Updated American College of Critical Care Medicine–Pediatric Advanced Life Support Guidelines for Management of Pediatric and Neonatal Septic Shock

Relevance to the Emergency Care Clinician

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Abstract: Shock is a major preventable cause of morbidity and mortality in children referred to emergency care. The recently updated American College of Critical Care Medicine guidelines for the management of newborns and children with septic shock emphasize the role of emergency care in improving survival and functional outcomes. Implementation of these guidelines of stepwise use of fluids, antibiotics, and, if necessary, inotropes within the first hour of admission to the emergency department can reduce mortality and neurological morbidity risks 2-fold. Therapies should be goal directed to maintain age-specific threshold heart rates and blood pressure as well as a capillary refill of less than 3 seconds or 2 seconds or less. Inotropes should be delivered through peripheral intravenous or intrasosseous access when central access is unavailable because delay in inotrope delivery can greatly increase mortality risks. Emergency care systems should be organized to facilitate recognition, triage, and treatment of shock in the first hour. Emergency departments should be stocked with ready access to antibiotics, fluids, and inotrope infusions, and clinicians should be trained in the delivery of goal-directed fluid, antibiotics, and inotrope therapies in the first hour of resuscitation. For newborns, in addition to fluids, antibiotics, and inotropes, a prostaglandin infusion should be available within 10 minutes if duct-dependent congenital heart disease is a possibility.

Key Words: sepsis, septic shock, guidelines, resuscitation

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Changes in the Revised Guidelines

The inflammatory triad of fever, tachycardia, and vasodilation is common in children with benign infections in the emergency department. Septic shock is suspected when children with this triad have a change in mental status manifested as irritability, inappropriate crying, drowsiness, confusion, poor interaction with parents, and lethargy or are becoming unarousable (Fig. 1). The clinical diagnosis of septic shock is made in children who (1) have a suspected infection manifested by hypothermia or hyperthermia and (2) have clinical signs of inadequate tissue perfusion including any of the following: decreased or altered mental status, prolonged capillary refill of more than 2 seconds (cold shock), diminished pulses (cold shock), mottled cool extremities (cold shock), or flash capillary refill (warm shock), bounding peripheral pulses and wide pulse pressure (warm shock), or decreased urine output of less than 1 mL/kg per hour. Hypotension is not necessary for the clinical diagnosis of septic shock; however, its presence in a child with clinical signs suggestive of an infection is confirmatory.

Recognition of Septic Shock

Children

The inflammatory triad of fever, tachycardia, and vasodilation is common in children with benign infections in the emergency department. Septic shock is suspected when children with this triad have a change in mental status manifested as irritability, inappropriate crying, drowsiness, confusion, poor interaction with parents, and lethargy or are becoming unarousable (Fig. 1). The clinical diagnosis of septic shock is made in children who (1) have a suspected infection manifested by hypothermia or hyperthermia and (2) have clinical signs of inadequate tissue perfusion including any of the following: decreased or altered mental status, prolonged capillary refill of more than 2 seconds (cold shock), diminished pulses (cold shock), mottled cool extremities (cold shock), or flash capillary refill (warm shock), bounding peripheral pulses and wide pulse pressure (warm shock), or decreased urine output of less than 1 mL/kg per hour. Hypotension is not necessary for the clinical diagnosis of septic shock; however, its presence in a child with clinical signs suggestive of an infection is confirmatory.

Neonates

Septic shock should be suspected in any newborn with tachycardia, respiratory distress, poor feeding, poor tone, poor

Volume 26, Number 11, November 2010 www.pec-online.com | 867
color, tachypnea, diarrhea, or reduced perfusion, particularly in the presence of a maternal history of chorioamnionitis or prolonged rupture of membranes. It is important to distinguish newborn septic shock from cardiogenic shock caused by closure of the patent ductus arteriosus in newborns with ductal-dependent complex congenital heart disease. Inborn errors of metabolism resulting in hyperammonemia or hypoglycemia may also simulate septic shock. Newborn septic shock is typically accompanied by increased pulmonary vascular resistance and pulmonary artery pressures, which can cause right ventricle failure with right-to-left shunting at the atrial and ductus arteriosus levels causing cyanosis.

**THE IMPORTANCE OF EARLY RECOGNITION OF SHOCK**

Shock can be recognized as a progression of hemodynamic abnormalities beginning with tachycardia, which is then followed by hypotension in the case of warm shock, or prolonged capillary refill in the case of cold compensated shock. Patients with hypotension and prolonged capillary refill are considered to have decompensated shock. Mortality risks increase as the patient progresses through this time-sensitive pathology (Fig. 2). Cercillo and colleagues examined over 5,000 children referred to five tertiary center sin the United States, they found that although only 7% of the children were referred for shock, 40% had shock defined by the presence of prolonged capillary refill of more than 3 seconds and/or hypotension. Use of Pediatric Advanced Life Support (PALS)/Advanced Paediatric Life Support (APLS)—recommended resuscitation in the emergency room in a 2-fold reduction in mortality and functional morbidity in these children (Fig. 2). These multicenter findings were very similar to the single-center report of Han and colleagues, who found that every hour’s delay in PALS/APLS resuscitation in the emergency room was associated with a 40% increase in mortality in children with septic shock.

**FIGURE 1.** Therapies in the ACCM-PALS guidelines are directed to attaining normal blood pressure for age and a capillary refill of 2 seconds or less in the emergency setting.

**FIGURE 2.** Degree of hemodynamic dysfunction in the emergency room predicts the degree of mortality and morbidity. Reversal of this hemodynamic abnormality in the emergency setting reduces mortality and morbidity.
TREATMENT

The management of shock initially entails evaluation and management of any airway compromise and obtaining rapid peripheral intravenous or intraoesophageal access. High-flow humidified and heated nasal cannula oxygen should also be begun through nasal cannula or a continuous positive airway pressure apparatus. If the liver is not enlarged and the patient does not have rales on lung examination, then isotonic fluid boluses should be pushed initially in boluses of 20 mL/kg with reassessment of the liver size and breath sounds in the lungs. If the liver is enlarged and/or rales are heard, then further fluid resuscitation is deferred, and the patient is administered a peripheral inotrope. Adrenaline is ideal for this situation.

Antibiotics should be pushed intravenously as soon as possible. Blood sampling should be obtained for rapid evaluation of blood glucose and ionized calcium as well as blood culture. In the case of newborns, a prostaglandin infusion should be begun until ductal-dependent congenital heart disease is ruled out. The fluid boluses and adrenaline infusions should be titrated to the goals of threshold heart rates and blood pressure for age (Table 1) and a capillary refill of 2 seconds or less. Hydrocortisone should be administered to children who are at risk of adrenal insufficiency. At the end of 1 hour, these interventions should result in a reduction in the shock index (heart rate/systolic blood pressure), an indicator of improving left ventricular ejection (Fig. 3). This is the expected emergency room expertise (Fig. 1). Close adherence to these guidelines will result in resolution of shock in about 90% of cases. Patients who fail to respond will require more aggressive therapy, including assisted ventilation and manipulation of inotropes and the circulation.

If the child remains in shock despite these interventions, then clinicians skilled in intubation and central line placement from the emergency room, critical-care unit, or other settings can intravenously administer atropine plus ketamine for intubation (if in respiratory distress) and/or central line placement. Central norepinephrine can be used to treat hypotension and adrenaline to treat cold shock (Fig. 1). Placement of central access at the right atrium/superior vena cava or right atrium/inferior vena cava junction allows for further goal-directed therapy toward maintaining a central venous oxygen saturation of greater than 70% (using blood transfusion if the hemoglobin is <10 g/dL, inotropes, and vasodilators). In settings where cardiac output can be measured, a goal cardiac index of greater than 3.3 L/min per m² and less than 6.0 L/min per m² should be attained. After intubation, newborns can be treated with inhaled nitric oxide to reverse persistent pulmonary hypertension.

These guidelines have great relevance to clinical practice and organization in the emergency care setting (Fig. 1). Those involved in triage will need to assess heart rate, blood pressure, and capillary refill measurements in all patients and promptly move patients to a suitable location for definitive therapy when they meet the criteria. Intravenous and intraoesophageal lines, fluids, high-flow nasal cannula oxygen, antibiotics, and inotrope infusions will need to be prepared and be readily available. A reference table of goal heart rates, blood pressures, and shock index for age will also need to be readily available to guide goal-directed therapy.

CONCLUSIONS

Early and aggressive management of shock may circumvent the development of irreversible shock, insults to vital organs, and morbidity or even mortality. The emergency department clinician has a vital role to play because most children will present initially to emergency departments. Care in the emergency department may determine the ultimate outcome in most cases. The ACCM guidelines provide a sound framework to guide initial management.

REFERENCES


TABLE 1. Threshold Heart Rate and Blood Pressure Goals

<table>
<thead>
<tr>
<th>Threshold Rates</th>
<th>Heart Rate, beats/min</th>
<th>Mean Arterial Pressure–Central Venous Pressure, mm Hg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Term newborn</td>
<td>120–180</td>
<td>55</td>
</tr>
<tr>
<td>Up to 1 y</td>
<td>120–180</td>
<td>60</td>
</tr>
<tr>
<td>Up to 2 y</td>
<td>102–160</td>
<td>65</td>
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<tr>
<td>Up to 7 y</td>
<td>100–140</td>
<td>65</td>
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<tr>
<td>Up to 15 y</td>
<td>90–140</td>
<td>65</td>
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