A Neurosurgeon’s Guide to Pulmonary Critical Care for COVID-19

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Introduction

As the number of people infected with the novel coronavirus rapidly increases, some neurosurgeons are being asked to participate in the care of critically ill patients, even those without neurological involvement. This presentation is meant to be a basic guide to help neurosurgeons achieve this mission.
Disclaimer

• The protocols discussed in this presentation are from the Mission: Possible program at University Hospitals of Cleveland, based on guidelines and recommendations from several medical societies and the Centers for Disease Control (CDC).

• Please check with your own hospital or institution to see if there is any variation from these protocols before implementing them in your own practice.
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COVID-19

- Coronavirus disease 2019 (COVID-19) is a respiratory tract infection caused by a newly emergent coronavirus, SARS-CoV-2, that was first recognized in Wuhan, China, in December 2019.

- Genetic sequencing of the virus suggests that SARS-CoV-2 is a betacoronavirus closely linked to the SARS.
Personal Protective Equipment

When taking care of COVID-19 patients, please adhere to all of your institution’s policies regarding personal protective equipment (PPE)

To help others, you must stay healthy yourself!
Our Isolation Protocols

- Admit to negative pressure room if available; if not enough negative pressure rooms available for all admitted COVID patients, preference given to non-intubated patients since their respiration is in an open system and they may require intubation
- Patient requires surgical mask when out of room for tests/procedures and when on HFNC
- Patient must remain in room with door closed
- No visitors unless comfort measures are being implemented – then, provide visitors with PPE and educate on procedures – one visitor at a time
- Use clear cassette drape/probe covers for portable imaging to minimize equipment contamination
- Staff require strict contact and droplet precautions
- Nurses to perform lab draws from lines to minimize contact among staff
- Minimize number of staff interacting with patients
- Bundle patient care duties to minimize number of interactions with patient by nurse (medications, vitals, I/Os, lab draws, meal service, etc)
ICU Admission for COVID-19

- Pneumonia with hypoxic respiratory failure
- Acute Respiratory Distress Syndrome (ARDS)
- Sepsis
- Septic shock
- Post cardiac arrest
Pulmonary Function

- Gas exchange occurs in the alveoli of the lung
  - Respiration: oxygen exchange
  - Ventilation: CO$_2$ exchange

- Acid-base balance: Because CO$_2$ is in equilibrium with H$^+$, ventilation affects pH
Causes of Respiratory Symptoms

- Inflammation or fluid in the alveoli preventing adequate gas exchange
- Airway sections
- Airway inadequacy
- Reactive airway disease
- Gas trapping
- Gas exchange abnormalities

Clinically significant hypoxia is defined by:

- $\text{SpO}_2 \leq 90\%$ in non-pregnant adults
- $\text{SpO}_2 \leq 92-95\%$ in pregnant patients
Managing Hypoxia

- **Standard supplemental oxygen therapy** – by nasal cannula - Start immediately to patients with SARI (severe acute respiratory infection) and respiratory distress, hypoxemia, or shock.

- **Initiate oxygen therapy** at 6L/min low flow nasal cannula or with face mask with or without reservoir bag (flow rates of 10-15 L/min, which is typically the minimum flow required to maintain bag inflation; FiO₂ 0.60-0.95)
Managing Hypoxia

High-flow nasal oxygen (HFNC)

- Use in pure hypoxic respiratory failure – aim for SpO₂ ≥94%
- Start flow at 20-30 L and FiO₂ 50%
- If FiO₂ > 80%, may increase flow up to a maximum of 40 L
- Use an isolation mask on top of the HFNC
- Patient should be closely monitored
  - Increases in flow or FiO₂ should prompt immediate reassessment for intubation, especially if accompanied by an increase in respiratory rate
Managing Hypoxia

Non-invasive ventilation (NIV)
- Use in selected group of patients
- Don’t transfer on NIV
- If used, all personnel in room must wear N95 masks
- Must have viral filter placed prior to expiratory limb
- Titrate EPAP to 8-10 cm H₂O
- Monitor every 2 hours
  - If FiO₂ needs or EPAP continue to increase, consider early initiation of mechanical ventilation
Bronchodilators

- In spontaneously breathing patients, **avoid nebulizing medication**
  - Increases risk of provider infection due to aerosolized particles
  - MDIs are preferred

- In mechanically ventilated patients, nebulizers are tolerated because the circuit is closed
  - If MDI is used, use 4 puffs with a spacer per dose
Mechanical Ventilation

Mechanical ventilation is to be implemented early in patients with COVID-19 pneumonia in respiratory failure

Positive pressure ventilation (PPV)

Most common mode is Volume Control

- Delivers a set volume with each breath
- Airway pressures will vary with respiratory mechanics and must be monitored to avoid further injury to the lungs
Goals Of Mechanical Ventilation

- Oxygenation - $\text{PaO}_2$ 55-80 mmHg or oxygen saturation ($\text{SpO}_2$) 88-95% in ARDS in general
  - Improved outcomes in COVID-19 patients when $\text{SpO}_2$ is kept above 94%

- I:E ratio - Duration of inspiration $\leq$ duration of expiration as long as tolerated hemodynamically in patients with ARDS
Ventilator Parameters

- $\text{FiO}_2$ - percent inspired oxygen
- RR - respiratory rate
- $V_T$ - tidal volume
- PEEP - positive end-expiratory pressure

Minute ventilation = RR x $V_T$
Initiating Mechanical Ventilation

- Calculate predicted body weight (PBW) in kg
  - **Males** = 50 + 2.3 [height (inches) - 60]
  - **Females** = 45.5 + 2.3 [height (inches) -60]

- Select ventilator mode as volume control/assist control

- Set ventilator breath at $V_T = 8 \text{ ml/kg PBW}$

- Set initial rate to approximate baseline minute ventilation (not > 35 breaths/min)

- If $P_{plat} > 28$-30, Reduce $V_T$ by 1 ml/kg at intervals $\leq 2$ hours until $V_T = 6\text{ml/kg PBW}$ and $P_{plat} < 30$
Initiating Mechanical Ventilation

- Start PEEP at 10 cm H$_2$O. Titrate PEEP/FiO$_2$ as guided by chart below
- If patient develops hypotension associated with increased PEEP do not continue to increase PEEP
- Initially, low PEEP strategies should be used. High PEEP may be used for patients who require increased support and have low lung compliance.

ARDSnet table

<table>
<thead>
<tr>
<th>Lo</th>
<th>FiO2</th>
<th>0.3</th>
<th>0.4</th>
<th>0.5</th>
<th>0.5</th>
<th>0.6</th>
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<th>0.9</th>
<th>0.9</th>
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<tbody>
<tr>
<td>PEEP</td>
<td>5</td>
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<td>8</td>
<td>8</td>
<td>10</td>
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<td>14</td>
<td>14</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td>Hi</td>
<td>FiO2</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>0.5</td>
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<td>0.7</td>
<td>0.8</td>
<td>0.8</td>
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<tr>
<td>PEEP</td>
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<td>20</td>
<td>20</td>
<td>22</td>
<td>22</td>
</tr>
</tbody>
</table>
Hemodynamic Effects of PPV

Decreased preload

- **Mechanism - Positive alveolar pressure**
  - compression of the heart by the inflated lungs
  - the intramural pressure of the heart cavities rises
  - venous return decreases
  - preload is reduced
  - stroke volume decreases
  - cardiac output and blood pressure may drop

- **Treatment – fluid therapy**
  - restore adequate venous return and preload
  - Over-resuscitation however should be avoided in this patient population

- **Conditions sensitive to change in preload include**
  - hypovolemia, pericardial tamponade, Pulmonary embolism, pulmonary HTN, and severe air trapping like asthma and COPD
Hemodynamic Effects of PPV

Reduced afterload

- Lung expansion increases extramural pressure (which helps pump blood out of the thorax) and thereby reduces LV afterload.

- When the cardiac performance is mainly determined by changes in afterload than in preload conditions (e.g., hypervolemic patient with systolic heart failure), PPV may be associated with an improved stroke volume. PPV is very helpful in patients with cardiogenic pulmonary edema, as it helps to reduce preload (lung congestion) and afterload. As a result stroke volume tends to increase.
Ventilator Airway Pressures

- **Peak pressure**
  - Maximal airway pressure any time during inspiration
  - Amount of pressure necessary to overcome airway resistance and expand the thoracic cage

- **Plateau pressure**
  - Amount of pressure necessary to overcome the elastic recoil of the lung and thoracic cage
  - Measured at the end of an Inspiratory Hold maneuver
From lecture by Kacmarek, RM
Goals Of Mechanical Ventilation

Plateau pressure goal: \( \leq 30 \text{ cm H}_2\text{O} \)

- Check \( P_{\text{plat}} \) (0.5 second inspiratory pause) at least q 4h and after each change in PEEP or tidal volume (\( V_T \))
  - If \( P_{\text{plat}} > 30 \text{ cm H}_2\text{O} \): decrease \( V_T \) by 1ml/kg steps (minimum = 4 ml/kg)
  - If \( P_{\text{plat}} < 25 \text{ cm H}_2\text{O} \) and \( V_T < 6 \text{ ml/kg} \), increase \( V_T \) by 1 ml/kg until \( P_{\text{plat}} > 25 \text{ cm H}_2\text{O} \) or \( V_T = 6 \text{ ml/kg} \).
  - If \( P_{\text{plat}} < 30 \) and breath stacking or dyssynchrony occurs: may increase \( V_T \) by 1ml/kg increments to 7 or 8 ml/kg if \( P_{\text{plat}} \) remains < 30 cm H\text{2O}
Acid-Base Management

- Arterial blood gas
  - pH, PaO$_2$, PaCO$_2$, calculated bicarbonate level
- Comprehensive metabolic panel
  - measured bicarbonate level, anion gap

Baseline pH and CO$_2$ levels may be altered in patients with chronic conditions such as COPD and kidney disease. Adjustments to treatment goals may be necessary.
Acid-Base Management

Respiratory acidosis

- pH<7.4, PaCO$_2$>40
- Treat by increasing minute ventilation (avoid increasing $V_T$ if barotrauma is a concern)

Metabolic acidosis

- pH<7.4, PaCO$_2$<40
- Anion gap acidosis: consider elevated lactate from hypoperfusion or sepsis, ketoacidosis, etc.
- Non-anion gap acidosis: often from renal dysfunction
- Treat underlying condition
Acid-Base Management

Respiratory alkalosis
- pH >7.4, PaCO2 < 40
- Treat by decreasing minute ventilation

Metabolic alkalosis
- pH >7.4, PaCO2 > 40
- Contraction alkalosis (hypovolemia)
  - Treat with intravascular volume resuscitation
- Loss of acid such as gastric suctioning
Acid-Base Management

pH goal: 7.30-7.45

Acidosis Management: (pH < 7.30)

- **If pH 7.15-7.30:** Increase RR until pH > 7.30 or PaCO₂ < 25 (Maximum set RR = 35)
- **If pH < 7.15:** Increase RR to 35.
- If pH remains < 7.15, Vₜ may be increased in 1 ml/kg steps until pH > 7.15 (Pplat target of 30 may be exceeded)

Alkalosis Management: (pH > 7.45) Decrease vent rate if possible
Berlin Definition of ARDS

- **Timing**: Within 1 week of a known clinical insult or new or 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 $200 \text{ mmHg} < \frac{\text{PaO}_2}{\text{FIO}_2} \leq 300 \text{ mmHg}$ with PEEP or CPAP $\geq 5 \text{ cmH}_2\text{O}$
  - Moderate $100 \text{ mmHg} < \frac{\text{PaO}_2}{\text{FIO}_2} \leq 200 \text{ mmHg}$ with PEEP $\geq 5 \text{ cmH}_2\text{O}$
  - Severe $\frac{\text{PaO}_2}{\text{FIO}_2} \leq 100 \text{ mmHg}$ with PEEP $\geq 5 \text{ cmH}_2\text{O}$
Barotrauma

Inflammation and fluid accumulation may result in stiffening of alveoli and inability to expand. When this occurs, positive pressure is shunted away from these alveoli into healthy alveoli. This can result in over-distention and injury, known as barotrauma.
Avoid Barotrauma: lung-protective measures

- 4-8 ml/kg tidal volumes (ideal body weight based on height)
- Higher positive end-expiratory pressure (PEEP) in patients with moderate or severe ARDS
- Plateau pressures <30 cm H$_2$O
Rescue Therapy

For patients requiring FiO$_2$ > 70% with optimal PEEP

- Proning
- Recruitment maneuvers
- Airway Pressure Release Ventilation (APRV)
- Inhaled Epoprostenol
- ECMO
Proning

- **Prone positioning** for 12-16 hours/day in severe ARDS in an option

Am J Respir Crit Care Med Vol 195, Iss 9, pp 1253-1263, May 1, 2017
Proning - Contraindications

- Shock (eg. Mean arterial pressure < 65mg)
- Acute bleeding (eg. hemorrhagic shock, massive hemoptysis)
- Multiple fractures or trauma (eg. unstable fractures of femur, pelvis, face)
- Spinal instability
- Pregnancy
- Raised intracranial pressure > 30mmHg or cerebral perfusion pressure < 60 mmHg
- Tracheal surgery or sternotomy within two weeks
Proning- Relative Contraindications

- Recent DVT treated for < 2 days
- Anterior chest tube(s) with air leaks
- Recent pacemaker
- Clinical conditions limiting life expectancy (e.g., Oxygen or ventilator dependent respiratory failure)
- Severe burns
- Lung transplant recipient
- Prior use of rescue therapies
Proning- Immediate Interruption

- Inadvertent extubation
- ETT obstruction
- Hemoptysis
- $\text{SpO}_2 < 85\%$ or $\text{PaO}_2 < 55$ for more than 5 min
- Cardiac arrest
- HR $< 30$ for more than 1 minute
- SBP $< 60$ mm Hg for more than 5 minutes
Proning- Technique

Prepare patient
Have one sheet under patient
Enteral feedings off for 1 hour
Pad face and contact points
Lubricate eyes
Proning- Technique

Prepare patient

Account for all lines and catheters

Remove ventral EKG leads

Have emergency airway equipment on hand in case of unplanned extubation

Pre-oxygenate with 100% O₂

Sedate to RAS -4 to -5

Neuromuscular blockade after sedation
Proning- Technique

Proning
Place second sheet (remove wrinkles) over patient
Place 3 pillows over the chest, pelvis, and shins
Place third sheet over pillows
Roll all sheets toward the patient until the patient is tightly held between them
Proning- Technique

Proning

Account for all lines and catheters, avoid placing under tension

Disconnect ventilator

Slide patient away from ventilator

Roll patient toward ventilator
Proning- Technique

After Proning

Turn head to one side
Reconnect ventilator
Remove sheet on back (first sheet)
Place dorsal EKG leads
Monitor for hemodynamic instability and treat (may last up to 10 minutes after proning)
Proning- Technique

After Proning

Place patient in swimmer’s pose
- Arm up on the side to which the head is turned
- Other arm at the patient’s side
- Alternate head position every 2 hours

May place patient in reverse Trendelenburg position if hemodynamically stable
Reverse technique to place supine
Proning- Complications

- Nerve Compression (eg. Brachial plexus injury)
- Crush injury
- Venous stasis (eg. Facial edema)
- Dislodging endotracheal tube
- Diaphragm limitation
- Pressure sores (eg. facial)
- Dislodging vascular catheters or drainage tubes
- Retinal damage
- Transient reduction in arterial oxygen
- Vomiting
- Transient arrhythmias
Proning Non-Ventilated Patients

There may be a role for proning patients not on mechanical ventilation to improve oxygenation and possibly prevent intubation.

Please check with your local institution for their protocol regarding non-invasive ventilation strategies.
Recruitment Maneuvers

Ensure Cuff is well inflated and patient hemodynamically stable
Set PEEP according to ARDSnet table
Switch to CPAP at 35-40 cm H₂O for 20-40 seconds
Return to original settings and PEEP

- **STOP** if hypotension, arrhythmias or desaturation < 85% O₂
- **Recruitability criteria** - SpO₂ increase > 5% Or compliance increase > 10% O₂
- **Contraindications** - Obstructive lung disease (bullous disease, COPD, Asthma) - Unilateral disease - Pneumothorax - Hemodynamic instability - Increased intracranial pressure
Other Rescue Therapies

Consult your pulmonologist regarding the need for:

- Airway Pressure Release Ventilation (APRV)
- Inhaled Epoprostenol
- Extracorporeal Membrane Oxygenation (ECMO)
Hemodynamic Goals in COVID-19

- Goal is **euvolemia** – WHO and ARDSnet recommended FACTT Algorithm
- Attempt de-resuscitation within 24-48 hours of achieving stability
- Point of care ultrasound of IVC and cardiac output maybe utilized in selected patients
- Pharmacy to concentrate all IV medications
- Enteral fluids to be determined on case by case basis by intensivist
## ICU Procedures

### Aerosol generating procedures – Maximal Precautions

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Procedure</th>
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<tbody>
<tr>
<td>Intubation</td>
<td>Extubation</td>
</tr>
<tr>
<td>suctioning</td>
<td>Bronchoscopy</td>
</tr>
<tr>
<td>Hi flow O2</td>
<td>Procedures in agitated patients</td>
</tr>
<tr>
<td>NIV</td>
<td>Tracheostomy</td>
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<tr>
<td>CPR prior to intubation</td>
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# Shock

<table>
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<th></th>
<th>Intravascular Volume Status</th>
<th>Cardiac Output</th>
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<tr>
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<td>↓</td>
<td>↑</td>
</tr>
<tr>
<td>Neurogenic</td>
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</tbody>
</table>
CONFERENCE REPORTS AND EXPERT PANEL

Surviving Sepsis Campaign: 


© 2017 SCCM and EISCM
2016 Sepsis Guidelines

- Obtain cultures before starting antibiotics
- Start broad-spectrum i.v. antibiotics within one hour
- Volume resuscitation with i.v. crystalloids > 30 mL/kg within the first 3 hours
- Colloid fluids may also be given if large amounts of crystalloids are being used
Treatment of Septic Shock

- Initial target MAP > 65 mmHg in patients with septic shock requiring vasopressors
- Norepinephrine is the first choice vasopressor for septic shock
- Vasopressin or epinephrine may be added if necessary
Treatment of Septic Shock

- Hemodynamic/cardiac assessment may be necessary (echo, cardiac output monitoring) if clinical examination does not reveal the cause of the shock.
- Hydrocortisone may be used as a supplement to pressors.
- Lactate measurement can be used to guide extent of resuscitation with the goal of returning to normal lactate levels.
General Critical Care

• GI prophylaxis
  H2 blocker
  Proton pump inhibitor

• DVT prophylaxis
  There have been reports of a prothrombotic state associated with COVID-19. Standard VTE prophylaxis may need to be adjusted for this. Consult your institutional protocols for your standard of care.

• Nutrition

• Glycemic control
  Goal blood glucose levels 140-180 g/dL
You May As Well Get Credit For This

Neurosurgeons are certified by the American Board of Neurological Surgery to provide critical care for patients.
Critical Care Billing

Based on time spent delivering critical care

- Examining the patient
- Reviewing laboratory, imaging, and other data
- Communicating and carrying out care plan

99291- 30-75 minutes of critical care

99292- each additional 30 minutes of critical care
Critical Care Documentation

Consider organizing notes by organ systems

- Pulmonary
- Cardiovascular
- Neurologic
- Renal
- GI
- Fluids/Electrolytes/Nutrients
- Hematologic
- Endocrine
- Infectious Disease
- Prophylaxis
- Code Status
Critical Care Billing

Requires documentation of **critical illness diagnosis**:

“The patient is critically ill with...”

Common diagnoses may include:

- Acute respiratory failure (document hypoxia, hypercapnea, ARDS, etc.)
- Respiratory distress
- Pneumonia
- Sepsis
- Septic shock
Critical Care Billing

Requires attestation of time and involvement:

“I have seen and examined the patient. I have reviewed the relevant clinical, laboratory, and imaging data. I have spent (insert time) minutes providing critical care for this patient.”
The End

Remember:

Follow your local protocols

Stay safe and healthy
## Appendix 1: Vasoactive Drugs

**ADULT PATIENTS ONLY**

### Dosing and Titration Recommendations for Vasoactive Agents

ALL titration endpoints need to be double-checked with the prescriber.

<table>
<thead>
<tr>
<th>Drug (infusion rate)</th>
<th>Concentration (EMR available concentrations listed)</th>
<th>Starting Dose</th>
<th>Upper Dosing Range</th>
<th>Bidirectional Titration Frequency</th>
<th>Bidirectional Titration Dose</th>
<th>Titration Endpoint/Goal</th>
<th>Alaris Min/Max</th>
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</thead>
<tbody>
<tr>
<td>Clevidipine (mg/hr)</td>
<td>25mg/50mL Premix (fat emulsion)</td>
<td>1-2 mg/hr</td>
<td>1-21 mg/hr</td>
<td>1.5 min -10 min</td>
<td>≤ 50% hourly dose</td>
<td>MAP or SBP</td>
<td>1-16 mg/hr</td>
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<tr>
<td>Diltiazem (mg/hr)</td>
<td>125mg/125mL DSW/NS 250mg/250mL DSW/NS</td>
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<td></td>
<td></td>
<td></td>
<td>HR between 80 to 100 bpm</td>
<td>1-15 mg/hr Hard Max: 20</td>
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<tr>
<td>Dobutamine (mcg/kg/min)</td>
<td>1000mg/250mL DSW Premix</td>
<td>2.5-5 mcg/kg/min</td>
<td>20 mcg/kg/min</td>
<td>5-10 min</td>
<td>2.5 mcg/kg/min</td>
<td>CI ≥ 2.5 L/min/m² or MAP</td>
<td>0.5-20 mcg/kg/min Hard Max: 40</td>
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<tr>
<td>Dopamine (mcg/kg/min)</td>
<td>400mg/250mL DSW Premix 800mg/250mL DSW/NS</td>
<td>5 mcg/kg/min</td>
<td>&gt;20 mcg/kg/min</td>
<td>2-5 min</td>
<td>0.5-2.5 mcg/kg/min</td>
<td>MAP between 60 and 70 mmHg</td>
<td>0.5-20 mcg/kg/min</td>
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<tr>
<td>Epinephrine (mcg/kg/min)</td>
<td>4mg/250mL DSW/NS 10mg/250mL DSW/NS</td>
<td>0.01-0.05 mcg/kg/min</td>
<td>0.5-1 mcg/kg/min</td>
<td>1-5 min</td>
<td>0.01-0.05 mcg/kg/min</td>
<td>MAP between 60 and 70 mmHg</td>
<td>0.01-1 mcg/kg/min</td>
</tr>
<tr>
<td>Esmolol (mcg/kg/min)</td>
<td>2500mg/250mL NS 2000mg/100mL NS (premixed)</td>
<td>Bolus: 500 mcg/kg Infusion: 50 mcg/kg/min</td>
<td>200-300 mcg/kg/min</td>
<td>4 min</td>
<td>50 mcg/kg/min</td>
<td>HR between 80 to 100 bpm</td>
<td>50-300 mcg/kg/min</td>
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<tr>
<td>Isoproterenol (mg/kg/min)</td>
<td>1mg/250mL DSW</td>
<td>0.01 mcg/kg/min</td>
<td>0.01-0.2 mcg/kg/min</td>
<td>1-2 min</td>
<td>0.01 mcg/kg/min</td>
<td>HR between 60 and 80</td>
<td>0.01-0.09 mcg/kg/min Hard Max: 0.2</td>
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<tr>
<td>Labetalol (mg/min)</td>
<td>300mg/300mL DSW/NS 500mg/100mL (undiluted)</td>
<td>Bolus: 10-20 mg Infusion: 0.5-2 mg/min (0.1 mg/min after 300 mg infused)</td>
<td>6-8 mcg/min</td>
<td>5-15 min</td>
<td>0.5-1 mcg/kg/min</td>
<td>MAP or SBP</td>
<td>1-6 mg/min Hard Max: 8</td>
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</tbody>
</table>

Peripheral administration: 4mg/250mL at a MAX rate of 0.2 mcg/kg/min for MAX of 8 hours.
## Appendix 1: Vasoactive Drugs

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<th>Upper Dosing Range</th>
<th>Bidirectional Titration Frequency</th>
<th>Bidirectional Titration Dose</th>
<th>Titration Endpoint/Goal</th>
<th>Alaris Min/Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milrinone (mcg/kg/min)</td>
<td>20mg/100mL DSW Premix</td>
<td>0.1 (Heart Failure) - 0.375 mcg/kg/min</td>
<td>0.5-0.75 mcg/kg/min</td>
<td>2 hours</td>
<td>0.1 mcg/kg/min</td>
<td>CI ≥ 2.5 L/min/m² or MAP</td>
<td>0.15-0.75 mcg/kg/min Hard Max: 0.75</td>
</tr>
<tr>
<td>Nitroprusside (mcg/kg/min)</td>
<td>50mg/100mL NS Premix</td>
<td>0.25-0.5 mcg/kg/min</td>
<td>3-5</td>
<td>3-5 min</td>
<td>0.5 mcg/kg/min</td>
<td>MAP or SBP</td>
<td>0.1-3 mcg/kg/min Hard Max: 5</td>
</tr>
<tr>
<td>Norepinephrine v (mcg/kg/min)</td>
<td>8mg/250mL DSW/NS 16mg/250mL DSW/NS</td>
<td>0.01-0.05 mcg/kg/min</td>
<td>0.5-1 mcg/kg/min</td>
<td>1-5 min</td>
<td>0.01-0.05 mcg/kg/min</td>
<td>MAP between 60 and 70 mmHg</td>
<td>0.01-3 mcg/kg/min Hard Max: 3.3</td>
</tr>
<tr>
<td>Phenylephrine v (mcg/kg/min)</td>
<td>10mg/250mL DSW/NS</td>
<td>0.5-1 mcg/kg/min</td>
<td>2 mcg/kg/min</td>
<td>1-5 min</td>
<td>0.5 mcg/kg/min</td>
<td>MAP between 60 and 70 mmHg</td>
<td>0.14 mcg/kg/min Hard max: 9.1</td>
</tr>
<tr>
<td>Vasopressin v (units/min)</td>
<td>20units/100mL DSW/NS</td>
<td>0.03 units/min</td>
<td>0.03 units/min</td>
<td>Titration per provider request in certain patient populations</td>
<td>MAP between 60 and 70 mmHg</td>
<td>0.01-0.06 units/min Hard max: 0.1</td>
<td></td>
</tr>
<tr>
<td>Nicardipine (mg/hr)</td>
<td>40mg/200mL DSW NS Premix</td>
<td>2.5-5 mg/hr</td>
<td>10-15 mg/hr</td>
<td>5-15 min</td>
<td>2.5-5 mg/hr</td>
<td>MAP or SBP</td>
<td>0.5-15 mg/hr</td>
</tr>
<tr>
<td>Nitroglycerin (mcg/min)</td>
<td>50mg/250mL DSW Use PVC Free tubing</td>
<td>5 mcg/min</td>
<td>200 mcg/min</td>
<td>3-5 min</td>
<td>5-10 mcg/min</td>
<td>MAP or SBP or chest pain relief</td>
<td>1-200 mcg/min</td>
</tr>
</tbody>
</table>

* = “vesicant”, v = “peripheral line”, c = “central line”
# Appendix 2: Sedative Drugs

## Dosing and Titration Recommendations for Analgesia, Sedation and Paralysis

**ADULT PATIENTS ONLY**

<table>
<thead>
<tr>
<th>Drug (infusion rate)</th>
<th>Concentration (EMR available concentrations listed)</th>
<th>Starting Dose</th>
<th>Upper Dosing Range</th>
<th>Bidirectional Titration Frequency</th>
<th>Bidirectional Titration Dose</th>
<th>Titration Endpoint/Goal</th>
<th>Alaris Min/Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fentanyl</strong> (mcg/hr)</td>
<td>1000 mcg/100mL NS 2500 mcg/250mL NS</td>
<td>Bolus: 25-50 mcg Infusion: 25 mcg/hr</td>
<td>200-300 mcg/hr</td>
<td>30 min</td>
<td>25 mcg/hr</td>
<td>RASS of 0 to -2 and/or CPOT</td>
<td>10-300 mcg/hr*</td>
</tr>
<tr>
<td></td>
<td>*use Sedation Algorithm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Propofol</strong> (mcg/kg/min)</td>
<td>1000 mg/100mL Premix (fat emulsion)</td>
<td>5 mcg/kg/min</td>
<td>50-100 mcg/kg/min</td>
<td>5 min</td>
<td>5 mcg/kg/min</td>
<td>RASS of 0 to -2</td>
<td>5-50 mcg/kg/min Hard max: 600</td>
</tr>
<tr>
<td>*use Sedation Algorithm</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Midazolam</strong> (mg/hr)</td>
<td>100 mg/100mL DSW/NS</td>
<td>Bolus: 2-4 mg Infusion: 2 mg/hr</td>
<td>15-20 mg/hr</td>
<td>30 min – 1hr</td>
<td>25%</td>
<td>RASS of 0 to -2</td>
<td>0.5-20 mg/hr*</td>
</tr>
<tr>
<td>*use Sedation Algorithm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dexmedetomidine</strong> (mcg/kg/hr)</td>
<td>400 mcg/100mL NS Premix</td>
<td>0.2 mcg/kg/hr</td>
<td>1-1.4 mcg/kg/hr</td>
<td>30 min</td>
<td>25%</td>
<td>RASS of 0 to -2</td>
<td>0.1-1.4 mcg/kg/hr Hard max: 2.5</td>
</tr>
<tr>
<td>*use Sedation Algorithm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Lorazepam</strong> (mg/hr)</td>
<td>50 mg/50mL DSW</td>
<td>Bolus: 2-4 mg Infusion: 1 mg/hr</td>
<td>5-10 mg/hr</td>
<td>30 min – 1 hr</td>
<td>25%</td>
<td>RASS of 0 to -2</td>
<td>0.5-10 mg/hr</td>
</tr>
<tr>
<td>*use Sedation Algorithm</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Ketamine</strong> (mg/kg/hr)</td>
<td>500mg/250 mL NS</td>
<td>Bolus: 0.1 mg/kg Infusion: 0.05 mg/kg/hr</td>
<td>1-2 mg/kg/hr</td>
<td>15 min</td>
<td>25%</td>
<td>RASS of 0 to -2</td>
<td>0.05-6 mg/kg/hr</td>
</tr>
<tr>
<td>*Doses vary highly based on indication</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Morphine</strong> (mg/hr)</td>
<td>100 mg/100mL NS</td>
<td>Bolus: 2-4 mg Infusion: 2 mg/hr</td>
<td>20-30 mg/hr</td>
<td>15-30 min</td>
<td>1 mg/hr</td>
<td>RDOS &lt; 3*</td>
<td>0.5-10 mg/hr</td>
</tr>
<tr>
<td>*End of Life ONLY, use Withdrawal of LST Algorithm or End of Life Ordersets</td>
<td></td>
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</tr>
<tr>
<td><strong>Cisatracurium</strong> (mcg/kg/min)</td>
<td>200 mcg/100mL DSW/NS</td>
<td>Bolus: 0.1 mg/kg Infusion: 3 mcg/kg/min</td>
<td>7.5-10 mcg/kg/min</td>
<td>30 min-1 hr</td>
<td>25%</td>
<td>TOF 2-3 out of 4</td>
<td>0.5-10 mcg/kg/min Hard max: 10</td>
</tr>
<tr>
<td>*use Paralysis Algorithm</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td><strong>Rocuronium</strong> (mcg/kg/min)</td>
<td>1000/250mL DSW/NS</td>
<td>Bolus: 0.6 mg/kg Infusion: 8 mcg/kg/min</td>
<td>12 mcg/kg/min</td>
<td>30 min-1 hr</td>
<td>25%</td>
<td>TOF 2-3 out of 4</td>
<td>1-12 mcg/kg/min</td>
</tr>
<tr>
<td>*use Paralysis Algorithm</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

* = High concentration drips available for patients with high dose requirements, call local pharmacy for assistance

RDOS = Respiratory Distress Observation Scale

* Separate dosing regimens available for Chronic Pain and Status Epilepticus, Depression and Migraine.
Appendix 3: Surviving Sepsis Campaign: Guidelines for the Management of COVID-19

I. Infection Control

- For aerosol-generating procedures, use fitted respirator masks (N95 respirators, FFP2, or equivalent) (best practice).
- Perform aerosol-generating procedures in negative pressure room (best practice).
- For usual care for non-ventilated patients, use surgical/medical masks (weak recommendation).
- For non-aerosol-generating procedures on ventilated patients, use surgical/medical masks (weak recommendation).
- For intubation, use video-guided laryngoscopy over direct laryngoscopy (weak recommendation).
- Intubation should be performed by provider most experienced with airway management (best practice).

II. Laboratory Diagnosis and Specimens

- For intubated and mechanically ventilated adults:
  - Obtain lower respiratory tract over nasopharyngeal/oropharyngeal samples (weak recommendation).
  - Obtain endotracheal aspirates over bronchial wash/bronchoalveolar lavage samples (weak recommendation).
Appendix 3: Surviving Sepsis Campaign: Guidelines for the Management of COVID-19

III. Supportive Care

- Use dynamic parameters, skin temperature, capillary refilling time, and/or serum lactate over static parameters to assess fluid responsiveness (weak recommendation).
- Use conservative over liberal fluid strategy (weak recommendation).
- Use crystalloids over colloids (strong recommendation).
- Use buffered/balanced crystalloids over unbalanced crystalloids (weak recommendation).
- Do not use hydroxyethyl starches (strong recommendation).
- Do not use gelatins (weak recommendation).
- Do not use dextrans (weak recommendation).
- Do not routinely use albumin for initial resuscitation (weak recommendation).
- Use norepinephrine as first-line vasoactive agent (weak recommendation).
- If norepinephrine not available, use vasopressin or epinephrine (weak recommendation).
- Do not use dopamine if norepinephrine is available (strong recommendation).
- Add vasopressin as second-line agent if target MAP can’t be achieved by norepinephrine alone (weak recommendation).
- Titrate vasoactive agents to target MAP of 60-65 mmHg (weak recommendation).
- For cardiac dysfunction and persistent hypoperfusion despite fluid resuscitation and norepinephrine, add dobutamine (weak recommendation).
- For refractory shock, use low-dose corticosteroid therapy (weak recommendation).
- Start supplemental O2 if SPO2 is < 92% (weak recommendation) and if SPO2 is < 90% (strong recommendation).
Appendix 3: Surviving Sepsis Campaign: Guidelines for the Management of COVID-19

- Maintain SPO2 no higher than 96% (strong recommendation).
- For acute hypoxemic respiratory failure despite conventional O2 therapy, use HFNC (weak recommendation).
- In acute hypoxemic respiratory failure, used HFNC over NIPPV (weak recommendation).
- If HFNC not available and no urgent indication for intubation, trial NIPPV with close monitoring (weak recommendation).
- No recommendation regarding use of helmet NIPPV compared with mask NIPPV.
- Recommend close monitoring for worsening of respiratory status (best practice).
- Use low tidal volume ventilation (Vt 4-8 mL/kg) (strong recommendation).
- Target plateau pressures (Pplat) of < 30 cm H2O (strong recommendation).
- For moderate to severe ARDS, use higher PEEP strategy (weak recommendation).
- For ARDS, use conservative fluid strategy (weak recommendation).
- For moderate to severe ARDS, use prone ventilation for 12 to 16 hours (weak recommendation).
- For moderate to severe ARDS:
  - Use intermittent boluses of neuromuscular blocking agents over continuous infusion (weak recommendation).
  - If persistent ventilator dyssynchrony, use continuous NMBA infusion for up to 48 hours (weak recommendation).
- Do not routinely use inhaled nitric oxide (strong recommendation).
- In severe ARDS and hypoxemia, trial inhaled pulmonary vasodilator; if no rapid improvement, treatment should be tapered off (weak recommendation).
- For hypoxemia despite optimizing ventilation, use recruitment maneuvers (weak recommendation).
- For recruitment, do not use staircase (incremental PEEP) recruitment maneuvers (strong recommendation).
- In refractory hypoxemia despite optimizing ventilation, rescue therapies, and proning, use venovenous ECMO (weak recommendation).
Appendix 3: Surviving Sepsis Campaign: Guidelines for the Management of COVID-19

IV. COVID-19 Therapy

- In respiratory failure (without ARDS), do not routinely use systemic corticosteroids (weak recommendation).
- In ARDS, use systemic corticosteroids (weak recommendation).
- In respiratory failure, use empiric antimicrobials/antibacterial agents (weak recommendation).
- For fever, use acetaminophen for temperature control (weak recommendation).
- Do not routinely use IVIG (weak recommendation).
- Do not routinely use convalescent plasma (weak recommendation).
- In critically ill adults:
  - Do not routinely use lopinavir/ritonavir (weak recommendation).
  - Insufficient evidence on the use of other antiviral agents.
- Insufficient evidence on the use of recombinant rIFNs.
- Insufficient evidence on the use of chloroquine or hydroxychloroquine.
- Insufficient evidence on the use of tocilizumab.