet, CPAP, BiPAP) may need to alternate devices with HFNC (or NRB) to take breaks from the positive pressure. This is ideally accomplished, if available, using a dual-capable mechanical ventilator, e.g. Servo-U or Hamilton C1/T1 with HFNC option. If an inhaled vasodilator is being used, NO is the preferred agent as EPO use in a mechanical ventilator requires frequent (at least q4) filter exchanges and close monitoring to avoid filter obstruction causing HCW aerosol exposure.
- Although the alternative options may be effective, *intubation* should also be considered to avoid the risk of significant desaturation associated with delayed intubation, particularly when (1) unable to meet oxygenation goal, (2) excessive work of breathing, or (3) decreasing level of consciousness.
- **If RR is > 30 and/or increased work of breathing**, check PaCO₂ first as Helmet CPAP is not indicated in acute hypercapnia. If the cause of acute or acute on chronic hypercapnia (PaCO₂ > 45 and pH ≤ 7.35) is readily reversible, e.g. CHF, COPD, narcotic overdose, a trial of NPPV may be considered (see section **NPPV Procedural Considerations for Acute or Acute-on-chronic hypercapnia** on page 6 for suggested initial settings); otherwise proceed with intubation.
- **Adjuncts to improve oxygenation:**
 1. Prone Positioning:
 Often improves oxygenation. In spontaneously breathing patients consider self-proning, if tolerated (see [Awake proning for non-intubated patients](#)), or prone ventilation in intubated ARDS patients if P:F ratio <150 on FiO₂ 0.60 (see [Prone in Severe ARDS](#))
Note: Also shown to reduce mortality in intubated ARDS patients
 2. Inhaled Vasodilators (iVD):



Inhaled Epoprostenol (iEPO) or Nitric Oxide (iNO- HUP only) may improve oxygenation quickly but neither reduces mortality. iVD may be considered in non-intubated patients, as described above; as well as for intubated patients with refractory hypoxemia and/or to treat RV failure. The Respiratory Care practice and Medical Board guidelines in place at each entity should be followed.

At entities that have an iEPO program, iEPO may be given through HFNC as this is the only oxygen support device that doesn't require an in-line bacterial/viral filter. If iEPO is being used through other oxygen support devices the in-line filters need to be replaced every 4 hours (to avoid filter occlusion)..

At HUP, iNO may be used safely through all oxygen support devices, except the Helmet (neither medication should be used with Helmet ventilation). When HFNC is used, iNO is preferred over iEPO, so it can be continued in patients requiring alternating oxygen devices (except Helmet). However, if iNO is unavailable, patients on a HFNC device can be transitioned to iEPO (since no filter is required).

Note: If iNO is used with BiPAP, this should only be done with a mechanical ventilator and a dual limb circuit.

- a. **Indication/Dosing:** For hypoxemia - start NO @ 20 PPM. For RH failure - with or w/o hypoxemia start NO at 40 PPM. For EPO always start @ 50 ng/kg/min.
- b. **Maintenance:** Within 30 minutes of initiation, if no objective benefit (e.g. PO₂ fails to increase by > 10 mm Hg) discontinue without weaning. If response confirmed, when stable titrate dose down q 30 min, per guidelines, to establish a minimal effective.
- c. **Weaning:** Once patient is stable and meeting/exceeding oxygenation (+/- LPV) goals, with provider approval start weaning off per protocol, as tolerated.

Chronic hypoxemia

If baseline oxygen requirements are ≥ 6 LPM (e.g. advanced/chronic lung disease, lung transplant), consider either HFNC at 10-60 LPM up to an FiO₂ of 1.0, or NRB mask from 10-15 LPM (with surgical face mask over either oxygen delivery device).



Guidelines for Treatment of Hypercapnia and Use of Non-Invasive Positive Pressure Ventilation (NPPV)

➤ General guidelines for all patients:

- **Approval is NOT required** for use of NPPV (CPAP, BPAP, VAPS, etc)
- Since NPPV is a **high-risk AGP**, to prevent HCW exposure or nosocomial SARS CoV-2 transmission NPPV should only be used for an appropriate indication, including:
 1. Acute hypoxemia failing or intolerant to HFNC and/or Helmet ventilation
 2. Acute hypercapnic respiratory failure ($\text{PaCO}_2 > 45$, $\text{pH} \leq 7.35$; e.g. COPD, narcotic OD, cardiogenic pulmonary edema)
 3. Acute on chronic hypercapnic respiratory failure (e.g. COPD)
 4. Chronic hypercapnia (e.g., OHS, COPD, neuromuscular disease, or an overlap syndrome)
 5. OSA:
 - a) **AVOID** in **COVID-positive** patients with **isolated, uncomplicated OSA** (no hypercapnia), as the risks to HCW's outweigh benefits. Exceptions should be approved by the RT supervisor.
 - ** Supplemental O_2 (goal SaO_2 88-92%) and HOB elevation are recommended as safe alternatives
 - b) **CONSIDER** in **COVID-positive** patients with **overlapping OSA/ hypercarbia** OR in the presence of complicating factors such as: **postoperative state, narcotic use, cardiovascular comorbidities**
- If NPPV is used proper PPE and isolation precautions are essential (See table on next page for *Summary of Clinical Scenarios, PPE, Room Environment and COVID Retesting Recommendations*)
- **Patient-owned devices should NOT be used**; switch to hospital-issued devices (both mask and machine). If an acceptable hospital product is unavailable or refused, exceptions can be made but require approval from the RT supervisor
 - ** Use a well-fitted, non-vented, full-face mask with anti-asphyxiation valve
 - ** If using the V60 ventilator, set mask setting to "1" for patient leak (not total leak)
 - ** Use a circuit with an expiratory filter
- **For COVID-negative patients**, with increasing clinical suspicion for COVID or new respiratory clinical emergency, code, or intubation, repeat COVID testing should be performed if no prior negative test within 24 hours

➤ Starting NPPV Outside the ICU for Acute Respiratory Failure:

NPPV may be initiated outside the ICU, based on current guidelines ([see entity-based guidelines for the Initiation and Maintenance of CPAP and NPPV outside of the ICU](#)) when the indication for initiation has a readily reversible cause (e.g., COPD exacerbation, pulmonary edema, narcotic overdose).

If **suspected COVID pneumonia, **immediate** ICU transfer is recommended (unless immediate intubation is required).

- Recommended initial settings for acute or acute on chronic hypercapnic respiratory failure:



1. FiO₂ .60, titrating to a goal SaO₂ of 88-92%.
2. IPAP 13-18, EPAP 8 (or PS 5-10, PEEP 8), ↑ RR to 14
 - *Note: If using Respironics V60: set I-time to 1 sec and rise time to 3 sec and adjust if needed
 - **Note: In all others: adjust I-time and rise time to prevent dysynchrony
 - Titration: Increase IPAP / (or PS) to a goal TV of 6-8 mL/kg IBW; then ↑RR to ↓ work of breathing; if the ↑ RR causes a ↓TV, cut back to reduce breath stacking
 - Once comfortable: ↑ IPAP / (or PS) by 2 cm H₂O approximately every 15-30 minutes until goal PaCO₂/pH achieved
 - To improve oxygenation ↑ EPAP and IPAP (or just PEEP) by 2 cm H₂O increments
- Sequence of action: Mask on → ventilation on; ventilation off → mask off
- Continue NPPV if respiratory status improves within 1 hour and patient stabilizes within 2 hours
- Proceed with intubation if (1) increased work of breathing, (2) altered consciousness, or (3) pH < 7.30 despite NPPV



Clinical Scenario	PPE	Isolation Precautions	Post AGP Sign?	Retesting Recommendations	PPE if COVID repeat testing negative*
A. COVID positive or PUI at any time during hospitalization and has an indication for NPPV	N95, face shield (or PAPR) + gown/ gloves	Private room with door closed, or negative pressure room, if available	Yes	N/A	N/A
B. COVID negative on admission <i>without</i> clinical suspicion <u>AND</u> chronic stable hypercapnic respiratory failure eligible for NPPV on admission	Universal Precautions	No special needs. Placement in private room preferred if available.	No	Repeat COVID testing only if clinical suspicion increases or patient has new respiratory clinical emergency, code, intubation. See E.	Continue universal precautions with surgical mask and eye protection
C. COVID negative on transfer from OSH <i>without</i> clinical suspicion <u>AND</u> chronic stable hypercapnic respiratory failure eligible for NPPV on admission	Universal Precautions	No special needs. Placement in private room preferred if available.	No	Repeat COVID testing only if clinical suspicion increases or patient has new respiratory clinical emergency, code, intubation. See E.	Continue universal precautions with surgical mask and eye protection
D. COVID negative on admission BUT <i>with</i> clinical suspicion (ie patient remains a PUI) <u>AND</u> chronic stable hypercapnic respiratory failure eligible for NPPV on admission	N95, face shield (or PAPR) + gown + gloves	Private room with door closed, or negative pressure room, if available	Yes	Repeat COVID testing at 24 hours from last negative test. If repeat negative and still clinical concern for COVID, discuss with Infection Control.	Move to universal precautions with surgical mask and eye protection
E. COVID negative on admission w/ Acute or Acute on Chronic hypercapnic respiratory failure and eligible for NPPV <u>OR</u> COVID negative but during hospitalization respiratory needs escalate to new NPPV eligibility	N95, face shield (or PAPR) + gown + gloves	Private room with door closed, or negative pressure room, if available	Yes	Repeat when initiating CPAP/BiPAP but wait 24 hrs from last neg test result. If neg, no need to retest at day 7.	Move to universal precautions with surgical mask and eye protection
F. COVID negative inpatient <i>without</i> clinical suspicion who undergoes a lower risk Aerosol Generating Procedure anytime (HFNC, open trach suctioning, nebulizers, NRB, venturi mask)	May wear N95, face shield (or PAPR) + gown + gloves during time of AGP.	No	Yes	For all OSH transfers consider retesting on admission. If patient has escalating O2 requirement > 6L repeat testing if no negative test within 24 hours.	Once initial retest negative, move to universal precautions with surgical mask and eye protection.



Guidelines for Respiratory Management of Patients With DNR/DNI Orders

- A. If patient goals are **restorative**, without invasive supportive therapies, follow the **same guidelines above** for hypoxemia and hypercapnia management, with the following exceptions/additions:
- Use opioid po or iv boluses prn as first line, in conjunction with oxygen therapies, to achieve adequate symptom control.
 - Consider whether patient might be safely managed on floor (i.e. not transfer to ICU) despite high FiO₂ or NPPV use. Encourage multi-disciplinary discussion to make this decision.
 - Consider **Palliative Care consult**.
- B. If patient goals are to receive **comfort measures only**, supplemental oxygen may be provided for comfort in addition to opioids and benzodiazepines based on the Comfort Care Pathway.
- If the patient remains breathless, despite these measures, and prefers not to receive additional sedatives to treat persistent dyspnea, NPPV may be considered to give the patient more time to either be with family or complete a personal goal (s).
 - When no longer desirable, NPPV should be discontinued while comfort is managed with additional pharmacology therapy +/- supplemental oxygen by NC, if desired.
 - Once comfort is achieved, weaning the oxygen off, or to 2LPM NC, should be considered.
 - Opioids remain the first line of therapy for achieving comfort

Guidelines for HCW Safety When Using Aerosol-Producing-Respiratory Care Procedures

- A. For all COVID-negative patients undergoing lower risk aerosol generating procedures (HFNC, open trach suctioning, nebulizers, non-rebreather, venturi mask):
- OSH patients transferred with open trach, HFNC or NRB/VM should have urgent COVID-19 testing repeated on transfer
 - Respiratory therapists and/or nursing may wear N95, face shield (or PAPR) during the first 7 days of admission
 - Respiratory therapists should be the only providers in patient room during nebulizer treatments and should wear N95, face shield (or PAPR) while administering nebulizer therapy for duration of stay (no room downtime needed following nebulizer therapy)
 - Unless change in clinical status or clinical concern for COVID, providers should follow universal mask + eye protection precautions
- B. See **[UPHS guidelines for Aerosol Generating Procedures \(AGP\)](#)**



Endotracheal Intubation

- A. Refer to specific UPHS guidelines. See [Difficult Airway Guidelines](#) and [Intubation Procedural Guidelines](#)
- B. All intubations, including in the ICU, should be called overhead STAT (follow the procedure in place at each UPHS entity).
- C. When possible, intubate in a negative pressure room.
Outside of the ICU:
 - If in a negative pressure room, intubate *before* ICU transfer to avoid transferring a non-intubated patient.
 - If not in a negative pressure room and intubation is not required immediately, transfer to the ICU first (with mask on patient; excluding NPPV*) and then intubate (given that intubation in a non-negative pressure room has greater risks to HCWs than does transferring a non-intubated patient).
 - ***Note:** NPPV should not be used to enable planned intubation in the ICU. Intubate prior to ICU transfer, unless plan is to continue NPPV in ICU.
 - If unstable for transfer, call anesthesia STAT for floor intubation. Minimize personnel and door opening.

Mechanical Ventilation Strategy

- A. Most patients intubated for COVID-19 have ARDS.
- B. Place mechanical ventilation order and select the Lung Protective Ventilation (LPV) protocol for ARDS using low PEEP/FiO₂ table. Also select Ventilator Liberation Protocol (VLP) so RT can screen daily for earliest time to start ventilator weaning (click embedded links to view protocol details).
- C. Consider early application of prolonged prone-positioning sessions and recommend initiating when guideline oxygenation criteria are met (p/f < 150, FiO₂ ≥ .60, PEEP ≥ 5) providing no contraindications (see [Prone in Severe ARDS](#))
- D. Other considerations for management of refractory hypoxemia, or when ventilator management is associated with injurious settings (excessive volume or pressures, c/b right heart failure) include deep sedation, neuromuscular blockade, inhaled pulmonary vasodilators, and VV ECMO for rescue therapy.
 - Note:** Contraindications to ECMO include: Age > 55-60, BMI >40, vented >10 days, cancer with life expectancy <1 year, MOSEF, severe liver, lung, or CNS disease, DIC, and BP fistula. Consider VA ECMO in appropriate patients with cardiogenic shock (e.g. severe myocarditis).



In-hospital Transport of a Patient in Acute Respiratory Failure

For transporting ED and Floor patients to the ICU:

1. See separate guideline [Respiratory Decomensation Quick Guide](#) for details.
2. **Threshold for ICU transfer:** Consider transfer when $F_iO_2 \geq .60$ and, if on HFNC, the flow rate ≥ 50 LPM to ensure that oxygen needs can be met appropriately during transport.
3. Perform a **Timeout** that includes:
 - a) Ensure patient stable for transport – consider whether intubation prior to transport is appropriate.
 - b) Selection of oxygen device and oxygen supply needs.
 - c) Receiving area notified and accepts patient with known COVID or PUI.
 - d) d)
 - e) **Before and during transport:**
 - i. Check and secure all tubing connections (if intubated see [Appendix 1](#) – for guidelines on securing ETT).
 - ii. **Have 2 FULL oxygen E-cylinders** ready. Consider 3 E-cylinders if prolonged transport time anticipated and/or patient requires high O_2 flow (see [Appendix 2](#) for estimated duration of O_2 supply based on F_iO_2 /flow rate settings) and plan for maximal F_iO_2 /flow rate support in case of any decompensation en route.
 - iii. Consider using Y-connector between O_2 tanks, if available, to ensure uninterrupted gas flow.
 - iv. Check and monitor E-cylinder reserve during transport.
 - f) **Transport Personnel:**
 - i. If a high flow oxygen device (HFNC, Helmet, NPPV, or Ventilator) is used, the patient should be accompanied by a RT and RN during hospital transport as special device set-up and additional supplies are needed.
 - ii. For other oxygen devices (NC, HTC, NRB, etc.) patient-specific transport needs should be individualized. Although RT and RN may not be required during transport, communication between the RT and RNs of the sending and receiving teams is essential.
 - iii. In all cases, evaluate individual patient needs and refer to entity based guidelines, to determine if a provider should be present during patient transfers.
4. **Oxygen Delivery System Options:**
 - a) **General Principles:**
 - i. Compared to a low flow oxygen device, the risk is increased significantly when transporting on a high flow oxygen device, i.e. HFNC, Helmet, NPPV, due to device complexity and risk of oxygen depletion. Thus, if patient is on a high F_iO_2 ($\geq .60$) a NRB mask is preferred for transport, if tolerated.
 - ii. Although infection risk to HCW and bystanders is less with low flow devices, surgical masks should be placed over these devices to reduce droplet dispersion.



b) **Transport Devices:**

- i. **NRB mask** at FiO_2 1.0 is the **preferred option** for all transports (to and from the ICU). If available, use mask with **expiratory valve/filter**; otherwise cover holes with a **surgical mask**.
 - 1) **O₂ source**: 1 E-cylinderii. If NRB is not tolerated, or ineffective, use either:
 - 1) **Option # 1: Helmet CPAP** at 5-10 cm H₂O with FiO_2 of .50 - .60 at a flow rate of 50 LPM; or
 - 2) **Option # 2: HFNC** (with surgical mask over nose and mouth)
 - 3) **O₂ source**: For both options (**Helmet or HFNC**) may use either:
 - a. Hamilton C1/T1 ventilator with 2 E-cylinders.
 - b. Max venturi system with 2 E-cylinders.

Note: At the 50 LPM flow rate required for the Helmet, the Max venturi may not be able to achieve FiO_2 of 1.0 (expect approx. FiO_2 of 0.9).

Note: For HFNC, to conserve oxygen supply consider titrating down flow rate (prior to transport) to lowest amount necessary to maintain stable SaO_2 and comfort.
- iii. If both **HFNC** and **Helmet** are not tolerated, or ineffective, consider **NPPV** (CPAP or BIPAP) as a last resort using full facemask (refer to mask/circuit specs), but only if plan is to continue NPPV in the ICU. Do NOT use NPPV to facilitate transport for a planned intubation in the ICU; intubate patient *prior* to transfer instead.

Note: **If hypercapnic**, intubate prior to transport *unless* patient stabilized on NPPV and cause of hypercapnia is readily reversible e.g. CHF, COPD, narcotic OD.

 - 1) **O₂ source**: **V60 ventilator** with **2 or 3 E-cylinders**.
 - 2) Ensure minimal air leak prior to, and throughout, transfer by tightening/adjusting mask. If available, consider placing **hood apparatus** over patient's head/mask to ensure any leak is contained. However, if a large air leak persists proceed with intubation for infection control purposes.
- iv. **If intubated:**
 - 1) When available, use a ventilator for transport; otherwise, can use Ambu bag **with** bacterial/viral filter.
 - 2) Secure ETT connection with tubing using a trach tie (see **Appendix 1** – for guideline on securing ETT).
 - 3) **O₂ source**: 1-2 E-cylinders.

Nebulizers

See separate guideline [Use of Nebulizers and MDIs](#) for details



Bronchoscopy

See separate guideline [Bronchoscopy](#) for details

Extubation

See separate guidelines [Ventilator Liberation, Extubation, and Cuff Leak Test](#) and [Palliative Withdrawal of Mechanical Ventilation in COVID-19](#) for details.

Tracheostomy Considerations

See separate [Tracheostomy Procedure Guidelines](#) for details.

Hemodynamic Fluid Management

Patients with COVID who have evidence of shock should be managed based on guidelines developed for shock in non-COVID patients. As in the case for non-COVID patients, the presence of ARDS and/or hypoxemia is not necessarily a contraindication to guideline mediated IV fluid therapy.

Diagnostic Studies:

1. Perform CXR and KUB after initial intubation and orogastric tube insertion to confirm position of tubes and assess lung fields.
2. Avoid routine imaging studies (x-ray, CT scan, ultrasound, echocardiogram), electrocardiograms, etc. unless the study has the potential to change management.



Reference:

Surviving Sepsis Campaign: Guidelines on the Management of Critically Ill Adults with Coronavirus Disease 2019 (COVID-19). Critical Care Medicine 2020; 48: e440-469.

Appendix 1:

Guideline for Securing ETT for COVID/PUI Patients

If ETT and Vent. Adaptor/in-line Suction Become Disconnected Repeatedly:

- Contact CDR for a roll of trach ties
 - Stock on unit if able
- Place Trach Tie around HUB and In-line sx or adaptor (see picture →)
 - Attempt to tie in bow type knot for easy removal
 - Scissors required at bedside in case of knot
 - Scissors must be easily accessible
- Consider using prophylactically when:
 - Proning
 - > 10cm PEEP

Transporting the Intubated Patient:

- Place Trach Tie as seen in pic-→
- Scissors required during transport
- In-line sx adaptor can be used to bag ventilate patient with filter
 - If any disconnection is necessary
 - Place vent in standby



Appendix 2: Estimated Duration of O2 Supply Based on Level of Support

	Time (Minutes) Available for Transport*					
FIO2	Total Air Flow Rate L/min	O2 Flow L/min		1 E-Cylinder	2 E-Cylinders	3 E-Cylinders
0.5	50	25		22	44	66
0.6	50	30		19	38	57
0.7	50	35		16	32	48
0.8	50	40		14	28	42
0.9	50	45		12	24	36
1	50	50		11	22	33
*Actual times may vary (Note: Low pressure warning will alert ~2 min prior to tank depletion)						