# Emergency Department Management of Pediatric Shock

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**KEYWORDS**

• Pediatric • Children • Shock • Hypotension • Sepsis • Vasopressors
• Emergency department

**KEY POINTS**

- Clinical history and physical examination findings are crucial for the early recognition and classification of shock in the pediatric patient.
- Hypotension is a late and ominous finding in the pediatric patient in shock.
- Rapid fluid resuscitation is the first line of treatment in most forms of shock.
- Three 20 mL/kg isotonic crystalloid boluses should be given within the first 20 to 60 minutes after shock is identified.
- Epinephrine is usually the preferred vasopressor in pediatric shock and should be started peripherally if central access is not present.

## INTRODUCTION

Shock is a state of acute energy failure stemming from a decrease in adenosine triphosphate production and subsequent failure to meet the acute metabolic demands of the body. More simply put, it is a state of inadequate oxygen supply to meet the body's cellular demands. Hypoxemia or decreased perfusion results in decreased oxygen delivery to the tissues, causing a shift from more efficient aerobic pathways to anaerobic metabolism, resulting in the production of lactic acid. As oxygen deprivation persists, cellular hypoxia leads to the disruption of critical biochemical processes, eventually resulting in cell membrane ion pump dysfunction, intracellular edema, inadequate regulation of intracellular pH, and cell death.

Disclosures: None.
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Emerg Med Clin N Am ■ (2018) ■–■
https://doi.org/10.1016/j.emc.2017.12.010 **emed.theclinics.com**

Oxygen delivery to the tissues is determined by cardiac output and arterial oxygen content. Cardiac output depends on heart rate and stroke volume. Stroke volume is determined by preload (the amount of filling of the ventricle at end-diastole), afterload (the force against which the ventricle must work to eject blood during systole, which is greatly affected by systemic vascular resistance [SVR]); contractility (the force generated by the ventricle during systole), and lusitropy (the degree of myocardial relaxation during diastole). In children, compared with adults, cardiac output is more dependent on heart rate than stroke volume owing to myocardial immaturity, which limits the ability to increase contractility. Arterial oxygen content depends on hemoglobin concentration, arterial oxygen saturation, and the arterial partial pressure of oxygen, with most oxygen being carried on hemoglobin and a small portion delivered as dissolved $O_2$.[1]

Under normal conditions of increased oxygen demand, such as exercise, oxygen delivery must increase by redistribution of blood flow. Similarly, in pathologic instances of increased oxygen demand or decreased oxygen delivery (shock), initial compensatory mechanisms occur to preserve tissue perfusion. In compensated shock, vital organ function is maintained and blood pressure remains normal. In uncompensated shock, hypotension develops and organ and cellular function deteriorate. Left untreated, uncompensated shock progresses to irreversible shock, characterized by irreversible organ failure, cardiovascular collapse, cardiac arrest, and death.

Pediatric shock results in a significant amount of morbidity and mortality worldwide. Sepsis and hypovolemia owing to infectious gastroenteritis are leading causes of child mortality worldwide, with an estimated 3 to 5 billion cases of acute gastroenteritis and nearly 2 million deaths occurring each year in children under 5 years of age, with 98% of those deaths occurring developing countries.[2] In developed countries like the United States, shock is also a common occurrence in the emergency department (ED). These children have a higher mortality rate compared with patients not in shock (11.4% vs 2.6%). The presence of shock is also associated with worse outcomes in a variety of emergency conditions, including traumatic brain injury and cardiac arrest.[3,4]

## CLASSIFICATIONS OF SHOCK

Several classifications of shock exist (**Table 1**). Rapid identification of the etiology may help to guide specific therapies.

**Table 1**
**Categories of shock**

| Category | Hemodynamics | Causes |
|---|---|---|
| Hypovolemic | ↓Preload, ↑SVR, ↓CO | Gastrointestinal loses, renal loses, hemorrhage, third spacing, burns |
| Distributive | ↓Preload, ↓↓SVR, ↓↑CO | Sepsis, anaphylaxis, neurogenic shock |
| Cardiogenic | ↑Preload, ↑SVR, ↓CO | Congenital heart disease, arrhythmia, cardiomyopathy, myocarditis, severe anemia |
| Obstructive | ↓↑Preload, ↑SVR, ↓CO | Pulmonary embolus, pericardial tamponade, tension pneumothorax, certain congenital heart lesions |

*Abbreviations:* CO, cardiac output; SVR, systemic vascular resistance.