Optimized supportive care of children and young persons with critical COVID-19

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Objectives

- Management of pediatric acute respiratory distress syndrome (PARDS)
- Management of shock, including septic shock
- ECMO considerations
- Other supportive care strategies

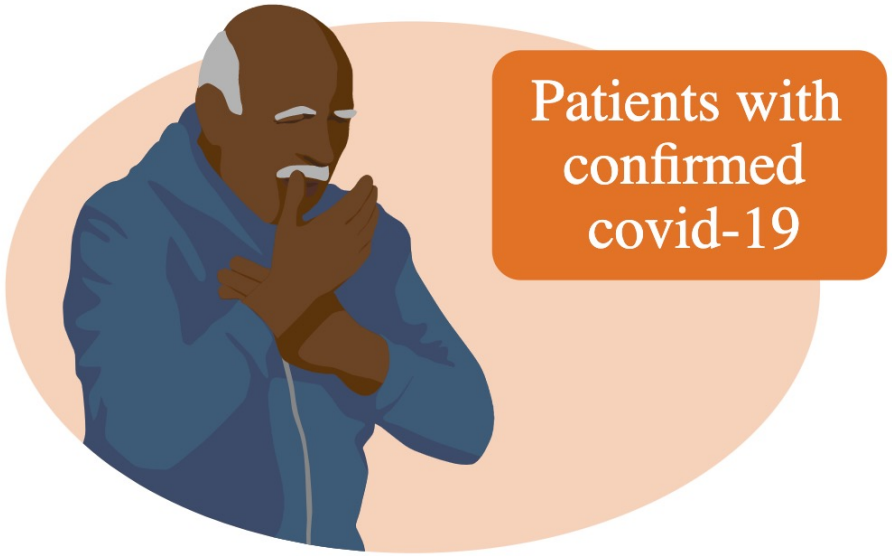
Note that the term "COVID-19" refers to the acute infection with SARS-CoV-2; will separately refer to multisystem inflammatory syndrome in children (MIS-C), as applicable

World Health Organization

WHO. Living guideline for clinical management of COVID-19. Available at: https://app.magicapp.org/#/guideline/j1WBYn.

Critical COVID-19

This recommendation applies only to people with these characteristics:



Patients with confirmed covid-19

Disease severity

Non-severe	Severe	Critical
Absence of signs of severe or critical disease	Oxygen saturation <90% on room air	Requires life sustaining treatment
	Signs of pneumonia	Acute respiratory distress syndrome
	Signs of severe respiratory distress	Sepsis
		Septic shock

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Definitions

Pediatric Acute Respiratory Distress Syndrome (PARDS)

Bilevel (NIV or CPAP) ≥ 5 cm H2O via full face mask:

- PaO2/FiO2 ≤ 300 or SpO2/FiO2 ≤ 264

Invasively ventilated:

- Mild PARDS: 4 ≤ OI <8 OR 5 ≤ OSI <7.5
- Moderate PARDS: 8 ≤ OI <16 OR 7.5 ≤ OSI <12.3
- Severe PARDS: OI ≥ 16 or OSI ≥ 12.3

Sepsis/shock

Sepsis: suspected or proven infection and ≥ 2 age-based SIRS criteria, of which one must be abnormal temperature or WBC count

Septic shock: any hypotension (SBP <5th centile or 2 SD below normal for age) OR at least 2 signs of impaired perfusion*

Signs of impaired perfusion: bradycardia (HR <90 bpm in infants, <70 bpm in children) or tachycardia (>160 bmp in infants or >150 bmp in children); prolonged capillary refill time or weak pulse; fast breathing; mottled or cool skin or petechial or purpuric rash ; high lactate; reduced urine output; hyperthermia or hypothermia

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Management of Acute Respiratory Failure and Pediatric Acute Respiratory Distress Syndrome (PARDS)

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Non-invasive respiratory support

In selected patients with COVID-19 and mild ARDS, a trial of HFNO, non-invasive ventilation – continuous positive airway pressure (CPAP), bilevel positive airway pressure (BiPAP) may be used. Refer to Table 6.3 for definitions of mild, moderate and severe ARDS.

- No comparative pediatric data supporting superiority of high-flow nasal canula (HFNC) versus non-invasive ventilation (NIV)* among children with respiratory failure who do not require intubation
- HFNC flow rates of up to 2 L/kg/minute (max: 40-60 L) can be used in children
- NIV may be an appropriate “rescue” mode for patients who fail HFNC AND who do not require intubation

*Continuous positive airway pressure or bi-level modes of non-invasive mechanical ventilation

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WHO. Living guideline for clinical management of COVID-19. Available at: https://app.magicapp.org/#/guideline/j1WBYn. Rimensberger P, et al. Pediatr Crit Care Med 2015;16:S51-60. Essouri S, et al. Pediatr Crit Care med 2015;16:S102-110. Milesi C, et al. Intensive Care Med 2017;43:209-216. Milesi C, et al. Intensive Care Med 2018;44:1870-1878. Maitland K, et al. Intensive Care Med 2021;47:566-576. Christi M, et al. Lancet 2015;386:1057-1065.

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- Short interval reassessment (e.g., ~1 hour after initiation) to evaluate for deterioration or failure to improve, which may indicate a need for intubation
  - Assess for improvement in degree of hypoxia, respiratory rate and work of breathing, mental status, heart rate, synchrony/tolerance of interface

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Intubation

We recommend that endotracheal intubation be performed by a trained and experienced provider using airborne precautions.

- Cuffed, rather than uncuffed, endotracheal tubes should be used in all ages → minimize aerosol generation, ensure delivery of ventilator pressures, decrease aspiration risk
  - Endotracheal tube size: (age in years/4) + 4 – size down by 0.5 when using a cuffed tube
  - Broselow tape

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WHO. Living guideline for clinical management of COVID-19. Available at: https://app.magicapp.org/#/guideline/j1WBYn. Rimensberger P, et al. Pediatr Crit Care Med 2015;16:S51-60. Weiss M, et al. Br J Anaesth 2009;103:867-873. Fenmei S, et al. J Anesth 2016;30:3-11. Matava C, et al. Anesth Analg 2020;131:61-73.

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Mechanical ventilation targets: PARDS

Oxygenation:
SpO2 of 92-97% for most; for children with severe PARDS, may target lower SpO2 of 88-92% with monitoring of adequacy of oxygen delivery (e.g., ScvO2)

Ventilation:
Permissive hypercapnia (e.g., pH > 7.15-7.30), as long as no contraindication (e.g., pulmonary hypertension, significant ventricular dysfunction)

- Low tidal volume (e.g., 4-8 mL/kg)
- Higher PEEP, individualized to patient physiology (oxygenation and hemodynamics)
- Plateau pressure $\leq$ 28 cm H2O (up to $\leq$ 32 cm H2O if decreased chest wall compliance)

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WHO. Living guideline for clinical management of COVID-19. Available at: https://app.magicapp.org/#/guideline/j1WBYn. Rimensberger P, et al. Pediatr Crit Care Med 2015;16:S51-60. Bhalia AK, et al. Crit Care Med 2021;49:1779-1789. Khemani RG et al. Am J Respir Crit Care Med 2018;198:77-89.

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Non-ventilatory support: PARDS

- Judicious fluid management following initial resuscitation, aiming to prevent overly positive fluid balance while maintaining intravascular volume

- Minimal effective sedation dose to facilitate ventilation, optimize gas exchange, and minimize ventilator-induced lung injury; nurse-driven protocols may be beneficial and are unlikely to be associated with harm

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WHO. Living guideline for clinical management of COVID-19. Available at: https://app.magicapp.org/#/guideline/j1WBYn. Valentine SL, et al. Crit Care Med 2012;40:2883-2889. Black C, et al. Pediatr Crit Care Med 2021;22:795-805. Lima L, et al. Pediatr Crit Care Med 2021;22:114-124. Curley M, et al. JAMA 2015;313:379-389. Blackwood B, et al. JAMA 2021;326:401-410. Smith HB, et al. Pediatr Crit Care Med 2022;23:e74-e110.

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Severe PARDS: Prone Ventilation

In adult patients with severe ARDS (PaO_2/FiO_2 < 150) prone ventilation for 12–16 hours per day is recommended.

Remarks:

1. Application of prone ventilation is recommended for adult patients, preferably for 16 hours per day, and may be considered for paediatric patients with severe ARDS but requires sufficient human resources and expertise to be performed safely; protocols (including videos) are available (140)(141).

- Pediatric randomized trial demonstrated no difference in ventilator free days or mortality in children with acute lung injury randomized to prone ventilation
- Mortality benefit with prone ventilation was detected in a subsequent meta-analysis and a randomized trial performed in adults with **severe ARDS**
- Ongoing international pediatric trial evaluating prone ventilation for severe PARDS (NCT03896763)

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WHO. Living guideline for clinical management of COVID-19. Available at: https://app.magicapp.org/#/guideline/j1WBYn. Tamburro RF, et al. Pediatr Crit Care Med 2015;16:S61-72. Curley M, et al. JAMA 2005; 294:229-237. Sud S et al. Intensive Care Med 2010;36:585-599. Guerin C, et al. N Engl J Med 2013;368:159-2168.

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Severe PARDS: Other Ancillary Therapies

After optimization of other oxygenation strategies, may also consider per usual standards for non-COVID-19 patients:

- **Neuromuscular blockade** - if sedation alone is inadequate to achieve oxygenation/ventilation targets with lung protective ventilation
- **Inhaled nitric oxide** – if no improvement in oxygenation is observed, nitric oxide should be discontinued
- **Recruitment maneuvers** – if used, suggest incremental PEEP titrations to minimize harm
- **High frequency oscillatory ventilation**

World Health Organization

Valentine SL, et al. Pediatr Crit Care Med 2015;16:573-585. Tamburro RF, et al. Pediatr Crit Care Med 2015;16:S61-72. Bronicki RA et al. J Pediatr 2015;166:365-369. Rimensberger P, et al. Pediatr Crit Care Med 2015;16:S51-60. Gupta P, et al. Crit Care Med 2016;44:1901-1909. Bhalla A, et al. Crit Care Med 2018;46:1803-1810. El-Nawawy A, et al. Turk J Pediatr 2017;59:130-143. Samransamruajkit R, et al. Indian J Crit Care Med 2016;20:72-77.

Management of Shock

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Fluid resuscitation

Recognize septic shock in children with any hypotension (SBP < 5th centile or > 2 SD below normal for age) or two or more of the following: altered mental status; bradycardia or tachycardia (HR < 90 bpm or > 160 bpm in infants and HR < 70 bpm or > 150 bpm in children); prolonged capillary refill (> 2 sec) or feeble pulses; tachypnoea; mottled or cold skin or petechial or purpuric rash; increased lactate; oliguria; hyperthermia or hypothermia (see Table 6.3).

In resuscitation for septic shock in children, give 10–20 mL/kg crystalloid fluid as a bolus in the first 30–60 minutes.

- Hypotension is a late finding in pediatric shock – attention to other, more subtle signs of impaired perfusion is critical (e.g., mental status, tachypnea, oliguria)

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Assessing response to fluid resuscitation

Recognize septic shock in children with any hypotension (SBP < 5th centile or > 2 SD below normal for age) or two or more of the following: altered mental status; bradycardia or tachycardia (HR < 90 bpm or > 160 bpm in infants and HR < 70 bpm or > 150 bpm in children); prolonged capillary refill (> 2 sec) or feeble pulses; tachypnoea; mottled or cold skin or petechial or purpuric rash; increased lactate; oliguria; hyperthermia or hypothermia (see Table 6.3).

In resuscitation for septic shock in children, give 10–20 mL/kg crystalloid fluid as a bolus in the first 30–60 minutes.

- Re-assess for signs of volume overload (e.g., hepatomegaly, rales, pulmonary edema) – particularly in patients with suspected MIS-C given ~one-third have ventricular dysfunction

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WHO. Living guideline for clinical management of COVID-19. Available at: https://app.magicapp.org/#/guideline/j1WBYn. Weiss SL, et al. Pediatr Crit Care Med 2020;21:e52-106. Feldstein LR, et al. JAMA 2021;325:1074-1087.

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Vasopressors: choice and indication

In children, administer vasopressors if signs of fluid overload are apparent or the following persist after two fluid bolus:

- signs of shock such as altered mental state;
- bradycardia or tachycardia (HR < 90 bpm or > 160 bpm in infants and HR < 70 bpm or > 150 bpm in children);
- prolonged capillary refill (> 2 seconds) or feeble pulses;
- tachypnoea; mottled or cool skin or petechial or purpuric rash; increased lactate; oliguria persists after two repeat boluses;
- or age-appropriate blood pressure targets are not achieved *(110)*.

- Epinephrine or norepinephrine are favored over dopamine, with epinephrine considered first-line by the WHO

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WHO. Living guideline for clinical management of COVID-19. Available at: https://app.magicapp.org/#/guideline/j1WBYn. Weiss SL, et al. Pediatr Crit Care Med 2020;21:e52-106. Ventura A, et al. Crit Care med 2015;43:2292-2302. Ramaswamy K, et al. Pediatr Crit Care Med 2016;17e502-512.

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If central venous catheters are not available, vasopressors can be given through a peripheral IV, but use a large vein and closely monitor for signs of extravasation and local tissue necrosis. If extravasation occurs, stop infusion. Vasopressors can also be administered through intraosseous needles.

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WHO. Living guideline for clinical management of COVID-19. Available at: https://app.magicapp.org/#/guideline/j1WBYn. Weiss SL, et al. Pediatr Crit Care Med 2020;21:e52-106. Abrams J, et al. Lancet Child Adolesc Health 2021;5:323-331. Feldstein LR, et al. JAMA 2021;325:1074-1087.

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Assessing response to resuscitation

- Response to resuscitation (e.g., fluid administration, vasopressor) should be assessed serially and could include:
  - clinical assessments (e.g., mental status, urine output, perfusion)
  - laboratory markers (e.g., lactate)
  - cardiac ultrasound/echocardiography, if available

- Multimodal approach may be particularly valuable in patients with shock due to MIS-C, where shock may be distributive, cardiogenic, and/or hypovolemic, although no high-quality studies have evaluated this approach

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Extracorporeal Membrane Oxygenation (ECMO)

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ECMO

- ECMO can be considered for children with refractory hypoxemia or shock due COVID-19 or MIS-C, if available and sufficient local expertise exists for management
- ECMO candidacy and management principles should align with approaches for non-COVID-19 patients
- As of 3/20/2022, 386 children managed with ECMO were reported to ELSO
  - 73% received respiratory ECMO
  - In hospital mortality ~30%

World Health Organization

WHO. Living guideline for clinical management of COVID-19. Available at: https://app.magicapp.org/#/guideline/j1WBYn. Dalton H, et al. Pediatr Crit Care Med 2015;16:S111-117. Weiss SL, et al. Pediatr Crit Care Med 2020;21:e52-106. Badulak J, et al. ASAIO J 2021;67:485-495. Barbaro RP, et al. Am J Resp Crit Care Med 2018;197:1177-1186. ELSO COVID-19 Registry Dashboard. Available at: https://www.elso.org/Registry/FullCOVID-19RegistryDashboard.aspx?goHash=1&sO=1&all=true&NA=false&Eur=false&Asia=false&La=false&Africa=false&AA=false&Neo=true&Ped=true&Adlt=false#TheFilter

Other Supportive Care Priorities

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Other supportive care priorities

- Deliver usual care bundles in order to prevent complications among hospitalized patients, adapted to local circumstances
  - Examples: bundles to prevent central line associated bloodstream infections or ventilator-associated pneumonia; promote appropriate antimicrobial prescribing; promote early mobilization and ventilator liberation
- Optimize management of co-morbid medical conditions present in many children with critical COVID-19
- Prioritize family presence at bedside, with attention to strict infection control guidelines

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Thank You!