Statement from the South African Paediatric Critical Care working group

PAEDIATRIC CRITICAL CARE MANAGEMENT OF COVID-19 INFECTED CHILDREN (SUSPECTED OR PROVEN)
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Rossouw B\textsuperscript{1}, Wege M\textsuperscript{1}, Ahrens JO\textsuperscript{1}, Appel I\textsuperscript{2}, Argent AC\textsuperscript{1}, Bruckmann E\textsuperscript{3}, Coetzee S\textsuperscript{4}, Cawood S\textsuperscript{5}, Demopoulos D\textsuperscript{6}, Du Plooy E\textsuperscript{1}, Hlophe ST\textsuperscript{7}, Jeena P\textsuperscript{8}, Kloeck D\textsuperscript{3}, Kritzinger FE\textsuperscript{9}, Lake L\textsuperscript{1}, Morgan M\textsuperscript{7}, Morrow B\textsuperscript{1}, Murphy S\textsuperscript{3}, Naidoo KD\textsuperscript{3}, Oosthuizen K\textsuperscript{1}, Pienaar M\textsuperscript{10}, Parker NM\textsuperscript{2}, Riemer L\textsuperscript{1}, Salie S\textsuperscript{1}, Singh SA\textsuperscript{8}, Salloo A\textsuperscript{3}, Scott C\textsuperscript{1}, Solomon LJS\textsuperscript{10}, McCulloch MI\textsuperscript{1}

1. Red Cross War Memorial Children's Hospital, University of Cape Town
2. Tygerberg Children's Hospital, University of Stellenbosch
3. Chris Hani Baragwanath Academic Hospital, University of the Witwatersrand
4. Waterfall City Hospital
5. Nelson Mandela Children's Hospital, University of Witwatersrand
6. Wits Donald Gordon Medical Centre
7. Pietermaritzburg Metropolitan Complex, University of KwaZulu Natal
8. Inkosi Albert Luthuli Central Hospital, University of KwaZulu Natal
9. Chest & Allergy Centre, Christiaan Barnard Memorial Hospital, University of Stellenbosch
10. Universitas Academic Hospital, University of the Free State
PAEDIATRIC CRITICAL CARE
MANAGEMENT OF COVID-19 INFECTED CHILDREN (SUSPECTED OR PROVEN)

STATEMENT FROM THE SOUTH AFRICAN PAEDIATRIC CRITICAL CARE WORKING GROUP

This practice guideline is intended to support the safe and responsible treatment of critically ill Covid-19 children. We recognize the limited evidence in the treatment of paediatric Covid-19 infection. This document is based on the current best practices. As our knowledge expands, this guideline will be adjusted to reflect what we have learnt from evidence-based practice.

1. TRIAGE AND RESOURCE ALLOCATION:

- Children are less affected by Covid-19 disease, compared to adults. Less than 1% will develop Covid-19 related critical illness and international data demonstrate a good outcome compared to adults [9-11]. However, the effect of Covid-19 infection on immunosuppressed children is as yet unknown. [11]

- South African under-five mortality is higher than other middle-income countries such as Brazil and Cuba [19-21]. There is a shortage of paediatric critical care beds to accommodate the needs of South Africa’s 19.7 million children. The Covid-19 pandemic in South Africa overlaps with the winter pneumonia surge period when paediatric critical care (PCC) resources are already stretched beyond limits. This pandemic will place extra demands on the current limited PCC bed capacity.

- Given the overall good prognosis of Covid-19 infected children compared to adults, PCC beds should be ring fenced to support the paediatric population and not redistributed to the adult population.

- Paediatric triage and resource allocation during the Covid-19 pandemic should continue as per usual local paediatric intensive care (PICU) practice. Covid-19 and non-Covid patients should be triaged according to similar principles.

- Resource allocation should be made on an individual basis to patients with the best long-term prognosis and likelihood to benefit from PICU treatment [32].

2. INFECTION PREVENTION AND CONTROL:

- Hand hygiene remains the most important aspect of IPC for both staff and carers.

- See National Department of Health Guidelines on Infection Control and Prevention (IPC) [22].

- See Department of Health Guidelines for quarantine and isolation in relation to Covid-19 exposure and infection [27].

- For severe Covid-19 patients, de-isolation can occur 14 days after onset of symptoms in mild cases, 14 days after clinical stability in severe cases. Repeat Covid-19 testing is not required after infection [15].
### Diagnosis

<table>
<thead>
<tr>
<th><strong>Clinical signs of severe acute respiratory infection (SARI)</strong></th>
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<tbody>
<tr>
<td><strong>Mild SARI</strong></td>
</tr>
<tr>
<td>1. Cough</td>
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<tr>
<td>2. Difficult breathing and</td>
</tr>
<tr>
<td>3. Fast breathing</td>
</tr>
<tr>
<td>- &lt; 2 months: ≥60 bpm</td>
</tr>
<tr>
<td>- 2-11 months: ≥50 bpm</td>
</tr>
<tr>
<td>- 1-5 yr: ≥40 bpm [13]</td>
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<table>
<thead>
<tr>
<th><strong>Severe SARI</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Cough or</td>
</tr>
<tr>
<td>2. Difficult breathing and</td>
</tr>
<tr>
<td>3. One of following</td>
</tr>
<tr>
<td>• SpO2 &lt; 92%</td>
</tr>
<tr>
<td>• Severe distress</td>
</tr>
<tr>
<td>- Grunting</td>
</tr>
<tr>
<td>- Severe chest indrawing</td>
</tr>
<tr>
<td>• General danger signs</td>
</tr>
<tr>
<td>- Inability to feed</td>
</tr>
<tr>
<td>- Lethargy</td>
</tr>
<tr>
<td>- Reduced level of consciousness</td>
</tr>
<tr>
<td>- Convulsions</td>
</tr>
<tr>
<td>• Fast breathing</td>
</tr>
<tr>
<td>- &lt; 2 months: ≥60 bpm</td>
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<tr>
<td>- 2-11 months: ≥50 bpm</td>
</tr>
<tr>
<td>- 1-5 yr: ≥40 bpm [13]</td>
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<table>
<thead>
<tr>
<th><strong>Acute respiratory distress syndrome (ARDS)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>On CPAP/ BIPAP PEEP ≥ 5 cmH20:</td>
</tr>
<tr>
<td>• SpO2/FiO2 ratio ≤ 264</td>
</tr>
<tr>
<td>• PaO2/FiO2 ≤ 300</td>
</tr>
<tr>
<td>1. Mild ARDS ventilated:</td>
</tr>
<tr>
<td>• 4 ≤ OI &lt; 8 or</td>
</tr>
<tr>
<td>• 5 ≤ OSI &lt; 7.5</td>
</tr>
<tr>
<td>2. Moderate ARDS ventilated:</td>
</tr>
<tr>
<td>• 8 ≤ OI &lt; 16 or</td>
</tr>
<tr>
<td>• 7.5 ≤ OSI &lt; 12.3</td>
</tr>
<tr>
<td>3. Severe ARDS ventilated:</td>
</tr>
<tr>
<td>• OI ≥ 16 or</td>
</tr>
<tr>
<td>• OSI ≥ 12.3</td>
</tr>
</tbody>
</table>

| OI = Oxygenation Index (mean airway pressure × FiO2 + PaO2) |
| OSI = Oxygenation Index using SpO2 (mean airway pressure × FiO2 + SpO2) [13] |

Table 1: WHO Paediatric SARI symptom guide
3. COVID-19 SEVERE ACUTE RESPIRATORY INFECTION: GENERAL CONSIDERATIONS IN CHILDREN

- SARI is caused by various pathogens including Influenza, RSV, adenovirus and bacterial pneumonia, especially during winter season. Symptoms of paediatric Covid-19 may be similar to bronchopneumonia and bronchiolitis [7,33].
- Compared to adults, most children with severe acute respiratory infection (SARI), including Covid-19, have a good prognosis and should receive maximum available medical treatment [9, 10].

- Health care facilities caring for children with SARI should be equipped with pulse oximeters, functioning oxygen systems and disposable, single-use, oxygen delivery interfaces (nasal cannula, simple face mask, and mask with reservoir bag). All staff should wear appropriate PPE when working with potential Covid-19 patients [13].
- Limit aerosol generating procedures (AGP) when possible. However, AGP may be necessary if the child deteriorates. Limit staff numbers in close proximity when performing AGP, ensure appropriate PPE and perform AGP in isolation areas.

**Figure 1: Paediatric SARI treatment guide [1, 2]**

HFNC: high flow nasal cannula; NIV: non-invasive ventilation; SARI: severe acute respiratory infection

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**PAEDIATRIC SARI FIRST TIER RESPIRATORY SUPPORT:**
Start nasal cannula or mask [supplemental oxygen](#) if saturations < 92% in room air

**PAEDIATRIC SARI SECOND TIER RESPIRATORY SUPPORT:**
Consider [HFNC or NIV](#) if on oxygen therapy and:
- $\text{SpO}_2/\text{FiO}_2$ ratio 221 – 264 or
- Arterial blood gas $\text{PaO}_2/\text{FiO}_2$ 200 – 300 or
- Clinical deterioration and increase $\text{FiO}_2$ requirement
- Target $\text{SpO}_2$ 92% – 97% and $\text{FiO}_2$ < 60%
- Careful ongoing monitoring is essential
- Consider intubation directly if $\text{SpO}_2/\text{FiO}_2$ < 221

**PAEDIATRIC SARI THIRD TIER RESPIRATORY SUPPORT:**
Consider [intubation](#) if:
- $\text{SpO}_2/\text{FiO}_2$ ratio < 221 or
- $\text{PaO}_2/\text{FiO}_2$ < 200 or
- Clinical deterioration on NIV and increase $\text{FiO}_2$ requirement
- Target $\text{SpO}_2$ 92% – 97% and $\text{FiO}_2$ < 60%
- Careful ongoing monitoring is essential
4. PAEDITRIC SARI FIRST TIER RESPIRATORY SUPPORT: SUPPLEMENTAL OXYGEN

- Provide supplemental oxygen therapy if the child is hypoxaemic, demonstrating obstructed breathing, cyanosis, shock, severe respiratory distress, coma or convulsions.

- Target SpO\textsubscript{2} >92-94\% (in patients with a cyanotic heart lesion target SpO\textsubscript{2} 75-85\%)\cite{1, 7, 12G 15}. Titrate oxygen therapy to target oxygen saturations.

- Nasal prongs are the preferred first line treatment for hypoxia at standard flow rates (0.5–1 L/min for neonates; 1–2 L/min for infants; and 2–4 L/min for older children) to reach an SpO\textsubscript{2} of ≥ 92\% \cite{12}.

- Consider placing a surgical face mask over the nasal cannula to limit aerosolization \cite{26}.

- An appropriately sized face mask can be used as alternative to reach SpO\textsubscript{2} of ≥ 92\% and has less aerosol dispersion than nasal canulas.

- If unable to maintain SpO\textsubscript{2} > 92\% in NPO at 2l/min then change to 40\% venturi face mask (pink) at 8 l/min \cite{15}. Venturi face masks can provide higher oxygen concentrations, and accurate concentrations, but generates high gas flow rates and potentially increased aerosolization risk \cite{31, 48}.

  If unable to maintain SpO\textsubscript{2} > 92\% in 60\% face mask oxygen at 10l/min, change to face mask oxygen with a reservoir bag (non-rebreather face mask) at 15l/min \cite{15}.

  If unable to maintain SpO\textsubscript{2} > 92\% in a face mask oxygen with reservoir bag (non-rebreather face mask) at 15l/min, consider transfer to nearest PICU if bed available, considering non-invasive ventilation (NIV) or high flow nasal cannula (HFNC)\cite{15}.

- It is advisable to use oxygen blenders when providing supplemental oxygen to titrate FiO\textsubscript{2} accurately. Oxygen delivered via nasal cannula are affected by the flow rate and cannula size, depending on the nostril diameter. According to WHO, an appropriately sized nasal cannula in infants weighing up to 10 kg, oxygen flows of 0.5 L/min, 1 L/min and 2 L/min result in FiO\textsubscript{2} of about 35\%, 45\% and 55\%, respectively \cite{12}. However, this is controversial.

- Monitor children closely and escalate treatment in event of deterioration. Use WHO paediatric SARI clinical signs (table 1) to assess severity.

  Consider prone positioning for any child with respiratory difficulty \cite{2}. Do not re-use nasal canulas. Face masks should be disinfected before re-use.

NEBULIZATION:

- Nebulization is AGP and may have increase the risk to staff. Metered dose inhalers (MDI) with spacer is preferred.

- When nebulization is required, it should be performed as an AGP, in an isolation room with appropriate PPE for staff and limit staff numbers at the bedside during the procedure \cite{15}.
5. PAEDIATRIC SARI SECOND TIER RESPIRATORY SUPPORT: HIGH FLOW NASAL CANNULA OR NON-INVASIVE VENTILATION

- Consider an increase in respiratory support to HFNC or NIV when the child is clinically deteriorating, unable to maintain SpO2 > 92%, SpO2/FiO2 ratio 221-264 or when arterial blood gas PaO2/FiO2 ratio 200-300. NIV modalities to consider include CPAP or BIPAP [1, 2, 7, 12, 15G 17].

- To help assess the child’s disease course use the trend of
  - SpO2/FiO2 ratio or
  - Arterial blood gas PaO2/FiO2 ratios or
  - Clinical condition and FiO2 requirement

- Without a blender, accurate oxygen delivery is uncertain and absolute SpO2/FiO2 and PaO2/FiO2 values may be inaccurate. The trend, rather than absolute value, together with clinical condition should be used to assess the disease trajectory.

- Routine use of NIV is discouraged in patients with hypoxia or SARI. Likewise, NIV is not a substitute for children needing invasive ventilation.

- Compared with standard oxygen therapy, NIV reduce the need for intubation. Internationally, NIV is recommended as second-line treatment to reduce the need of ventilation for children with SARI, including Covid-19 patients. Avoidance of NIV, when available, may lead to unnecessary intubation and unsafe practice [1, 2, 7, 12, 13, 16]. Paediatric intensive care resources are limited. Therefore, we cannot ventilate all SARI children.

- Consider placing a surgical face mask over the interface to limit aerosolization and prone positioning [2, 26].

- Hospital oxygen levels should be taken into consideration if high flow oxygen or NIV is used in a large number of patients.

AEROSOLIZATION CONCERNS:

- All NIV are AGP as exhalation is not sealed or through a filter. Opinions vary about the degree of aerosolization. In children, NIV flow rates are lower than used in adults. Aerosol dispersion range from a few centimeters to a few meters. Currently, there is no strong evidence to support the notion that HFNC has higher aerosol risk than to other forms of NIV [7, 8, 28-31].

- Provide the type of NIV with an interface that staff are familiar with to ensure optimal use. If possible, select an interface that seals well to limit aerosol generation.

- Isolate children receiving NIV, ideally to single negative pressure rooms or cohort children receiving NIV to cubicles/wards more than one meter apart, with extraction fans if isolation rooms are not available. Staff to wear appropriate PPE [13].

- Because of uncertainty around the potential for aerosolization in NIV, it should be used with airborne precautions until further evaluation of safety can be completed. All staff should comply with PPE practice. Limit the number of staff working in the NIV area [7].

- Consider prone positioning and ensure nostrils are clear when applying NIV [1, 2, 7]. Avoid suctioning the nose, if possible, but if suctioning is necessary, perform procedure with appropriate PPE on and under plastic barrier.

- If possible, avoid nebulization while on NIV and rather use inhalers via a spacer to administer bronchodilators. If nebulization is necessary, ensure appropriate PPE use.

- In Covid-19 patients, consider placing a face mask over the NIV interface to limit aerosolization. Nostrils should be inspected regularly to ensure proper placement [26].
ESCALATION OF TREATMENT:

- If the child is not improving after 1-2 hours on NIV, alternative treatment approach should be considered.
- Signs of deterioration include:
  - Sustained increase in respiratory rate,
  - Increased oxygen requirement,
  - Increased heart rate and
  - Worsening of SpO₂/FiO₂ ratio [1, 2, 7, 8].

Consider intubation if:
- SpO₂/FiO₂ ratio < 221 or
- Arterial blood gas PaO₂/FiO₂ < 200 or
- Clinical deterioration on NIV and increased FiO₂ requirement

6. INTUBATION:

- There is limited evidence-based data on the safe intubation of Covid-19 PUI children but multiple paediatric consensus guidelines and expert opinions are available [2, 3, 5-8].
- Adult guidelines are inappropriate for children e.g. avoidance of bagging during intubation which may not be possible in critically ill children with low FRC and high VO₂ [2, 7].
- Identify patients needing intubation early, plan the procedure well and take your time [7, 34]. Intubation check lists are very useful to plan procedures and identify children with potentially difficult airways [1, 3, 4, 6, 7, 16, 36-39].

KEY ASPECTS FOR SAFER INTUBATION:

- Intubation is a AGP and thus a risk to health care workers [3, 5, 34]. Appropriate PPE for staff performing intubation with attention to donning and doffing procedures to limit self-contamination [22, 45].
- Limit aerosol and droplet generation by adding filters to circuits, the use of plastics sheets to cover patients or boxes to create a barrier between the patient and the health care workers [7, 46]. If these barriers are preventing a quick intubation, they should be abandoned to perform a quick intubation as per usual practice.
- Minimise staff performing the procedure by using the most experienced clinician available (wearing appropriate PPE) with a 2nd clinician assisting with airway manoeuvres and bagging; and a professional nurse with equipment and monitoring. A runner should be available outside the intubation room for further assistance [2, 3, 6]. Good communication is essential between the team inside and outside the room.
- Ideally intubate in a dedicated negative pressure isolation room or a dedicated room with adequate ventilation (6-12 volume changes per hour) [3, 8, 16].

INTUBATION PROCEDURE:

- See Appendix A: Intubation procedure flow chart and check list
- Preoxygenate with 100% FiO₂ using CPAP/ HFNC or NPO. Limit manual ventilation and ideally use an Ayers T-piece with filter to allow spontaneous breathing.
- Nasogastric / orogastric tube in place, empty stomach.
- Prepare cuffed ETT with in-line suction connected BEFORE starting procedure to limit disconnections
- **Safe bag-mask ventilation**, if needed
  - Two person technique (one bagging and the other person holding the face mask to ensure a good seal)
  - Place a filter between face-mask and bag.
  - Use small tidal volumes, sufficient to achieve chest rise.
  - Bag-mask ventilate under clear plastic sheet/box to limit droplet spread.
• Intubation drugs: Ketamine 1.2mg/kg + Rocuronium 1mg/kg → flush → wait 45-60 seconds → intubate [2-4]

• If video laryngoscope available: use screen, keeping distance from airway. If the intubator is not comfortable with a video laryngoscope, use a conventional laryngoscope.

• Choice between nasal or oral route of intubation should be balanced against a quick intubation procedure and risk of ETT dislodgment. Use the route you are most comfortable with.

• Connect ventilator, EtCO2 and in-line suction immediately after intubation and only START the ventilator once connected to ETT. REMEMBER to connect capnograph to ventilator circuit prior to intubation to limit disconnections.

• Ideally, confirm ETT position with EtCO2 but if not available use standard methods. It is advisable to use a patient specific stethoscope, however if not available, ensure appropriate decontamination between patients. [8, 16].

• Inflate ETT cuff and perform manometric cuff pressure check. Manometers are ESSENTIAL when using a cuffed ETT.

• Secure ETT as per usual practice. Do not take gloves off when securing ETT.

**UNSUCCESSFUL INTUBATION ATTEMPT:**

• Start safe bag-mask ventilation as described above.

• Attempt intubation again once patient adequately oxygenated.

• Consider LMA, if available.

• Avoid multiple, prolonged intubation attempts.

• In event of a difficult intubation—call for help early (ENT, anaesthetist, consultant, etc) and follow institutional escalation practice.

**POST INTUBATION**

• Consider getting all other procedures done while in PPE to avoid multiple donning and doffing. This includes tracheal aspirate, vascular access, urinary catheter, special investigations etc.

• Decontamination: Place all disposable equipment into the labelled bins inside isolation room. Wipe down all surfaces and non-disposable items in the room. Follow correct removal of aerosol intubation box and plastic sheet to prevent aerosol generation [6, 16, 22]

• Follow cleaning recommendations for video laryngoscope and intubation equipment.

• Correct doffing procedure outside room under supervision or with buddy system.

<table>
<thead>
<tr>
<th>Plastic sheets</th>
<th>Intubation Box</th>
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<tbody>
<tr>
<td><strong>PROS</strong></td>
<td><strong>CONS</strong></td>
</tr>
<tr>
<td>Can be pulled away easily if access to patient required</td>
<td>Restricts movement</td>
</tr>
<tr>
<td>Disposable and low cost</td>
<td>Difficult access patient if needed [49, 50]</td>
</tr>
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<table>
<thead>
<tr>
<th>Plastic sheets</th>
<th>Intubation Box</th>
</tr>
</thead>
<tbody>
<tr>
<td>gets in the way, sticks to plasters and tubes</td>
<td>Requires training before use [51]</td>
</tr>
<tr>
<td>Easily contaminated surface</td>
<td>More equipment to clean</td>
</tr>
<tr>
<td>Remove with caution, potential for aerosolization</td>
<td>Heavy and bulky</td>
</tr>
<tr>
<td>Expensive</td>
<td><strong>CONTR</strong></td>
</tr>
</tbody>
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**Table 2: Plastic sheets vs Intubation Box [4, 49-51]**
7. SUCTIONING:

- Suctioning is AGP and should only be performed for obvious secretions. **No routine suctioning.** [1, 2] All should wear appropriate PPE while performing suctioning.

- Inline (closed suction catheter) suctioning is recommended to decrease risk of aerosolization. These catheters should be connected to the endotracheal tube prior to intubation to limit disconnection from ventilator. Appropriate staff training is essential.

- Inline suctioning can also be used to collect tracheal aspirate specimens for viral and bacterial studies without increasing exposure to droplets/aerosol. Avoid disconnection from ETT.

- If inline suction is not available, use open suctioning with caution to limit aerosolization and cover child with a plastic sheet. [7]  
  - Ventilator flow should be turned off before circuit disconnection (suction support mode). **This should be well communicated to staff to prevent confusion and to ensure the ventilator is restarted timeously.**
  - Consider additional sedation and paralysis to limit aerosolization.

- Remove and discard suction catheter in a safe manner.

- Avoid instilling saline in ETT prior to suctioning as this increase aerosolization risks.
8. PAEDIATRIC SARI THIRD TIER RESPIRATORY SUPPORT: LUNG PROTECTIVE VENTILATION

- Target SpO₂ >92-94% and >88% in severe disease, FiO₂ < 60%, permissive hypercapnia with pH > 7.25. Tidal volume (TV) 5-7ml/kg ideal body weight, PEEP 6-10 depending on disease severity, limit plateau pressures < 30cmH2O. Titrate PEEP according to oxygenation, blood pressure and lung compliance. [1, 2, 7]

- Ensure adequate sedation and consider paralysis to limit dyssynchronous breathing if ongoing hypoxia

- Consider prone position. [2, 7]

- If the patient desaturates, avoid ETT disconnection and bagging, if possible. Rather aim to recruit by adjusting the ventilator settings and use inline suctioning. If disconnection is unavoidable, practise the safe bagging technique. Ventilator flow should be turned off before circuit disconnection to minimize aerosolization.

- Minimize hand bagging when ETT is disconnected. When hand bagging is completed, clamp ETT with an artery forceps/clamp before disconnecting from bag-mask ventilator/ T-piece. Reconnect ETT to ventilator and only thereafter release the artery forceps/clamp. This will prevent lung de-recruitment and limit aerosolization

GENERAL CONSIDERATIONS:

- Limit total fluid intake to 70-80% of normal maintenance in ventilated patients with SARI when there is no evidence of shock. Ensure normoglycaemia when restricting fluids. Start early enteral nutrition once shock is resolved. [2, 7]

- Blood transfusion threshold in haemodynamic stable children with SARI is Hb < 7g/dl.[7]

- High frequency oscillation could be considered if the child deteriorates but should be used with caution as aerosolization is a major risk and consider inhaled nitric oxide for severe hypoxia, if available [2].

- Consider antibiotic or antiviral cover for influenza, as co-infections often exist. De-escalate on the basis of microbiology results and clinical judgment [13].

- Consider early mobilization within 24 hours once cardiovascular and respiratory stability is achieved [47].
9. FILTERS AND HUMIDIFICATION:

- Use a viral/bacterial filter between the patient and the bag-mask-ventilator/anaesthetic bag when bagging. Filters protect staff against aerosolization and limit contamination of the circuit. Some filter only microorganisms, others include humidification (HME).

- Filters add dead space and can block with secretions. Therefore, in infants, filters should only be used during bagging and not routinely connected to a ventilator. For older children and adults, a hydrophobic filter should be added between the ETT and circuit. Higher ventilator pressure may be needed initially to recruit the lung [2].

- Bacterial/viral filters should be added to the end of the expiratory limb of ventilators and NIV devices to prevent device contamination. These filters do not protect the expiratory circuit against contamination and do not protect staff against the potential high viral load in the circuit.

Problems with all filters:

- Can get wet, with increase resistance
- Can block with secretions
- Needs to be changed at least every 24 hours, or when wet. This requires disconnection and increase aerosolization risk. Important to turn the flow of ventilator/ NIV device off when changing filters and to discard used filter safely.

- There is currently no strong evidence to recommend HME’s filters to active humidifiers [2].

- Active humidification cause fluid accumulation in ventilator tubing and concerns of circuit contamination with increase aerosolization exist. However, the evidence is not substantive.
10. EXTUBATION:

- Extubation is an AGP. There is limited evidence-based data available on the safe extubation but multiple consensus guidelines and expert opinions.

PREPARATION IS KEY:

- Ensure patient meets criteria for extubation as per institutional practice.
- PPE for extubation is similar as for intubation.
- Ideally extubate in an isolation room with negative pressure, alternatively in a single room with adequate ventilation [3, 18].
- Clear all non-essential staff. Two staff members in room only.
- Consider prophylactic corticosteroids 12 hours prior to extubation in patients at risk for extubation stridor[2]. The role of steroids remains unclear, routine corticosteroid use is not recommended [43, 44].
- Consider using medication to reduce the risk of coughing and minimise agitation e.g. dexametomidine if available [3, 6, 18].

SEQUENCE OF PROCEDURE FOR EXTUBATION: [3, 6, 18]

- Cover patient with plastic sheet. Consider turning the patient on their side and standing behind the patient when extubating.
- Pre-oxygenate with 100% fio2 or 3-5 minutes.
- Perform gentle oral suction under plastic sheet. Take care not to stimulate coughing. Use in-line suction with cuff inflated.
- Avoid cuff leak test.
- Remove ETT strapping.
- Turn ventilator off.
- Deflate cuff, hold ETT with plastic bag and remove (with in line suction and circuit attached) by pulling it immediately into plastic bag. Discard
- Do not encourage patient to cough
- Place nasal prongs on patient under plastic sheet with flow off. Place surgical mask over patient’s nose and mouth over the nasal cannula.
- Avoid the routine use of NIV. If HFNC or CPAP is necessary, manage as per aerosol-generating procedure (AGP) with staff in room in full PPE.
- Remove plastic sheeting
- Use adrenaline nebulisation for stridor, only if necessary. If utilised, manage as per AGP with staff in room in full PPE.

11. RENAL SUPPORT:

- Acute kidney injury (AKI) treatment in COVID-19 infected patients should be based on standard practice. Individualize treatment and dialysis to what staff are comfortable with. Children with chronic renal disease should be managed on a case by case basis.
  - Monitor fluid in vs fluid out and weight (if possible) on a daily basis
  - If fluid overload – try conservative techniques –
    - Furosemide 1mg/kg/dose or as infusion 0.1 – 1mg/kg/hour
    - Aminophylline 1mg/kg/dose 6hrly – if no arrhythmias
  - Avoid Nephrotoxins in AKI – Aminoglycosides/Contrast
  - Consider dialysis for:
    - Anuria/Oliguria
    - Electrolyte abnormalities – Hyperkalaemia
    - Acidosis not responding to treatment
    - Uraemic features
12. ECMO:

- Consider ECMO in COVID-19 infected children with anticipated favourable outcomes with short ECMO runs.
- ECMO resources should be kept available for non-COVID-19 related patients with conditions known to have excellent outcomes such as meconium aspiration syndrome.
- See ELSO guidelines [24].

PATIENT SELECTION:

- Use existing indications and thresholds for ECMO as per currently published ELSO guidelines.
- Candidacy for ECMO should be pre-emptively considered before reaching the stage of irreversible disease.
- Multiple co-morbidities may influence consideration of ECMO support.

INDICATIONS:

- ARDS related refractory hypoxemia and/or worsening hypercapnia despite lung protective ventilation.
- ARDS and/or ongoing requirement for vasoactive drugs secondary to COVID-19 septic shock, cardiogenic shock, intractable arrhythmia or pulmonary embolus.
- Cardio-circulatory failure due to cardiogenic shock e.g. hyperinflammatory shock,
- E-CPR in paediatric COVID-19 patients is not recommended due to poor prognosis and significant risks to staff.

CONTRAINDICATIONS:

- Severe or multiple comorbidities
- Immunocompromised status
- Chronic Lung Disease
- Critical congenital heart disease
- Severe global developmental delay
- Acute neurological complication
- Intracranial haemorrhage
- Irreversible severe brain damage
- Uncontrolled haemorrhage
- Contraindication to anticoagulation
- Severe multiple organ failure
- Mechanical ventilation for > 14 days before ECMO initiation
- Lethal Chromosomal anomalies (e.g. Trisomy 13 or 18)
- Extreme prematurity or low birth weight in neonates (<34wk or <2.0 kg)

SOUTH AFRICAN CENTRES OFFERING PAEDIATRIC ECMO DURING THE COVID-19 PANDEMIC:

- Private Hospitals:
  Gauteng: Unitas, Sunninghill, Garden City, Clinton, Wits Donald Gordon Medical Centre
  Western Cape: Christiaan Barnard

- Department of Health Hospitals:
  Gauteng: Nelson Mandela Children’s Hospital
13. THROMBOPROPHYLAXIS:

- Adult population have an increased risk for venous thromboembolism (VTE) during Covid-19. There is limited evidence on VTE in Covid-19 positive children and no evidence-based recommendations on thromboprophylaxis.
- The risk (of bleeding) – benefit ratio for VTE prophylaxis is assessed on an individual patient basis. This should happen on admission, at 48 – 72 hours for high risk patients.
- VTE risk factors include [25].
  - Central venous catheter (Femoral > Subclavian > Internal jugular)
  - Immobility: GCS <8/ Severe Head injury /Spinal cord injury
  - Exogenous oestrogen
  - Adolescence (>13 years old)
  - Obesity
  - Ventilation
  - Complex lower limb or pelvic fractures
  - Active inflammatory diseases

<table>
<thead>
<tr>
<th>Risk profile [35]</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
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<tbody>
<tr>
<td>Definition</td>
<td>&lt;13 years old 0 Risk Factors</td>
<td>1 – 2 risk factors</td>
<td>➪ 3 risk factors</td>
</tr>
<tr>
<td>Interventions</td>
<td>None</td>
<td>Encourage ambulation and adequate hydration when appropriate</td>
<td>Compression stockings</td>
</tr>
<tr>
<td></td>
<td>Consider chemoprophylaxis (heparin infusion, low molecular weight heparin, Aspirin) based on bleeding risk and/or surveillance for asymptomatic DVT</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Recommendations for prophylaxis:
  - Enoxaparin at 0.75 mg/kg/dose for neonates <2 months or 0.5 mg/kg/dose for children > 2 months, SC per 12 hours. Monitor with anti-Xa levels targeting: 0.2 – 0.4 anti-Xa u/ml
  - Alternatively, unfractionated heparin continuous infusion at 10u/kg/hr IV. Monitor with PTT [40].

14. RESUSCITATION:

- Ensure all staff don appropriate PPE before starting CPR, even though it will delay the resuscitation.
- Use two handed mask technique with filter between mask and bag.
- Ensure high quality CPR as per usual practice.
15. MULTISYSTEM INFLAMMATORY SYNDROME IN CHILDREN WITH COVID-19:

• In May 2020 a paediatric multisystem Paediatric inflammatory syndrome (PIMS-TS/MIS-C) associated with Covid-19 was observed [23, 41].

• Symptoms include fever, organ dysfunction and laboratory markers in keeping with an exaggerated inflammatory response.

• SARS-COV2 testing may be positive or negative.

• Symptoms include: Hypotension, tachycardia confusion, headache, syncope, conjunctivitis, respiratory symptoms including cough or supplemental oxygen requirement, sore throat, mucous membrane changes lymphadenopathy, neck swelling abdominal pain, diarrhea, vomiting, rash, swollen hands and feet.

• Laboratory features include: Raised C-Reactive protein (CRP), erythrocyte sedimentation rate (ESR), procalcitonin (PCT), fibrinogen, d-dimer, ferritin, lactic acid dehydrogenase (LDH), neutrophils, troponin T and Pro BNP. Reduced lymphocytes and low albumin

• Organ dysfunction includes: Shock, cardiac, respiratory, renal, gastrointestinal or neurological disorder.

• See appendix C for diagnostic criteria and treatment of PIMS-TS/MIS-C.

16. STERIODS IN CHILDREN WITH COVID-19:

1. ARDS:

• Dexamethasone 0.15mg/kg daily IV (max 6mg)
  OR
• Prednisone 1mg/kg/day PO (max 40mg)
  OR
• Hydrocortisone 4mg/kg/day IV in divided doses (max 160mg)

2. Multi organ failure:

• Dexamethasone 0.3 mg/kg daily IV (max 6mg)
  OR
• Prednisone 2 mg/kg/day PO (max 40mg)
  OR
• Hydrocortisone 4-8 mg/kg/day IV in divided doses (max 160mg)
17. PARENTS AND CAREGIVERS IN THE PICU:

- We advocate for patient- and family-centred care (PFCC) in PICU. PFCC is grounded in a mutually beneficial partnership between the patients, families and health care workers. Having a suspected or proven COVID-19 child in PICU will cause significant parental and family stress. It is therefore necessary to find balanced ways to deliver PFCC to provide for the child’s basic needs of love and security, while ensuring minimal additional risk to health care workers.

- Covid-19 infected or suspected children should be cared for in a child friendly environment, by staff who are knowledgeable and well-trained in holistic paediatric care and if possible, not cohorted with adults.

- 90% of Covid-19 infected children acquire the infection at home or in the community and thus all adult carers should be presumed positive until proven otherwise [15].

- Each Covid-19 infected patient’s circumstance and family context is different. Health care facilities differ in terms of infrastructure and resources to accommodate parents. Given the diversity, five principles should be considered when supporting parents after their child is admitted to PICU with suspected or proven Covid-19.

1. PHYSICAL PRESENCE OF PARENT/CAREGIVER

- One asymptomatic and well parent/caregiver should be allowed to remain with the child if feasible, especially if the mother is breastfeeding. Parents should practise hand hygiene, social distancing and respiratory etiquette [13, 15]. The wearing of a mask should be enforced, and staff should educate the parent/caregiver to wear it correctly.

- All parents/caregivers should undergo testing for COVID-19 if not already performed, as part of contact tracing.

- Ideally, parents/caregivers with confirmed COVID-19 should not remain with the child unless the child is also confirmed positive and the pair can be admitted in a COVID-19 isolation area.

- Parents/caregivers who are either unaware of their COVID-19 status or are COVID-19 negative, should remain in hospital at their own risk and should be given a daily screening tool to complete.

- Parents separated from their children, should receive psychological support from appropriate trained staff [13].

2. PARENTS/ CAREGIVERS UNABLE TO BE PRESENT

- Where possible a communication system should be set up so that information sharing, updates, counselling and consent issues can be dealt with by video conferencing, phone or electronic device.

- Age appropriate communication between the parents/caregivers and admitted child should be enabled.

- Conversations should be scheduled at a time amenable to both the caregivers and the health care team.

3. INFORMATION AND GUIDANCE FOR CHILDREN, PARENTS AND CAREGIVERS

(In addition to the usual information that is shared on admission to PICU)

- Provide details of Covid-19 disease including handwashing, mask principles as well as social distancing.

- Discuss ongoing isolation or quarantine when appropriate e.g. after close contact with confirmed or suspected Covid-19 person or after discharge from hospital. Symptom monitoring must continue for the entire isolation period.)
4. CONSENT

- Healthcare workers should be familiar with the consent provisions of The Children’s Act of 2005 and contact details should be carefully recorded to obtain consent telephonically if the parent is not present in PICU.
- Parents, legal guardians and caregivers can consent for medical treatment while only parents and legal guardians can consent to surgical treatment.
- Healthcare workers should be familiar with the steps to take to obtained emergency consent or court/ministerial consent if parents or legal guardians are not available.

5. BREASTFEEDING

- To date, SARS-CoV-2 has not been found in breastmilk.
- Breastfeeding should be actively encouraged as long as the mother wears a mask and practices hand hygiene before and after breastfeeding, practice respiratory hygiene. Contact surfaces should be disinfected routinely if the mother is Covid-19 positive [13]. Mothers should be actively supported to continue breastfeeding.
- Where expressed breast milk (EBM) is required and the mother is present, she should express the milk into a sterile container whilst wearing a mask and having practiced hand hygiene prior to expressing.
- Where EBM is required and the mother is not present, but able to provide the milk, arrangements should be made for her to express into a sterile container at home taking appropriate IPC precautions as above. The container should be placed into a plastic bag and the outside of the bag sprayed with alcohol solution before being transported to the hospital.
- If milk is required and the mother is not able to supply EBM, alternative options should be discussed with the family. These could include donor breast milk and as a last resort appropriate breast milk substitutes.

18. ABBREVIATIONS

AGP: aerosol generating procedure
AKI: acute kidney injury
ARDS: Acute respiratory distress syndrome
BiPAP: bi-level positive airway pressure
CPAP: continuous positive airway pressure
EBM: expressed breast milk
ETT: endotracheal tube
ETCO₂: end tidal CO₂
FRC: functional residual capacity
FiO₂: Concentration inspired oxygen
HFNC: high flow nasal cannula
IPC: Infection control and prevention
MDI: metered dose inhaler
MISC: multisystem inflammatory syndrome in children with Covid-19 NIV:
non-invasive ventilation
NPO: nasal prong oxygen
OI: Oxygenation Index (mean airway pressure × FiO₂ +PaO₂)
OSI: Oxygenation Index using (mean airway pressure × FiO₂ +SpO₂)
PEEP: positive end expiratory pressure
PFCC: patient-centred and family-centred
PICU: paediatric intensive care unit
PPE: personal protective equipment
RSI: rapid sequence induction
PUI: person under investigation
SpO₂: oxygen saturation
VO₂: oxygen consumption
VTE: venous thromboembolism


APPENDIX A:

- Flowchart for intubation procedure for Covid-19 suspected or proven children
- Intubation check list

APPENDIX B:

- Flowchart paediatric advanced cardiac arrest algorithm for Covid-19 pandemic

APPENDIX C:

- Paediatric multi-system inflammatory syndrome (PIMS-TS/MIS-C) guideline.