Temporary Circulatory Support and Extracorporeal Membrane Oxygenation

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KEYWORDS

• Cardiogenic shock • Temporary mechanical circulatory support • ECMO • V-A ECMO
• Decompensated heart failure • Acute on chronic heart failure

KEY POINTS

- The treatment of cardiogenic shock continues to plague providers, with high mortality rates and complex clinical presentations, making it challenging to successfully intervene.
- Temporary mechanical circulatory support should be considered early in the progression of cardiogenic shock and deployed quickly to improve patient outcomes and mortality.
- Veno-arterial extracorporeal membrane oxygenation is a viable form of temporary mechanical circulatory support and can provide systemic support and improved end-organ function.

INTRODUCTION

Despite significant advances in medical care, the prognosis for patients with refractory cardiogenic shock (CS) remains grim. High mortality rates, especially in those with an underlying diagnosis of acute on chronic heart failure, continue to plague providers when attempting to intervene and treat this acutely ill cohort of patients. CS is the most severe form of acute heart failure, causing a low cardiac output state and launching a cascade of symptoms, including systemic hypoperfusion, end-organ failure, systemic inflammatory response, and eventually death if left untreated.[1–3] Derangements within the circulatory system as the body attempts to compensate for low blood pressure (BP) by vasoconstricting are ultimately counteracted by pathologic vasodilation, triggering systemic inflammation and circulatory dysfunction. Myocardial oxygen demand increases in the setting of drastically reduced contractile function, creating an environment of intensified wall stress and diminished coronary blood flow. Diagnostic criteria have been established for CS, and those include (1) systolic BP less than 90 mm Hg for more than 30 minutes or vasopressors required to achieve a BP greater than or equal to 90 mm Hg, (2) pulmonary congestion or elevated left ventricular (LV) filling pressures, and (3) signs of impaired end-organ perfusion, which include cold and clammy skin, oliguria, increased serum lactate, and altered mental status.[4,5] Despite earlier intervention with rapid reperfusion, revascularization,

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inotrope and vasopressor therapy, and mechanical circulatory support, 1-year mortality rates remain high at almost 50%.[3–5] Acute myocardial infarction with associated ventricular dysfunction accounts for 50% to 80% of all CS cases, with other causes, such as myocarditis, valvular disease, drug overdose, aortic dissection, and exacerbation of chronic heart failure, contributing to this high morbidity rate.[4,6]

Noninvasive treatment strategies to help mitigate the deterioration of decompensated heart failure and the progression of CS include diuretic therapy in escalating doses, inotropes, and vasodilators. Inotropic agents are beneficial in that they have minimal vasodilatory effect and provide afterload reduction, thus improving overall cardiac output.[3] Clinically, the objective of therapy is to maintain end-organ perfusion without creating worsening ischemia or myocardial oxygen demand. Once these conventional measures have been maximized and CS continues to progress, temporary mechanical circulatory support (tMCS) therapy should be considered and initiated as early as possible.

MULTIDISCIPLINARY TEAM

Because of the wide range of therapies that a patient may require, a team-based approach tends to be optimal when managing the CS patient because each member is able to offer individual expertise for the combined effort of comprehensive care. The team may include an interventional cardiologist, a heart failure cardiologist, a cardiothoracic surgeon, an intensivist, an anesthesiologist, advanced practice clinicians including nurse practitioners and physician assistants, ICU nurses, and other clinical support staff.[3,6] This multidisciplinary team is crucial in determining timing of intervention and appropriate patient and device selection when required. Goals for the multidisciplinary team should focus on rapid identification of CS and the underlying etiology. Team-based patient management requires a primary leader, who should be a qualified cardiovascular intensivist with training in heart failure, CT surgery, or critical care. This individual's key roles include deciphering appropriateness of patient referral, triaging of the patient based on acuity, rapidly assessing end-organ function based on laboratory and diagnostic testing, and determining proper device strategy for the clinical scenario of the patient.[2,3]

MORTALITY AND PREDICTION SCORES

As the general population continues to age and the number of heart failure cases continues to rise, more patients will require acute intervention for decompensated heart failure and refractory CS. Scoring systems may be helpful at predicting mortality rates and outcomes as well as stratifying patient level of shock to determine the level of therapy required. Much like other risk-predicting scores for disease severity and organ dysfunction in critically ill patients, such as acute physiology and chronic health evaluation (APACHE), simplified acute physiology score (SAPS), multiple organ dysfunction score (MODS) and sequential organ failure assessment (SOFA) scores, studies, such as the CardShock and survival after veno-arterial ECMO registry, attempt to classify patient levels of shock using a scoring system to predict outcomes and mortality risk.[7–10]

TEMPORARY MECHANICAL CIRCULATORY SUPPORT

The application of a tMCS device provides time to determine whether the patient has the potential for improvement and recovery from the inciting event, or whether they will require additional support in the form of durable MCS or cardiac transplantation.[8–11] Much like the rapidly evolving field of durable MCS, tMCS technology has allowed for expanded application in more critical situations warranting short-term hemodynamic support and end-organ perfusion. The ease of application and cannulation, as well as the ability to place percutaneously at the patient bedside, has helped usher in the use of these devices in the acute care setting.[5,9–11] More contemporaneous percutaneous MCS devices have greatly reduced the time between decision for use and actual application compared with earlier, pulsatile predecessors. The Clinical Expert Consensus Statement on the Use of Percutaneous Mechanical Circulatory Support Devices Study in 2015[12] confirmed that the use of percutaneous MCS devices was superior to medical management alone and should be considered when managing patients with refractory CS. National trends on the use of tMCS from 2007 to 2011 have shown an overwhelming growth rate of 1511%.[10,11,13,14]

The decision to use a tMCS device must be made quickly and thoroughly in the setting of acute CS, ultimately avoiding the sequala of circulatory collapse, inflammatory activation, and end-organ failure. Recognizing the severity and degree of CS and proactively determining short-term and long-term goals of tMCS will help establish what type of device is most suitable for the specific patient scenario, because there are multiple devices that offer a wide range of hemodynamic support. Devices range from limited cardiac output augmentation with the intra-aortic balloon pump