

**Supplement 1:**

Care of the SARS-CoV-2 Positive Patient in Neurointensive Care - 2020  
COVID-19 Pandemic Initial Action Cards for Staff Working in  
Neurosurgical and Neuromedical Intensive Care

## APPROACH

**Safe:** For staff and patient

**Accurate:** Avoiding unreliable, unfamiliar or repeated techniques

**Swift:** Timely, without rush or delay

## NEED FOR AIRWAY INTERVENTION & RISKS

- Patients suffering COVID-19 may require intubation for airway support and advanced respiratory therapy
- Transmission is thought to be predominantly by droplet spread and direct contact with the patient or fomites, rather than 'airborne spread'
- Procedures during initial airway management and in ICU may generate aerosols which will increase risk of transmission.
- Healthcare workers (HCWs) treating patients with COVID-19 are at increased risk of contracting the illness

## SAFETY

The highest viral load of SARS-CoV-2 appears in sputum and upper airway secretions

Aerosol-generating procedures:	Other potentially aerosol-generating procedures include
<div> <div>Highest Risk</div> <div>Lowest Risk</div> </div> <ul style="list-style-type: none"> <li>Tracheal intubation</li> <li>Tracheostomy</li> <li>Emergency front-of-neck airway</li> <li>Non-invasive ventilation Mask ventilation</li> </ul>	<ul style="list-style-type: none"> <li>Disconnection of ventilatory circuits during use</li> <li>Extubation</li> <li>Cardiopulmonary resuscitation (before tracheal intubation)</li> <li>Bronchoscopy</li> <li>Tracheal suction without a 'closed in-line system'</li> </ul>

## NASAL OXYGENATION

- Older HFNO machines may expose staff to greater risk
- Risk of viral spread has not been studied
- HFNO is not currently recommended for COVID-19 patients **around the time of intubation**
- Low flow nasal oxygen (<5 L/min) may provide some oxygenation during apnoea and might therefore delay or reduce the extent of hypoxaemia during intubation
- In patients who are not hypoxaemic, without risk factors for a short safe apnoea time, and predicted to be easy to intubate it is not recommended

AIRWAY

Staff who should avoid involvement in airway management: > 60 years, cardiac disease, chronic respiratory disease, diabetes, recent cancer, immunosuppressed, pregnant, and perhaps hypertension and obesity

Planning	<p><b>Timing</b></p> <ul style="list-style-type: none"><li>- Consider early intubation</li><li>- Minimise staff exposure</li><li>- Maximise preparation</li><li>- If transferring from ward: Pre-notify ICU</li></ul> <p><b>Location</b></p> <ul style="list-style-type: none"><li>- Negative pressure room with anteroom, <b>or</b></li><li>- Neutral pressure room with door closed</li></ul> <p><b>Patient Assessment</b></p> <ul style="list-style-type: none"><li>- Assess &amp; Document MACOCHA Score: _____ →</li></ul> <p><b>Pre-oxygenate (3mins)</b></p> <ul style="list-style-type: none"><li>- Tight-fitting BVM + PEEP valve at <b>10cmH<sub>2</sub>O</b> at <b>15L/min</b> <b>100% O<sub>2</sub></b></li></ul>	<table><tr><th>Factor</th><th>Score if present</th></tr><tr><td><b>Patient</b></td><td></td></tr><tr><td>Mallampati score 3 or 4</td><td>5</td></tr><tr><td>Obstructive sleep apnoea syndrome</td><td>2</td></tr><tr><td>Reduced mobility of cervical spine</td><td>1</td></tr><tr><td>Limited mouth opening &lt;3cm</td><td>1</td></tr><tr><td><b>Pathology</b></td><td></td></tr><tr><td>Coma</td><td>1</td></tr><tr><td>Severe hypoxemia (&lt;80%)</td><td>1</td></tr><tr><td><b>Operator</b></td><td></td></tr><tr><td>Non-anaesthetist</td><td>1</td></tr></table>	Factor	Score if present	<b>Patient</b>		Mallampati score 3 or 4	5	Obstructive sleep apnoea syndrome	2	Reduced mobility of cervical spine	1	Limited mouth opening <3cm	1	<b>Pathology</b>		Coma	1	Severe hypoxemia (<80%)	1	<b>Operator</b>		Non-anaesthetist	1
	Factor	Score if present																						
<b>Patient</b>																								
Mallampati score 3 or 4	5																							
Obstructive sleep apnoea syndrome	2																							
Reduced mobility of cervical spine	1																							
Limited mouth opening <3cm	1																							
<b>Pathology</b>																								
Coma	1																							
Severe hypoxemia (<80%)	1																							
<b>Operator</b>																								
Non-anaesthetist	1																							
Preparation	<p><b>1. PPE: Be thorough, do not rush</b></p> <ul style="list-style-type: none"><li>- FFP3 Mask</li><li>- Long-sleeved gown</li><li>- Gloves</li><li>- Eyewear</li><li>- Wipeable shoes</li><li>- Buddy Check Completed</li></ul> <p><b>2. Allocate Roles</b></p> <ul style="list-style-type: none"><li>- At bedside:<ul style="list-style-type: none"><li>- Intubator &amp; Team Leader</li><li>- Assistant</li><li>- Drugs + Monitoring + Timing</li></ul></li><li>- Outside: Runner</li></ul> <p><b>3. Equipment (USE DUMP MAT)</b></p> <ul style="list-style-type: none"><li>- BMV/Mapleson Circuit + HME</li><li>- Guedel</li><li>- Suction</li><li>- Videolaryngoscope</li><li>- Bougie/stylet</li><li>- ETT (+ ties + 10ml syringe)<ul style="list-style-type: none"><li>- 8.5 + 8.0 (Male)</li><li>- 8.0 + 7.5 (Female)</li></ul></li><li>- Supraglottic airway</li><li>- FONA Set</li><li>- Monitoring</li></ul> <p><b>4. Drugs</b></p> <ul style="list-style-type: none"><li>- Sedation:<ul style="list-style-type: none"><li>- Propofol: 1.5-2.5mg/kg <b>or</b></li><li>- Ketamine 1-2mg/kg <b>and</b></li><li>- Fentanyl 1-2microg/kg</li><li>- +/- Midazolam 1mg</li></ul></li><li>- Neuromuscular Blockade:<ul style="list-style-type: none"><li>- Rocuronium 1.2-1.6mg/kg (IBW) <b>or</b></li><li>- Suxamethonium 1.5-2.0mg/kg (TBW)</li></ul></li><li>- Vasopressor: Metaraminol 0.5mg/ml</li></ul>																							
	Induction	<p><b>Modified Rapid Sequence Induction</b></p> <ul style="list-style-type: none"><li>- <b>Recommend</b> a modified RSI approach.</li><li>- <b>Important modifications:</b><ul style="list-style-type: none"><li>- Do not routinely use cricothyroid pressure</li><li>- Avoid BVM ventilation in apneic period unless refractory life-threatening hypoxaemia (consider supraglottic airway)</li><li>- Wait until cuff inflated before commencing ventilation</li></ul></li></ul>																						
Post	<ul style="list-style-type: none"><li>- Confirm ETT position with ETCO<sub>2</sub>: <b>Do Not Auscultate</b></li><li>- Establish ventilation (See RESPIRATORY Card)</li><li>- Use closed suction system</li><li>- Avoid unplanned disconnections</li><li>- Clamp ETT prior to any planned disconnection</li><li>- Insert NGT</li><li>- Careful equipment disposal</li><li>- Clean re-usable instruments</li><li>- Remove PPE: <b>Use checklist, Observed by buddy, meticulous disposal, wash hands</b></li></ul>																							
COMPLETE A TEAM DEBRIEF																								

**AIRWAY**

Staff who should avoid involvement in airway management: > 60 years, cardiac disease, chronic respiratory disease, diabetes, recent cancer, immunosuppressed, pregnant, and perhaps hypertension and obesity

Based on local modifications to the Airway Algorithm from The Alfred Hospital ICU

AIRWAY

Staff who should avoid involvement in airway management: > 60 years, cardiac disease, chronic respiratory disease, diabetes, recent cancer, immunosuppressed, pregnant, and perhaps hypertension and obesity

Based on local modifications to the Airway Algorithm from The Alfred Hospital ICU

## APPROACH

Intubated COVID-19 Patients will have ARDS: Manage with a lung-protective strategy  
Consideration may need to be given to the use of non-invasive ventilation

## ACUTE RESPIRATORY DISTRESS SYNDROME: DEFINITION

- Within 1 week of a known clinical insult or new or worsening respiratory symptoms
- The presence of bilateral opacities on chest imaging, not fully explained by effusions, lobar/lung collapse or nodules
- The presence of pulmonary oedema not fully explained by cardiac failure or fluid overload
- A PaO<sub>2</sub>:FiO<sub>2</sub> ratio of <300mmHg with PEEP or CPAP ≥5cmH<sub>2</sub>O
  - Mild ARDS: PF ratio 200mmHg<300mmHg with PEEP or CPAP ≥5cmH<sub>2</sub>O
  - Moderate ARDS: PF ratio 100<200mmHg with PEEP or CPAP ≥5cmH<sub>2</sub>O
  - Severe ARDS: PF ratio <100mmHg with PEEP or CPAP ≥5cmH<sub>2</sub>O

## VENTILATORY STRATEGIES IN ARDS

- High Flow Oxygen Therapy and CPAP will only be offered in Critical Care Areas
- **NON-INVASIVE BI-LEVEL POSITIVE AIRWAY PRESSURE IS NOT INDICATED IN COVID-19**
- **AVOID THE USE OF SPONTANEOUS VENTILATION MODES**
- Low tidal volume ventilation (4-8ml/kg IBW), High PEEP, Permissive Hypercarbia
- Optimise Driving Pressure
  - Driving pressure (ΔP) can be calculated at the bedside as plateau pressure minus positive end-expiratory pressure (P<sub>plat</sub> – PEEP)
- Consider use of adjunctive therapies in refractory hypoxaemia
  - Contact Consultant or Senior Fellow on duty. Refer to Prone Checklist & Protocol

## PRONING: INDICATIONS

- Moderate to severe ARDS with PaO<sub>2</sub>:FiO<sub>2</sub> ratio < 150 mmHg and FiO<sub>2</sub> ≥ 0.6
- **Early** within the course of the disease (**ideally < 48 hours**) **following 12-24 hours** of mechanical ventilation allowing for treatment optimisation

## PRONING: CONTRAINDICATIONS

- Absolute:
  - Spinal instability
- Relative:
  - Multiple Trauma e.g. Pelvic or Chest fractures, Pelvic fixation device
  - Severe facial fractures
  - Head injury/Raised intracranial pressure
  - Frequent seizures
  - Raised intraocular pressure
  - Recent tracheostomy <24hrs
  - CVS instability despite resuscitation Intolerance of prone position
  - Morbid obesity

## RESPIRATION

CALCULATION OF IDEAL BODY WEIGHT  
Males =  $0.91 \times (\text{height [cm]} - 152.4) + 50$   
Females =  $0.91 \times (\text{height [cm]} - 152.4) + 45.5$

Non-Neurosurgical Patients  
ONLY

## COVID-19 PATIENT INTUBATED

Establish Mechanical Ventilation

### 1. Choose any ventilator mode with which you are comfortable

We recommend VC-SIMV or PC-SIMV. Commencing in Pressure-Regulated Volume Control limits interpretability of pressure-time and flow-time curves due to ventilator adjustments for pressure regulation

### 2. Set:

- Respiratory Rate: 18/min
- Tidal volume: 7ml/kg ideal body weight
- Set PEEP to FiO<sub>2</sub> requirement (Use ARDSNet High PEEP/Low FiO<sub>2</sub> Table):

FiO <sub>2</sub>	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5-0.8	0.8	0.9	1.0	1.0
PEEP (cmH <sub>2</sub> O)	5	8	10	12	14	14	16	16	18	20	22	22	22	24

### 3. Targets:

- Plateau pressure ≤28cmH<sub>2</sub>O
- Driving Pressure 12-14cmH<sub>2</sub>O
- PaO<sub>2</sub> 7.3-10.7 (55-80mmHg) **or** SpO<sub>2</sub> 88-94%
- pH 7.30-7.45 (Tolerate elevated PaCO<sub>2</sub>)
  - pH 7.15 tolerable, consider concurrent bicarbonate infusion

### 4. Adjust the Ventilator to Achieve Targets:

- Perform a 2sec inspiratory pause q4-hourly to assess plateau pressure.
  - If P<sub>plat</sub> >28cmH<sub>2</sub>O reduce VT by 1ml/kg IBW in incremental steps.

**Minimum VT = 4ml/kg IBW.**

- If P<sub>plat</sub> <25cmH<sub>2</sub>O, increase VT by 1ml/kg IBW in incremental steps.
- If patient is not paralysed, observe spontaneous tidal volumes and adjust pressure support downwards to achieve calculated VT.
- Target I:E ratio 1:1 to 1:3
- Maintain T<sub>insp</sub> 0.8 sec
- Optimise driving pressure

## Manoeuvres to Improve Oxygenation

- Optimise PEEP
- Increase FiO<sub>2</sub>
- Set I:E ratio 1:1
- Commence a neuromuscular junction blocker infusion
  - Atracurium (TOF Target = 0)
    - Bolus 0.1-0.2mg/kg
    - Infusion 0.3-0.6mg/kg/hr

### Recruitment manoeuvres

Significant risk of haemodynamic compromise or other patient deterioration. Consultant or Senior Fellow presence required.

**Recruitment manoeuvres must not be used routinely.**

## RESPIRATION

CALCULATION OF IDEAL BODY WEIGHT  
Males =  $0.91 \times (\text{height [cm]} - 152.4) + 50$   
Females =  $0.91 \times (\text{height [cm]} - 152.4) + 45.5$

Non-Neurosurgical Patients  
ONLY

## APPROACH

Maintain haemodynamic stability AND negative fluid balance (Min. -500ml)

Judicious use of fluids only

NO IV MAINTENANCE FLUID WITHOUT CONSULTANT OR SENIOR FELLOW

### APPROVAL

Target mean arterial pressure  $\geq 65$ mmHg (Higher target may be required in elderly patients or those with pre-existing hypertension)

Assess ECG daily; Consider regular TpT and BNP (Elevation associated with mortality)

Consider Cardiac Output monitoring (PiCCO)

## FLUID MANAGEMENT

- Assess fluid responsiveness with dynamic manoeuvres
  - Pulse pressure variation  $<13\%$
  - Pulse pressure or cardiac index increase  $\geq 5\%$  during an expiratory hold manoeuvre
  - Passive leg raise
  - Stroke volume variation
  - Capillary refill time
  - IVC ultrasonography
- Assess for adequacy of fluid resuscitation
  - ScvO<sub>2</sub>  $>70\%$
  - Lactate clearance  $>10\%$  over 2 hours
  - Arteriovenous CO<sub>2</sub> difference  $<6$ mmHg ( $<1$ KPa)
  - Urine output  $\geq 1$ ml/kg/hr

## VASOPRESSOR THERAPY

- Commence vasopressor therapy **early** in COVID-19
- Minimise IV fluid use
  - Pulmonary oedema common in COVID-19; excess fluid appears associated with worse outcomes
- Agents
  - Noradrenaline
  - Vasopressin
- Initiate if cardiac output is adequate, and preload has been optimised, yet resuscitation goals unmet despite noradrenaline infusion.

## ASSESS CARDIAC OUTPUT

- COVID-19 is associated with the presence of early cardiomyopathy
- Consider sending troponin and proBNP. There may be a role for daily troponins to monitor for myocarditis.
- Identify patients who may benefit from inotropes
  - Low cardiac output.
  - Resuscitation goals (above) inadequate despite adequate preload and mean arterial pressure.
- Consider formal ECHO and FICE assessments
- Inotropes
  - Dobutamine
  - Adrenaline
  - NB: Do not routinely use milrinone in septic shock. ***Discuss with Consultant or Senior Fellow if you feel that milrinone may be required.***

## CORTICOSTEROIDS

- Steroids are not indicated in the management of COVID-19 and may delay viral clearance.
- Steroids may be indicated in COVID-19 with septic shock, particularly if an intercurrent bacterial infection is present.
- Medication:
  - Hydrocortisone 50-100mg IV q6H

## ELECTROLYTE TARGETS

- Sodium 135-145mmol/L
- Potassium 4.5-5.5 mmol/L
- Magnesium  $\geq 1.0$ mmol/L
- Phosphate  $\geq 0.75$ mmol/L
- Ionised Calcium (measure on ABG)  $\geq 1.2$

## HAEMATOLOGY

- COVID-19 is associated with lymphopaenia. Mild thrombocytopenia is common (rarely  $<100$ )
- Lower platelet count is a poor prognostic sign
- Maintain [Hb]  $\geq 70$ g/L in non-neurosurgical patients; target  $\geq 80$ -100g/L in neurosurgical cases
- Some patients may respond to COVID-19 with a profound cytokine storm. Features of haemophagocytic lymphohistiocytosis may be present. Consider sending serum ferritin

## INFECTION

- CRP is elevated in COVID-19, and may correlate with disease severity and prognosis
- There are no available antiviral therapies effective against COVID-19
- There is some evidence of possible effect from combined Lopinavir and Ritonavir (Kaletra), however the evidence is of low quality
- Chloroquine has reportedly been used in the management of COVID-19, however efficacy data is not available
- Neuraminidase inhibitors do not work against COVID-19
- Antibiotics should be commenced if there is clinical suspicion of superimposed bacterial infection
  - Discontinue antibiotics within 48 hours if there is not evidence of bacterial infection.
  - Use the MicroGuide and/or microbiology advice to target antibiotic at suspected source of bacterial infection

## NEUROLOGY

- If patients do not have co-existent neurological conditions, maintain a normal cerebral perfusion pressure
- Optimise sedation and neuromuscular blocking agents, and define clear targets for both

## FEEDING

- Every patient will require dietician review
- Ensure patients are receiving 25kcal/kg/day caloric intake
- Account for caloric content of infusions, particularly propofol
- Consider TPN if unable to ensure enteral caloric intake

## ANALGESIA

- Ensure patients receive adequate opioid and non-opioid analgesia

## POSITIONING

- Supine patients must be positioned at a minimum of 30o head-up tilt
- Ventilation may be improved by further elevation.

## GI Protection

- PPIs are not routinely indicated.
- If patients are **not** receiving enteral feed, or are at high risk of gastric ulceration, commence PPIs.

# MULTISYSTEM CARE OF THE COVID-19 PATIENT WITHOUT A CONCURRENT NEURO-ICU CONDITION

## IMAGING

- Chest radiographs should be ordered:
  - On admission
  - Following an airway procedure
  - Following insertion of an intrathoracic vascular access device
  - In light of worsening respiratory failure
- **Minimise CT scans**
  - CT scanning is rarely required in the management of COVID-19, and may increase infection within the hospital due to disruption to circuits and intra-hospital transports

## SEDATION

- Daily sedation hold
  - Patients must have a daily hold of neuromuscular blocking agents and sedation where possible.
- A daily interruption of sedation is a strategy designed to reduce exposure to sedative agents, allow assessment of neurological status and assess readiness for extubation and to reduce duration of mechanical ventilation.
- Potential adverse effects of daily interruption of sedation:
  - Patient discomfort and risk of PTSD and other long term psychological issues
  - Dislodgment of ETT, CVC, arterial lines etc.
  - Increased nursing workload.
- Contraindications:
  - Physiological instability
  - Hypertension
  - Tachycardia
  - Ventilator dysynchrony
  - Hypoxaemia

## BOWEL CARE

- Abdominal distension may compromise ability to ventilate the patient.
- Commence aperients on all patients admitted to the ICU, according to standard protocol.
- Commence prokinetics in the event of ≥2 consecutive large gastric residual volumes.

## ENVIRONMENTAL MANAGEMENT

- Optimise patient sleep/wake cycle if on limited/no sedation
- Consider clamping the ET tube when disconnecting the ventilator if the patient is sedated and paralysed
- Maintain a clean workspace, and ensure PPE is accessible. Ensure that donning and doffing guidelines are visible
- Coronavirus can survive up to 4 hours on surfaces as a fomite. Ensure bed space is cleaned readily, and that hand hygiene equipment is available
- There is evidence for widespread environmental contamination of patient rooms so effective cleaning and decontamination is essential
- Coronaviruses and Influenza are fairly fragile, surviving outside the body 24/48 hours. Cleaning environmental surfaces with water and detergent and applying commonly used disinfectants (such as peracetic acid/DiffX) is effective
- When the patient is discharged a UV clean is recommended
- Waste and linen to follow the clinical infectious waste/linen streams

## DE-ESCALATION & DISPOSITION

- Once patients are weaned from ICU-level supports, rapid discharge to the ward must be facilitated

# MULTISYSTEM CARE OF THE COVID-19 PATIENT WITHOUT A CONCURRENT NEURO-ICU CONDITION

# MULTISYSTEM CARE OF THE COVID-19 PATIENT WITHOUT A CONCURRENT NEURO-ICU CONDITION

**APPROACH**

- It may become necessary, in the event of a catastrophic sustained pandemic, to ration access to critical care resources, with a view to providing intensive care to those patients with the greatest chance of survival
- ICU triage and rationalisation is not yet necessary, and decisions to admit to ICU rest with the duty Consultant or Senior Fellow
- The National Hospital for Neurology and Neurosurgery is considering establishing an ethics committee to determine the hospital's response in the event of a sustained pandemic resulting in depletion of ICU resources

**APPROACH**

- Resuscitation of the COVID-19 patient is as per standard ALS management
- ***PPE must be donned before entering room/attending to patient***

***NO PPE = NO CPR***

- If mechanically ventilated at the time of arrest:
  - Commence ALS algorithm
  - ***Do not disconnect the ventilator***
  - Set the peak airway pressure alarm to maximum
  - Increase FiO<sub>2</sub> to 1.0
  - Consider reducing PEEP if the arrest is not felt to be due to hypoxia (improve venous return)
- If not mechanically ventilated at time of arrest:
  - ***Do not*** look, listen and feel
  - If the patient looks dead, treat as cardiac arrest
  - Start BLS as per trust guidelines
  - Ring 2222; also inform operator that PPE is required
  - Have a PPE buddy and runner outside room
  - Minimise the number of responders in the room
    - ***PPE buddy limits access to room***
  - BLS/ALS ***only*** if PPE in place
  - ***No stethoscopes*** – do not auscultate chest