Teaching Pediatric Life Support in Limited-Resource Settings: Contextualized Management Guidelines

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Abstract

Keywords

- Pediatric Advanced Life Support
- cardiopulmonary resuscitation
- pediatric emergency conditions
- limited-resource setting
- mortality

Of the estimated 6.3 million global annual deaths in children younger than the age of 5 years, nearly all (99%) occur in low- to middle-income countries (LMIC). Existing management guidelines for children with emergency conditions as taught in a variety of current pediatric life support courses are mostly applicable to high-income countries with a different disease range and full resources compared with LMIC. A revised curriculum with evidence-based application to limited-resource settings would expand their potential for reducing pediatric mortality worldwide. This review provides a supplemental curriculum of standards for selected pediatric emergency conditions with attention to the context of disease range and level-specific resources in LMIC. During training sessions, contextualized management guidelines create the framework for realistic and fruitful case simulations.

Introduction

Of the estimated 6.3 million global annual deaths in children younger than the age of 5 years, nearly all (99%) occur in low- to middle-income countries (LMIC): 51% in sub-Saharan Africa, 29% in south Asia, and 19% in other regions.^{1–3} Children in need of emergency care often do not reach even the simplest health care facilities.^{4,5} The majority of pediatric deaths occur outside hospitals.^{6–8} About 50% of deaths of children admitted to hospital occur within 24 hours of admission.⁹

Existing management guidelines for children with emergency conditions as taught in a variety of current pediatric life support courses are mostly applicable to high-income countries with a different disease range and full resources compared with LMIC. For this reason, these courses lack universal applicability despite their universal acceptance.^{10–14} A revised curriculum with evidence-based application to limited-resource settings would expand their potential for reducing pediatric mortality worldwide.¹⁵

This review provides a supplemental curriculum of standards for selected pediatric emergency conditions with attention to the context of disease range and level-specific resources in LMIC.¹⁶ During training sessions, contextualized management guidelines create the framework for realistic and fruitful case simulations. The guidelines find their basis in current evidence and are compatible with World Health Organization (WHO) standards and protocols for pediatric emergency and critical care across the continuum of care for children, including Integrated Management of Childhood Illness and Emergency Triage, Assessment, and Treatment.^{17,18}

Components of effective contextualized training sessions include:

- *Learner materials:* summarizing management considerations
- Precourse assessment and preparation
- *Credible consistent instruction:* by faculty working in limited-resource settings

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- *Interactive small group sessions*: emphasizing team participation
- *Skills practice*: with low-technology equipment available to learners
- *Realistic case scenarios*: to disease range/available resources/scope of practice
- *Debriefing*: in accordance with local/national/international standards and protocols
- Refresher assessment and training.

In an abbreviated format of instructor discussion points, management considerations are provided for selected emergency conditions occurring in children outside the neonatal age range (i.e., defined as 0–28 days), which are as follows:

- *Respiratory*: hypoxemia, upper airway obstruction, lower airway obstruction, lung tissue disease, disordered control of breathing
- *Circulatory*: dehydration/hypovolemic shock, distributive shock (i.e., septic shock, anaphylactic shock, neurogenic shock), cardiogenic shock, obstructive shock
- *Neurological*: meningitis, cerebral malaria, seizure, structural lesion, stroke
- *Other*: severe malnutrition, hypothermia, severe viral infection, severe bacterial infection, severe malaria, trauma, severe anemia, micronutrient deficiency, hypoglycemia, cardiac arrest.

Guidelines for referral and transport of critically ill or injured children in limited-resource settings are also provided.

Management of Selected Emergency Respiratory Conditions

Hypoxemia

Indication for oxygen therapy by oxygen saturation measured with pulse oximetry is:¹⁹

- $\text{SpO}_2 \leq 90\%$ ($\leq 2,500$ m above sea level)
- $\text{SpO}_2 \leq 87\%$ ($> 2,500$ m above sea level).

Central cyanosis is visible at arterial oxygen saturation $\leq 85\%$ at normal hemoglobin (Hb) concentration.²⁰ Dark skin pigmentation decreases the accuracy of pulse oximetry at low oxygen saturation and makes identification of central cyanosis difficult.^{21–23} Children with severe anemia may be hypoxemic without showing central cyanosis.²³

Oxygen delivery systems which conserve oxygen and also limit its potential toxicity are generally preferred. For free-flow oxygen delivery, nasal prongs are typically used in children < 5 years of age.¹⁹

A schematic for advancing level of oxygen delivery based on pulse oximetry is provided in **Fig. 1**.

Upper Airway Obstruction

- *Croup*: Administer adrenaline (epinephrine) (1 mg/mL) 0.5 mL/kg (maximum dose 5 mL) in 3 mL NS via nebulizer PRN, repeat PRN,²⁴ dexamethasone 0.6 mg/kg oral/in-

tramuscular (IM)/intravenous (IV) $\times 1$ dose (maximum dose 16 mg)²⁴

- *Airway edema (allergy associated)*: Adrenaline (epinephrine) (1 mg/mL) 0.5 mL/kg (maximum dose 5 mL) in 3 mL NS via nebulizer, repeat PRN,²⁴ dexamethasone 0.6 mg/kg oral/IM/IV every 24 hours PRN (maximum dose 16 mg)²⁴
- *Diphtheria*: Procaine benzylpenicillin (procaine penicillin G) 50,000 units/kg (maximum dose 4.8 million units) IM (do not give IV) daily for 7 days + diphtheria antitoxin 40,000 units IM/IV^{18,25}
- *Epiglottitis*: Ceftriaxone 80 mg/kg (maximum dose 2 g) IV/IM every 24 hours for 7 days^{18,25}
- *Bacterial tracheitis*: Ceftriaxone 80 mg/kg (maximum dose 2 g) IV/IM every 24 hours + cloxacillin 25 to 50 mg/kg IV/IM every 6 hours (maximum dose 4 g per 24 hours) for 10 to 14 days, add metronidazole 20 to 30 mg/kg/day oral divided every 6 hours (maximum dose 4 g per 24 hours) for 10 to 14 days PRN^{25,26}
- *Neck abscess (retropharyngeal/parapharyngeal)*: Clindamycin 40 mg/kg/day IV/IM divided every 8 hours (maximum dose 4.8 g per 24 hours) for 10 to 14 days^{25,27–31}
- *Foreign body airway obstruction (FBAO)*: *Mild FBAO*: do not interfere, monitor³²; *Severe FBAO*: infant, perform back slaps and chest thrusts; child, perform abdominal thrusts³²; *Unconscious*: open airway, remove visible foreign body, avoid blind finger sweep, perform compressions/ventilations,³² consider bronchoscopy,^{18,33,34} and consider tracheostomy.^{18,33,35–37}

Lower Airway Obstruction

- *Asthma/bronchospasm (allergy associated)*: Administer bronchodilator: salbutamol 2 to 6 puffs (MDI with spacer) or 2.5 mg via nebulizer (at 5–10 LPM) every 20 minutes PRN¹⁸; alternate regimen: albuterol 4 to 8 puffs (MDI with spacer) every 20 minutes PRN or 2.5 mg (weight < 20 kg) or 5 mg (weight > 20 kg) via nebulizer every 20 minutes PRN²⁴; alternate regimen: adrenaline (epinephrine) (1 mg/mL) 0.01 mg/kg SQ every 15 minutes (maximum dose 0.3 mg)²⁴; magnesium sulfate 50 mg/kg IV (maximum dose 1 g)^{18,38}; corticosteroid: prednisolone 1 mg/kg oral daily for 3 to 5 days (maximum dose 60 mg)¹⁸; alternate regimen: dexamethasone 0.6 mg/kg oral/IM/IV (maximum dose 16 mg) every 24 hours²⁴
- *Bronchiolitis*: Supportive measures (i.e., suctioning, hydration).^{18,39}

If a regular spacer device is not available for use with the MDI, consider use of a sealed-soda bottle as a suitable alternative.⁴⁰ Attach a face mask to the cap end for use in infants.

Lung Tissue Disease

- *Pneumonia*: Administer: *Very severe pneumonia*: ampicillin 50 mg/kg (maximum dose 12 g per 24 hours) or benzylpenicillin (penicillin G) 50,000 units/kg (maximum dose 24 million units per 24 hours) IV/IM every 6 hours + gentamicin 7.5 mg/kg IV/IM every 24 hours for at least

Fig. 1 Oxygen delivery systems. FiO_2 is based on delivery of 100% oxygen by cylinder (maximum flow rate 15 LPM). An oxygen concentrator can deliver up to 90% oxygen (maximum flow rate 10 LPM).^{106,107} High-flow nasal prong flow rates are calculated as 2 L/kg/min (wt ≤ 10 kg) + 0.5 L/kg/min (for every kg > 10 kg).¹²⁴ Bubble CPAP can be operated without power supply using an oxygen cylinder.⁶¹ Oxygen/flow (use a blender if available) is weaned to maintain SpO_2 90 to 99% ($\leq 2,500$ m) or SpO_2 87 to 99% ($> 2,500$ m). Humidification for prolonged treatment is added. CPAP, continuous positive airway pressure; BiPAP, bilevel positive airway pressure; BMV, bag mask ventilation.

5 days; ceftriaxone 80 mg/kg (maximum dose 2 g) IV/IM every 24 hours if treatment failure^{19,25}; for human immunodeficiency virus (HIV) infection or exposure in infants aged 2 months to 1 year, administer empiric trimethoprim-sulfamethoxazole 20 mg/kg (dose based on TMP component) (maximum dose 320 mg per 24 hours) oral/IV divided every 6 to 8 hours for suspected *Pneumocystis jirovecii* (carinii) infection^{19,25}; *Severe pneumonia*: amoxicillin 40 mg/kg oral twice daily (maximum dose 3 g per 24 hours) for 5 days^{17,19,25}; exception: for HIV infection or exposure, follow all recommendations for very severe pneumonia; *Nonsevere pneumonia*: amoxicillin 40 mg/kg oral twice daily (maximum dose 3 g per 24 hours) for 3 days (low HIV prevalence) or for 5 days (high HIV prevalence)^{17,19,25}; *Nonsevere pneumonia + wheeze*: do not give antibiotics¹⁹; *Pleural effusion/empyema/lung abscess*: operative management PRN¹⁸; ampicillin (maxi-

mum dose 12 g per 24 hours) or cloxacillin (maximum dose 4 g per 24 hours) 50 mg/kg IV/IM every 6 hours + gentamicin 7.5 mg/kg IV/IM once daily for 7 days; if improvement, continue cloxacillin 50 mg/kg oral every 6 hours for total course of 3 weeks^{18,25}

- *Pulmonary edema*: Furosemide (Lasix) 1 to 2 mg/kg oral/IV every 12 hours PRN.^{18,24}

Disordered Control of Breathing

- Respiratory failure: Administer PPV²⁴
- Neurological cause: Central apnea: aminophylline¹⁸; Increased intracranial pressure (ICP): supportive measures, treat underlying cause^{24,41}; Meningitis: see guidelines for meningitis^{18,19}; Encephalitis/cerebral malaria: see guidelines for cerebral malaria^{18,42–45}; Seizure: see guidelines for seizure¹⁸

- Neuromuscular weakness: PPV PRN²⁴
- Metabolic cause: Metabolic acidosis (i.e., with associated deep “acidotic” breathing): isotonic crystalloid (lactic acidosis), insulin (diabetic ketoacidosis)^{18,24}; Toxin: antidote if available, supportive measures.^{18,24}

Substitute resources for the management of emergency respiratory conditions are listed in ►Table 1.

Management of Selected Emergency Circulatory Conditions

Dehydration and Hypovolemic Shock

Identify dehydration along a clinical continuum: mild to severe dehydration.^{24,46} The most accurate measure of dehydration (i.e., fluid deficit) is percent weight loss.⁴⁷ Clinical signs of dehydration are generally imprecise.⁴⁷ The first signs of dehydration appear variably along the continuum and over a relatively wide range, at approximately 3 to 9% dehydration.^{46–48} Signs of hypovolemic shock also appear variably along the continuum. Increased CRT (i.e., > 2 seconds) is the most useful predictor of 5% dehydration.⁴⁹

Start fluid resuscitation for dehydration and hypovolemic shock in the child without malnutrition:

- *Mild dehydration (fluid deficit < 50 mL/kg): Plan A:* Administer low-osmolarity ORS replacement of ongoing losses, for example, after each loose stool, give 50 to 100 mL oral (< 2 years) or 100 to 200 mL (2–10 years)^{17,46,50}
- *Moderate dehydration (fluid deficit 50–100 mL/kg)/compensated shock: Plan B:* Low-osmolarity ORS oral/NG 75 mL/kg over 4 hours in frequent small amounts + replacement of ongoing losses^{17,46,50}
- *Severe dehydration (fluid deficit > 100 mL/kg)/hypotensive shock: Plan C:* Isotonic crystalloid IV/IO 100 mL/kg (30 mL/kg over 1 hour, then 70 mL/kg over 5 hours if < 12 months); 30 mL/kg over 0.5 hour, then 70 mL/kg over 2.5 hours if ≥ 12 months); repeat PRN to restore radial pulse; if IV/IO therapy unavailable, give low-osmolarity ORS NG/oral 120 mL/kg over 6 hours (20 mL/kg/h); with improved consciousness give low-osmolarity ORS oral/NG 75 mL/kg over 4 hours in frequent small amounts + replacement of ongoing losses.^{17,46,50}

Avoid hypotonic fluids which can lead to hyponatremia, permanent neurological deficit, and death^{51,52} and use isotonic fluids.^{18,24} Reducing the need for IV hydration by approximately 40%, low-osmolarity ORS is preferred to WHO standard ORS.^{50,53}

Aggressive fluid resuscitation in children with severe malnutrition and shock may have adverse effects.^{54,55} Use a different plan for fluid resuscitation if dehydration and shock are present in the setting of malnutrition:

- *Mild dehydration:* Administer ReSoMal 5 mL/kg oral/NG every 30 minutes for first 2 hours, then 5 to 10 mL/kg/h for next 4 to 10 hours^{18,46,56}
- *Moderate dehydration/compensated shock:* ReSoMal (do not use in setting of profuse watery diarrhea including

cholera) 5 mL/kg oral/NG every 30 minutes for first 2 hours, then 5 to 10 mL/kg/h for next 4 to 10 hours^{18,46,56}

- *Severe dehydration/hypotensive shock:* Isotonic crystalloid IV/IO 15 mL/kg over 1 hour; repeat PRN; with improvement, start ReSoMal (do not use in setting of profuse watery diarrhea including cholera) oral/NG 10 mL/kg/h up to 10 hours; if deterioration, stop NG infusion.^{18,46,56}

Other management considerations for conditions associated with dehydration and hypovolemic shock include:

- *Diarrhea:* Administer zinc 10 mg (< 6 months), 20 mg (≥ 6 months) oral every 24 hours for 10 to 14 days^{18,46,57}
- *Bloody diarrhea:* Ciprofloxacin 15 mg/kg oral twice daily (maximum dose 1.5 g per 24 hours) for 3 days; ceftriaxone 50 to 80 mg/kg (maximum dose 2 g) IV/IM daily for 3 days if treatment failure^{19,25}
- *Cholera:* Azithromycin 20 mg/kg oral × 1 dose (maximum dose 1 g)⁵⁸; alternate regimen: chloramphenicol¹⁸
- *Hypoglycemia:* See guidelines for hypoglycemia.^{18,59,60}

Septic Shock^a

- *Initial resuscitation:* Recognize impaired consciousness and perfusion²⁴
- *Infection:* Administer empiric antibiotics (see guidelines for severe bacterial infection; give within 1 hour)^{24,62}; antimalarial treatment PRN^{18,42–45}
- *Fluid resuscitation:* Isotonic crystalloid 20 mL/kg boluses IV/IO titrated to therapeutic end points^{24,62,63}; see specific guidelines for dengue fever and hypotensive shock⁶⁴; note bolus fluid resuscitation with NS or albumin in children with severe infection and impaired perfusion increases 48-hour mortality in African settings with a high prevalence of malaria and no access to monitoring, inotropic/vasopressor therapy, and mechanical ventilation^{65–67}
- *Inotropic/vasopressor therapy:* Dopamine if fluid-refractory shock or (vs. fluid resuscitation) if hepatomegaly or crackles^{18,24,62}
- *Severe anemia:* Transfuse whole blood (WB) 10 mL/kg IV/IO to target Hb 10 g/dL if normotensive and hemolytic process (e.g., severe malaria or sickle cell crisis) or hypotensive and acute hemorrhage (e.g., dengue fever)^{24,62,64}
- *Refractory shock/adrenal insufficiency:* Hydrocortisone (dose 2 mg/kg IV/IO, maximum dose 100 mg) if fluid-refractory, catecholamine-resistant shock or if suspected/proven adrenal insufficiency^{24,62}
- *Hypoglycemia:* See guidelines for hypoglycemia^{18,59,60}
- *Hypocalcemia:* See guidelines for micronutrient deficiency (hypocalcemia)²⁵

Anaphylactic Shock

- *Hypotension:* Administer adrenaline (epinephrine) (1 mg/mL) 0.01 mg/kg IM every 15 minutes PRN (maximum dose 0.3 mg)^{18,24}; isotonic crystalloid 20 mL/kg boluses IV/IO PRN^{18,24}; diphenhydramine 1 to 2 mg/kg oral/IM every 4

^a 2015 ACCM/SCCM Pediatric Septic Shock Guidelines are currently being drafted, with anticipated publication in late 2015 or early 2016.

Table 1 Substitute resources for management of selected emergency conditions

Respiratory distress and failure	
Oxygen cylinder ²⁴	Oxygen concentrator (with power supply) ^{106–110}
Pulse oximetry ^{18,24}	Clinical indicators of hypoxemia ¹¹¹
Chest radiography ^{18,24}	Clinical indicators of pneumonia ^{112,113}
	Clinical tool predicting treatment failure of severe pneumonia ¹¹⁴
Oxygen mask ²⁴	Nasal prongs or nasopharyngeal catheter ¹¹¹
Oxygen mask with reservoir ²⁴	CPAP (nasal) ¹¹⁵
Nebulizer ^{18,24}	MDI and spacer (sealed bottle) ⁴⁰
Mechanical ventilation (endotracheal tube) ²⁴	CPAP (bubble with/without power supply) ^{116–120}
	BiPAP (with power supply) ^{121–123}
	High-flow nasal prongs ^{124–126}
CPAP (bubble) ^{116–120}	Pressurized room air technology (with power supply) ¹²⁷
Racemic epinephrine ²⁴	Adrenaline (epinephrine) 1 mg/mL ¹²⁸
Shock	
BP cuff (appropriate size for age) ²⁴	Clinical indicator of hypotension (i.e., nonpalpable peripheral pulses) ¹²⁹
IO needle ²⁴	Bone marrow needle ²⁴
	Hypodermic needle (standard, large bore) ²⁴
	Spinal needle (short, wide gauge, with internal stylet) ²⁴
Dopamine (by central line) ²⁴	Dopamine (by peripheral line) ⁵⁴
Bradycardia with pulse and poor perfusion	
Adrenaline (epinephrine) (0.1 mg/mL) ²⁴	Dilute adrenaline (epinephrine) (1 mg/mL) 1 mL by adding 9 mL NS ¹⁸
SVT	
Ice (for vagal maneuvers) or adenosine or amiodarone or procainamide or synchronized cardioversion ²⁴	Digoxin (for termination and maintenance ^a) ^{18,25,130,131}
	Propranolol (for maintenance ^a) ^{25,130,131}
Ventricular tachycardia with pulse	
Amiodarone or procainamide or synchronized cardioversion ²⁴	Quinidine ^{25,132,133}
	Propranolol ^{25,132,133}
Cardiac arrest	
Manual defibrillation ²⁴	AED ²⁴
Adrenaline (epinephrine) (0.1 mg/mL) ²⁴	Dilute adrenaline (epinephrine) (1 mg/mL) 1 mL by adding 9 mL NS ¹⁸

Abbreviation: BiPAP, bilevel positive airway pressure; CPAP, continuous positive airway pressure; SVT, supraventricular tachycardia.

^aConsider propranolol as first-line treatment (i.e., preferable to digoxin) for maintenance in most cases of SVT because of the concern for WPW syndrome and possible atrial fibrillation with antegrade conduction over the bypass tract (Atkins D, University of Iowa Hospital and Clinics, Iowa City, Iowa, United States, personal communication).

- to 6 hours (maximum dose 50 mg)²⁴; dexamethasone 0.6 mg/kg IM/IV every 24 hours PRN (maximum dose 16 mg)²⁴
- **Stridor:** Adrenaline (epinephrine) (1 mg/mL) 0.5 mL/kg (maximum dose 5 mL) in 3 mL NS via nebulizer; repeat PRN²⁴
- **Bronchospasm:** See guidelines for lower airway obstruction.^{18,24}

Neurogenic Shock

- **Positioning:** Place supine or head down²⁴
- **Hypotension:** Administer isotonic crystalloid 10 to 20 mL/kg IV/IO; repeat PRN avoiding fluid overload²⁴; dopamine for fluid-refractory shock^{18,24}

- **Bradycardia:** See ►Table 1 for hemodynamically significant condition²⁴
- **Hypothermia:** Warming techniques.^{17,18}

Cardiogenic Shock

- **Hypotension:** Administer isotonic crystalloid 5 to 10 mL/kg IV/IO; repeat PRN with caution, avoiding fluid overload^{18,24}
- **Myocardial dysfunction:** Dopamine^{18,24}; alternate regimen: digoxin^{18,25}
- **Pulmonary edema:** Furosemide (Lasix) 1 to 2 mg/kg oral/IV/IO every 12 hours PRN^{18,24}
- **Arrhythmia:** See ►Table 1.

Obstructive Shock

- **Obstruction:** Treat cause (e.g., tension pneumothorax, cardiac tamponade, ductal-dependent lesion) as soon as possible²⁴
- **Shock/hypotension:** Consider fluid challenge (i.e., isotonic crystalloid 10–20 mL/kg IV/IO).²⁴

Substitute resources for the management of emergency circulatory conditions are listed in ►Table 1. Consider the external jugular vein as a viable site with a low complication rate for central venous access.⁶⁸ If a cardiac monitor is available, electrode leads may be attached according to varying standards:

- **International Electrotechnical Commission:** Right shoulder (red), left shoulder (yellow), left flank or abdomen (green)⁶⁹
- **American Heart Association:** Right shoulder (white), left shoulder (black), left flank or abdomen (red).²⁴

Management of Selected Emergency Neurological Conditions

Meningitis

- **Bacterial:** Administer ceftriaxone 50 mg/kg IV/IM every 12 hours (may substitute 100 mg/kg every 24 hours) (maximum dose 4 g per 24 hours) for 7 to 10 days or cefotaxime 50 mg/kg IV/IM every 6 hours (maximum dose 12 g per 24 hours) for 10 to 14 days^{19,25}; if no known resistance to chloramphenicol and β -lactam antibiotics, chloramphenicol 25 mg/kg (maximum dose 4 g per 24 hours) + ampicillin 50 mg/kg (maximum dose 12 g per 24 hours) IV/IM every 6 hours for 10 days, or chloramphenicol 25 mg/kg + benzylpenicillin (penicillin G) (maximum dose 24 million units per 24 hours) 100,000 units/kg IV/IM every 6 hours for 10 days^{19,25}
- **Tuberculous:** Follow national/international guidelines¹⁸
- **Cryptococcal:** Follow national/international guidelines.¹⁸

Cerebral Malaria

Detecting retinopathy, which is highly specific for cerebral malaria, can reduce incorrect diagnosis of the condition.⁴⁴

- **Impaired consciousness:** Recognize condition using a coma scale (e.g., modified Glasgow, Blantyre)^{70–75}; recognize and treat other causes of impaired consciousness in the setting of malaria; use NG PRN^{18,44}
- **Malaria:** See guidelines for severe malaria^{18,42–45}
- **Hyperpyrexia:** Administer antipyretics, cooling techniques^{17,18}
- **Seizure:** See guidelines for seizure¹⁸
- **Increased ICP:** Supportive measures, treat underlying cause^{24,41}

Seizure

- **Antiepileptic treatment:** Administer: Age ≥ 2 weeks: diazepam (10 mg/2 mL) 0.5 mg/kg rectally (maximum total dose every 2–4 hours: 5 mg if < 5 years and 10 mg if ≥ 5 years); if seizure activity at 10 minutes, diazepam 0.5 mg/kg rectally or 0.25 mg/kg IV/IO; if seizure activity at 20

minutes, diazepam 0.5 mg/kg rectally or 0.25 mg/kg IV/IO or paraldehyde 0.3 to 0.4 mL/kg rectally or phenobarbital (200 mg/mL) 15 mg/kg IV/IM (maximum loading dose 40 mg/kg)^{18,25}; Age < 2 weeks: phenobarbital (200 mg/mL) 20 mg/kg IV/IM; if seizure activity at 30 minutes, phenobarbital 10 mg/kg IV/IM¹⁸

- **Hypoglycemia:** See guidelines for hypoglycemia.^{18,59,60}

Structural Lesion

- **Increased ICP:** Supportive measures, treat underlying cause^{24,41}
- **Antibiotics:** Administer PRN (e.g., cerebral abscess): ceftriaxone 50 mg/kg IV/IM every 12 hours (may substitute 100 mg/kg every 24 hours) (maximum dose 4 g per 24 hours) for 7 to 10 days or cefotaxime 50 mg/kg IV/IM every 6 hours (maximum dose 12 g per 24 hours) for 10 to 14 days^{19,24}; if no known resistance to chloramphenicol and β -lactam antibiotics, chloramphenicol 25 mg/kg (maximum dose 4 g per 24 hours) + ampicillin 50 mg/kg (maximum dose 12 g per 24 hours) IV/IM every 6 hours for 10 days, or chloramphenicol 25 mg/kg + benzylpenicillin (penicillin G) (maximum dose 24 million units per 24 hours) 100,000 units/kg IV/IM every 6 hours for 10 days^{18,19,25}
- **Seizure:** See guidelines for seizure.¹⁸

Stroke

- **Sickle cell disease:** Perform exchange transfusion (goal is to reduce sickle Hb to $< 30\%$ total Hb)⁷⁶
- **Vitamin K deficiency bleeding:** For late-onset form, administer vitamin K₁ 1 to 2 mg IV/IM/subcutaneous every 24 hours PRN^{25,77}
- **Increased ICP:** Supportive measures, treat underlying cause^{24,41}
- **Seizure:** See guidelines for seizure¹⁸
- **Dehydration/shock:** See guidelines for fluid resuscitation and hypovolemic shock^{17,18,46}
- **Hypotension:** Dopamine if fluid-refractory condition^{18,24}
- **Hyperpyrexia:** Antipyretics, cooling techniques^{17,18}
- **Severe anemia:** See guidelines for severe anemia.¹⁸

Management of Selected Other Emergency Conditions

Severe Malnutrition

Criteria for severe malnutrition in children aged 6 to 59 months are as follows:

- **Severe wasting:** WHZ $<$ minus 3 standard deviation; MUAC < 115 mm⁷⁸
- **Bilateral edema:** That is, involving lower legs/feet and lower arms/hands.⁷⁸

Severely malnourished children with infection have a different, typically more critical presentation and higher risk of mortality.^{79–86}

- **Complications:** Administer benzylpenicillin (penicillin G) 50,000 units/kg (maximum dose 24 million units per

24 hours) or ampicillin 50 mg/kg (maximum dose 12 g per 24 hours) IV/IM every 6 hours for 2 days, then amoxicillin 15 mg/kg oral every 8 hours (maximum dose 3 g per 24 hours) for 5 days + gentamicin 7.5 mg/kg IV/IM every 24 hours for 7 days¹⁹

- **Dehydration:** See guidelines for fluid resuscitation and severe malnutrition^{18,46}
- **Severe anemia:** See guidelines for severe anemia¹⁸
- **Hypoglycemia:** See guidelines for hypoglycemia^{18,59,60}
- **Hypocalcemia:** See guidelines for micronutrient deficiency (hypocalcemia)^{25,87}

Hypothermia

Treat hypothermia (i.e., defined as $< 35.5^{\circ}\text{C}$ rectal) with warming techniques, for example, skin-to-skin, clothing/hat, blankets, and heat/warmer/incubator.^{17–19}

Severe Viral Infection

Treat complications of severe viral infection (following national/international protocols) including:

- **Measles:** Croup (causing upper airway obstruction), pneumonia, diarrhea, hypovolemic shock (i.e., nonhemorrhagic), encephalitis, higher mortality risk (especially in children with severe malnutrition, HIV, and vitamin A deficiency), give empiric treatment for vitamin A deficiency to all children with measles^{8,18,88–90}
- **HIV:** More severe morbidity, comorbidity (including severe bacterial infection with different range of causative organisms and higher rates of antibiotic resistance, tuberculosis, cryptococcal meningitis, and cancer), high mortality risk^{8,18,91–94}
- **Dengue:** Hemorrhage (e.g., intracranial/gastrointestinal/skin), vascular leak, acute respiratory distress syndrome, hypovolemic shock (i.e., nonhemorrhagic and hemorrhagic), septic shock, hypotension (requiring a different plan for fluid resuscitation), high mortality risk^{95–98}
- **Ebola:** Hypovolemic shock (i.e., nonhemorrhagic and hemorrhagic), multisystem organ failure, high mortality risk.⁹⁹

Severe Bacterial Infection

Antibiotic management of selected conditions is shown in ►Table 2.

Severe Malaria

- **Initial resuscitation:** Recognize impaired consciousness, generalized weakness, respiratory distress/failure, jaundice, significant hemorrhage, hemoglobinuria, and dehydration/shock^{18,42–45}
- **Dehydration/shock:** See guidelines for dehydration/hypovolemic shock and septic shock^{17,18,46}
- **Antimalarial treatment**⁴²: See ►Table 3; follow local guidelines⁴²
- **Bacterial infection:** Recognize and treat common comorbidities (i.e., pneumonia, meningitis, bacteremia, diarrhea/dehydration); see guidelines for serious bacterial infection^{17,18,44}
- **Seizure:** See guidelines for seizure¹⁸

- **Severe anemia:** Confirm condition in severe malaria (i.e., $\text{Hb} < 5 \text{ g/dL}$ or hematocrit $< 15\%$ in children < 12 years + parasite count $> 10,000/\mu\text{L}$)⁴⁴; see guidelines for severe anemia¹⁸
- **Hyperpyrexia:** Administer antipyretics, cooling techniques^{17,18}
- **Hypoglycemia:** See guidelines for hypoglycemia.^{18,59,60}

Trauma

- **Initial resuscitation:** Establish responsiveness (i.e., determine Glasgow coma scale [GCS] score), open airway with jaw thrust maneuver if cervical spine trauma^{18,24,32,41,70–73}
- **Bleeding:** Apply direct pressure, do not remove protruding objects⁴¹
- **Shock:** Give fluid resuscitation according to guidelines for hypovolemic shock, consider transfusion WB or packed red blood cell (PRBC) 10 mL/kg if starting third bolus isotonic crystalloid or if deterioration in condition⁴¹
- **Spine immobilization:** Immobilize spine if spinal injury is suspected, position young child with neck in “neutral” position^{18,41,100}
- **Increased ICP:** Supportive measures, treat underlying cause^{24,41}
- **Infection:** Administer empiric antibiotics PRN^{18,25}
- **Tetanus:** Tetanus prophylaxis PRN^{25,41}
- **Burns:** Clean/debride/apply topical antibiotic/dress, fluid resuscitation formula (which does not replace need for simultaneously administered maintenance fluids); give 2 to 4 mL/kg Lactated Ringer’s per percent body surface area of second-degree and third-degree burns IV in first 24 hours (half of total calculated volume is provided in first 8 hours and remaining half is provided in next 16 hours); refer severe burns^{18,41,101}
- **Fracture:** Stabilize injury⁴¹
- **Non-accidental trauma:** Protect child from further inflicted injury.⁴¹

Severe Anemia

Identify severe anemia by Hb concentration:

- **Hb $\leq 2.48 \text{ mmol/L}$ (4 g/dL):** with or without associated clinical signs¹⁸
- **Hb 2.48 to 3.72 mmol/L (4–6 g/dL):** with associated clinical signs (i.e., dehydration, shock, lethargy, difficult breathing, deep breathing, congestive heart failure, malaria parasite count $> 10\%$ red blood cell).¹⁸

In the setting of severe anemia, transfuse according to the presence/absence of malnutrition:

- **Malnutrition:** Administer WB or PRBC 10 mL/kg IV/IO over 3 to 4 hours, do not repeat¹⁸
- **No malnutrition:** WB 20 mL/kg or PRBC 10 mL/kg IV/IO over 3 to 4 hours.¹⁸

Micronutrient Deficiency

In children with vitamin A deficiency, the mortality risk due to diarrhea, measles, and malaria is increased by 20 to 24%.¹⁰²
In children with zinc deficiency, the mortality risk due to

Table 2 Antibiotics for serious bacterial infection

Sepsis	Benzylpenicillin (penicillin G) 50,000 units/kg every 6 h (maximum dose 24 million units per 24 h) + chloramphenicol 25 mg/kg every 8 h (maximum dose 4 g per 24 h) IV/IM for 7 d; if no improvement in 48 h, change to ampicillin 50 mg/kg every 6 h (maximum dose 12 g per 24 h) + gentamicin 7.5 mg/kg every 24 h IV/IM; consider ceftriaxone 80 mg/kg (maximum dose 2 g) IV/IM every 24 h for 7 d; follow local guidelines ^{17,18,25}
Infective endocarditis	Benzylpenicillin (penicillin G) 50,000 units/kg (maximum dose 24 million units per 24 h) or ampicillin 50 mg/kg (maximum dose 12 g per 24 h) every 6 h or ceftriaxone 80 mg/kg (maximum dose 2 g) IV/IM every 24 h + gentamicin 7.5 mg/kg every 24 h IV/IM for 4–6 wk ^{18,25}
Mastoiditis	Cloxacillin 50 mg/kg IV/IM every 6 h (maximum dose 4 g per 24 h) or ceftriaxone 80 mg/kg (maximum dose 2 g) IV/IM every 24 h for 10 d ^{18,25}
Meningococemia	Ceftriaxone 100 mg/kg (maximum dose 2 g) IV/IM every 24 h for 2 d (0–2 mo) or 5 d (2 mo–5 y); alternate regimen: chloramphenicol 100 mg/kg (maximum dose 4 g) IV/IM, repeat after 24 h if no improvement ^{18,25}
Rheumatic fever	Benzathine benzylpenicillin (benzathine penicillin G) 600,000 units IM every 3–4 wk or penicillin V 250 mg oral twice daily (as prophylaxis) ^{18,25}
Typhoid fever	Ciprofloxacin 15 mg/kg oral twice daily for 7–10 d (maximum dose 1.5 g per 24 h); ceftriaxone 80 mg/kg (maximum dose 2 g) IV/IM every 24 h for 5–7 d; or azithromycin 20 mg/kg (maximum dose 1 g) oral every 24 h for 5–7 d if treatment failure; follow local guidelines ^{18,19,25}

Abbreviations: IM, intramuscular; IV, intravenous.

diarrhea, pneumonia, and malaria is increased by 13 to 21%.¹⁰³ Blood calcium threshold for hypocalcemia is < 2.12 mmol/L (< 8.48 mg/dL).⁸⁷

- **Vitamin A deficiency:** Administer vitamin A (all doses oral): first dose (day 1), second dose (day 2), third dose (2–4 weeks after second dose): < 6 months, 50,000 IU; 6 to 11 months, 100,000 IU; 12 to 59 months, 200,000 IU^{17,18,46,57}
- **Zinc deficiency:** Zinc (all doses oral every 24 hours for 10–14 days): < 6 months, 10 mg; > 6 months, 20 mg^{18,46,57}
- **Iron deficiency:** Iron supplement oral once daily for 14 days¹⁸

- **Hypocalcemia:** Calcium (elemental) 45 to 65 mg/kg oral every 24 hours in four divided doses.²⁵

Hypoglycemia

Blood glucose thresholds for hypoglycemia by age and clinical condition are^{24,104}

- **Neonate (preterm/term):** < 2.5 mmol/L (< 45 mg/dL)
- **Infant/child/adolescent:** < 3.3 mmol/L (< 60 mg/dL)
- **Severe malnutrition:** < 3 mmol/L (< 54 mg/dL).

Treat hypoglycemia with dextrose:

Table 3 Antimalarial treatment

<i>Plasmodium</i> sp. (severe)	Artesunate 2.4 mg/kg IV/IM then every 12 h x 2 doses then every 24 h; if limited supply of artesunate, give artesunate for minimum 24 h, then complete course of ACT or artesunate + doxycycline or quinine + doxycycline; if artesunate unavailable: artemether 3.2 mg/kg IM at diagnosis then 1.6 mg/kg IM daily, or quinine 20 mg salt/kg IV/IM at diagnosis then 10 mg/kg every 8 h (infusion rate should not exceed 5 mg/salt/kg/h); if complete treatment not possible, artesunate rectal (10 mg/kg in children < 5 y) or quinine IM or artesunate IM or artemether IM, then refer WHO ⁴²
<i>Plasmodium falciparum</i> (uncomplicated)	ACT (ensure dose is accurate and is retained) for at least 3 d; Second-line treatment: alternative ACT with known effectiveness in region; or Artesunate or Quinine + Tetracycline (avoid in children < 8 y) or doxycycline (avoid in children < 8 y) or clindamycin for 7 d ⁴²
<i>Plasmodium vivax</i> (uncomplicated)	For chloroquine-sensitive infection: chloroquine + primaquine; if chloroquine resistance: ACT (give long half-life partner medicine); for radical treatment, give primaquine for at least 14 days; if mild-to-moderate G6PD deficiency, give primaquine 0.75 mg/kg every wk for 8 wk (avoid in first month of life); if severe G6PD deficiency, do not use primaquine (contraindicated); if cotreatment needed for <i>P. falciparum</i> , give ACT (except AS + SP which is not effective against <i>P. vivax</i> in many areas) + primaquine (avoid primaquine in first month of life) ⁴²
Infants < 5 kg	Available evidence is insufficient to recommend ACT therapy; avoid sulfadoxine-pyrimethamine in first wk of life (may aggravate hyperbilirubinemia due to competitive displacement of bilirubin); avoid primaquine, tetracycline, and doxycycline ⁴²
Children < 5 y	Artemisinin derivatives are safe and well tolerated; choice of ACT is determined by safety/tolerability of partner drug; avoid tetracycline and doxycycline in children < 8 y; refer if unable to swallow medication (give artesunate rectal 10 mg/kg if referral is expected to take > 6 h) ⁴²

Abbreviations: IM, intramuscular; IV, intravenous; WHO, World Health Organization.

- **Alert:** Administer D10W 10 mL/kg/dose oral/NG¹⁸; consider sublingual route (faster absorption than oral route and as effective as IV route) 2.5 g/dose (< 15 kg) or 3.5 g/dose (≥ 15 kg)^{59,60}

Lethargy or unconsciousness: D10W 5 mL/kg/dose IV/IO every 30 minutes PRN; initiate dextrose-containing maintenance fluids.^{18,105}

Cardiac Arrest

Perform basic life support (i.e., cardiopulmonary resuscitation and use of an automated external defibrillator).^{18,24,32} Substitute resources for the management of cardiac arrest are listed in ► **Table 1**. Follow guidelines for postresuscitation care

(i.e., according to level of capability) or discontinuation of resuscitative efforts.²⁴

Guidelines for Referral and Transport

Referral

As a general rule, referral should be made if possible whenever local capabilities are exceeded. Time is of the essence in referring critically ill or injured children. It is important to initiate both life-saving treatment at the referring location (instead of deferring treatment until the child reaches the referral facility) and referral arrangements as soon as

Table 4 Transport considerations in limited-resource settings

Category	Consideration
Stabilization	Stabilize patient before transport
Timing	Plan/execute transport as soon as possible for patient whose condition exceeds local capabilities
Referral facility	Identify nearest appropriate receiving facility
Transport mode	Determine appropriate/safe mode of transport
Communication	Inform referral facility of treatment details (i.e., referral note or call)
Resources	Anticipate/carry sufficient resources for patient condition and length of transport (i.e., medications/fluids/equipment/disposables) Use established protocols if available
Training	Send personnel with appropriate training to accompany patient
Patient management	Respiratory
	Maintain airway (suctioning, positioning, maneuvers, adjuncts) Treat airway obstruction Provide oxygen PRN (by cylinder or battery-powered concentrator) Provide positive pressure ventilation (bag-mask device, battery-powered CPAP/BiPAP machine) Treat pneumonia (antibiotics)
	Circulatory
	Administer fluid resuscitation PRN Administer maintenance fluids (following rehydration phase) ^{24,105} Treat sepsis (antibiotics, antimalarial treatment)
	Neurological
	Treat meningitis (antibiotics) Treat seizures (antiepileptic treatment) Treat increased ICP (supportive measures)
	Other
	Avoid/treat hypothermia (administer warming techniques) Treat infection (antibiotics, antimalarial treatment) Identify/treat fever (antipyretics) Identify/treat pain (analgesics) ^{18,25} Protect spine (immobilization) Control external bleeding Protect abused child (i.e., from further abuse) Identify severe anemia Identify/treat hypoglycemia (dextrose)

Abbreviation: CPAP, continuous positive airway pressure.

Note: Considerations assume ideal capabilities which may not exist.

possible. Without these, the child may not survive the transport or hospitalization at the referral facility.

Referral indications for critically ill or injured children by emergency condition include:

- **Respiratory:** hypoxemia, bag-mask ventilation, severe upper airway obstruction, severe asthma, very severe pneumonia, pulmonary edema, tension pneumothorax
- **Circulatory:** severe dehydration, hypotension, septic shock, anaphylaxis, neurogenic shock, arrhythmia, congestive heart failure, central cyanosis
- **Neurological:** GCS score ≤ 12 ,^{70–73} meningitis, encephalitis/cerebral malaria, seizure, increased ICP, stroke
- **Other:** severe malnutrition, hypothermia, severe infection (i.e., viral, bacterial, malaria, fungal), severe trauma (including severe burns), severe anemia, jaundice, severe hypoglycemia, toxin.

Write a referral note to the referral facility indicating specific information about the patient including the type of treatment received at the referring location. The referral note should include the following information: date, referring location, referring practitioner, accepting practitioner (i.e., at referral facility), patient name, patient age, emergency condition, fluids (volume, date, time), medications (dose, date, time), and laboratory results.

Transport

Transport the critically ill or injured child as needed to an appropriate facility of higher capability. See ►Table 4 for a summary of transport considerations in limited-resource settings.

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