Abstract:
Shock is an acute, dynamic process that occurs when there is inadequate delivery of oxygen to meet tissue metabolic demands. In children, shock is relatively uncommonly encountered in the emergency department and has a high mortality rate. Recognition and differentiation of shock can be challenging. Early recognition of the etiology of shock and aggressive, prompt treatment may be lifesaving. As cardiac disorders are responsible for only 5% of cases of pediatric shock, recognition of cardiogenic shock requires a high index of suspicion. In this article, we will review the presentation of the most common etiologies of cardiogenic shock in the pediatric population and discuss the early treatment and stabilization of these disease processes.

Keywords:
cardiogenic shock; ductal-dependent systemic blood flow; anomalous left coronary artery originating from the pulmonary artery; acute decompensated heart failure; myocarditis; cardiomyopathy

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Cardiogenic Shock Masquerading as Septic Shock

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In children, cardiogenic shock is uncommon and is associated with substantial morbidity and mortality. A primary cardiac condition is responsible for only 5% of all cases of shock in children presenting to the emergency department, with a rate of 1 in 1600 treated patients.[1] Cardiogenic shock may develop secondary to congenital heart disease (CHD), primary myocardial dysfunction, or part of a spectrum of noncardiac disease states, such as sepsis. Depending on the etiology, patients may have a period during which their heart function is declining but still capable of keeping up with the metabolic oxygen demands of the body. During this period, patients may be asymptomatic or have symptoms that go unnoticed. As the heart function continues to decline, the patient may develop symptoms of heart failure, which vary based on age. At some point, the heart is no longer able to keep up with the oxygen demands of the body, and patients may present in acutely decompensated heart failure and/or shock.[2]

IMPACT OF AGE ON SIGNS AND SYMPTOMS AT PRESENTATION

The signs, symptoms, and clinical presentation of cardiogenic shock vary depending on age. In neonates and young infants, the most common causes of cardiogenic shock are undiagnosed CHD, congenital or acquired diseases of the myocardium, and arrhythmias. Many infants may have vague, nonspecific symptoms consistent with developing heart failure, including tachycardia, tachypnea, poor

feeding, failure to thrive, and increasing fatigue.[3–5] Symptoms may go unrecognized by parents, and by the time such infants are brought to medical attention, they may be in extremis. Clinicians may attribute these signs and symptoms to other disease processes, including sepsis. The history and physical examination may offer clues to an underlying cardiac diagnosis but require a high index of suspicion. In neonates, a specific assessment should be made to evaluate for critical aortic arch obstruction with ductal-dependent systemic blood flow. Physical examination should include 4-extremity blood pressure measurements, palpation and comparison of brachial and femoral pulses, and preductal and postductal oxygen saturation measurements.[5,6] Prompt diagnosis and initiation of appropriate treatment can be lifesaving, especially in the neonate presenting in shock within the first week of life. Pediatric cardiology consultation early in the course of evaluation should be considered.

Children and adolescents are more likely to present with acutely decompensated heart failure secondary to disease processes that affect the myocardium, including myocarditis and cardiomyopathy. The history and physical examination in this population may be more helpful in guiding the clinician toward the diagnosis of cardiac dysfunction. Abdominal pain is a common complaint in older children.[7] Physical examination findings may include a gallop, hepatomegaly, rales, and murmur.

INITIAL EVALUATION OF CARDIOGENIC SHOCK

In addition to history and physical examination, the initial workup for all patients in whom cardiac dysfunction is suspected should include a chest radiograph, electrocardiogram (ECG), and laboratory evaluation. Table 1 summarizes classic examination, chest radiography, and electrocardiogram findings for each disease process that will be discussed in this article. An enlarged cardiac silhouette with or without the presence of pulmonary congestion should raise concern for underlying cardiac pathology. A hemoglobin level should be checked and red blood cell transfusion given as needed for improvement of the oxygen carrying capacity. Electrolytes, including potassium, magnesium, and calcium, should be evaluated and corrected as indicated to increase myocardial stability and to minimize the propensity for arrhythmias. As renal function is a sensitive marker of the adequacy of cardiac output, blood urea nitrogen (BUN) and creatinine levels should be assessed. For patients presenting in shock, liver function tests, basic coagulation studies, an arterial blood gas and a lactate level, and a venous blood gas (ideally from a central vein) should be obtained. Transaminase elevation, elevation of BUN and creatinine, metabolic acidosis, and lactic acidosis are all potential markers of inadequate end-organ perfusion. To assess for early liver dysfunction, coagulation studies should also be obtained. Troponin T and I are cardiac-specific proteins that will be elevated in any disease process that causes cardiac cell injury or death. Creatinine kinase-MB fraction is a cardiac specific enzyme that is also released into circulation after myocyte injury. Severe septic shock and other states promoting intense release of inflammatory mediators may result in injury to the cardiac cells, making troponin and creatinine kinase-MB fraction levels less helpful when trying to differentiate between shock states.[9,10]

The measurement of B-type natriuretic peptide (BNP) levels has been shown to be helpful in differentiating cardiac from noncardiac disease in the emergency department setting. In a small pediatric cohort study by Maher et al,[11] BNP levels ranged from 521 to more than 5000 pg/mL in patients with newly diagnosed congenital or acquired heart disease, which were significantly higher when compared with levels of less than 5 to 174 pg/mL in noncardiac patients. This study was not limited to patients presenting in shock; however, all patients presenting with newly diagnosed heart disease were admitted to a cardiac intensive care unit. Cardiac diagnoses included cardiomyopathy, left-sided obstructive lesions, anomalous left coronary artery from the pulmonary artery, total anomalous pulmonary venous return, and persistent patent ductus arteriosus. The patients that made up the noncardiac cohort all presented with symptoms concerning for respiratory or infectious processes.

MANAGEMENT OF CARDIOGENIC SHOCK

Treatment of cardiogenic shock, like other forms of shock, should initially focus on achieving cardiopulmonary stabilization. Specific goals of treatments should be aimed at improving cardiac output. Fluid resuscitation should be considered for patients presenting with poor perfusion and/or hypotension. Note that patients with cardiogenic shock and acutely decompensated heart failure may be sensitive to fluid administration, and thus, frequent reassessments during fluid resuscitation are needed to evaluate for signs of worsening heart failure and pulmonary congestion.

In patients presenting in cardiogenic shock, intubation and mechanical ventilation should be considered to reduce the metabolic demands and left ventricular wall stress. The combination of induction agents to