

Mechanical Cardiac Support

Congestive heart failure is now recognized as the leading cause of death worldwide. The introduction of mechanical circulatory support for the treatment of heart failure has made possible the survival of many patients who otherwise would have died. A variety of devices are available to patients depending on the indications for support. Devices for circulatory support are currently used in three broad categories: 1) acute cardiogenic shock with support < 1 month; 2) more prolonged support from 30 days to > 1 year; and 3) permanent support as an alternative to transplantation. The acute, short-term group includes patients who have cardiac failure after cardiac surgery (postcardiotomy cardiogenic shock), myocardial infarction shock or acute cardiomyopathy due to myocarditis or other causes, with potential likelihood of recovery. In the intermediate or long-term group are those who are suitable candidates for transplantation but deteriorate before a heart is available. A small percentage of the patients in this group regain ventricular function and are able to have devices removed without requiring heart transplantation. The third group of patients has irreversible cardiac failure that requires circulatory support, but they are not good candidates for cardiac transplantation. Therefore, the devices are inserted permanently or as a destination therapy.

At present, the algorithm for the management of acute cardiogenic shock includes early institution of inotropic support, after load reduction, and intra-aortic balloon pump (IABP) counterpulsation. The IABP is the least invasive and least complex of the available cardiac assist devices. The IABP reduces the afterload, left ventricular work, and myocardial oxygen consumption during systole and it augments diastolic pressure and coronary perfusion during diastole. Despite these salutary effects, the balloon does not displace a significant volume, does not decompress (unload) the left ventricle, and results in only a modest improvement in cardiac output. Furthermore, its benefit for patients with nonischemic cardiogenic shock is uncertain.

Despite IABP support, a fraction of patients with acute cardiogenic shock remain in a refractory low-output state. For these patients, more effective

ventricular assistance is imperative to prevent death. The simplest device is extracorporeal membrane oxygenation (ECMO), a cardiopulmonary bypass system with venoarterial cannulation placed either through the femoral or intrathoracic vessels.

ECMO circulates and ventilates blood and can temporarily serve as a substitute for the entire circulation. However, like the heart/lung machine, ECMO activates blood elements to cause coagulation and inflammatory problems associated with cardiopulmonary bypass. These systems also do not always provide adequate left ventricular decompression, a primary deterrent of recovery. Often the ECMO system is used for acute resuscitation to salvage severely ill patients.

In many patients with acute cardiogenic shock, the native gas exchange system remains intact and therefore oxygenator support is often unnecessary and only increases the complexity of the circuit. Left heart distension is such a concern with ECMO circuits that many centers routinely insert a transseptal catheter to decompress the left side circulation. A ventricular assist device (VAD), however, bypasses the ventricle and therefore volume unloads the ventricle and allows the ventricle to completely rest. Optimal ventricular unloading will maximize the chance of myocardial recovery in patient with acute ventricular failure. There are a variety of devices currently available to patients in all three categories. In addition, there are many more devices under clinical development, especially devices that can be inserted permanently or used as a destination therapy.

Several centrifugal pumps are currently available and provide the advantage of their simplicity of operation, low cost, and may be used as a left ventricular assist device (LVAD), right ventricular assist device (RVAD), or biventricular assist device (BIVAD). Frequent pump malfunction or thrombus formation that requires pump exchange is a limitation of centrifugal pump support. In addition, patients are unable to ambulate, so there is no possibility of rehabilitation. This device was recently used as a LVAD to support a patient with acute fulminant myocarditis in our hospital. The

LVAD was success-fully weaned and explanted with full recovery of myocardial function. Major complications reported with the use of the centrifugal pump include bleeding, renal failure, infection, neurologic complications, hemolysis, and thromboemboli. Three extracorporeal VADs, i.e., the Abiomed, the Thoratec, and Berlin Heart, offer the advantage of pulsatility, specially integrated cannulas for a variety of cannulation options, and more sophisticated control systems. The Thoratec VAD and Berlin Heart VAD allow for ambulation and management out of an ICU setting. Both systems also are approved for bridge to recovery and bridge to transplantation. Four other bridge to transplantation devices that are currently available are TCI HeartMate, Novacor, Cardiowest, and, recently approved in Europe, Thoratec IVAD. All four devices are implantable systems which reduce risk of infection and allow for ambulation. TCI HeartMate is the only device that does not require any long term anticoagulation other than aspirin. In addition, FDA has approved TCI HeartMate as a destination therapy. The approval came after the publication of REMATCH trial results, in which the TCI HeartMate

vented electric LVAD was compared with optimal medical therapy in patients who were not candidates for cardiac transplantation. There was a 48% decrease in mortality in the LVAD group. The one year survival rate was 52% in the LVAD group vs. 25% in the medical therapy group.

In conclusion, mechanical cardiac support has gained increased acceptance as a treatment for patients with both acute cardiogenic shock and severe heart failure who are unresponsive to conventional treatment. Steady progress has been made with respect to technology, patient selection, and postoperative management. Currently, a wide array of circulatory assist pumps offers various levels of assistance and degrees of postoperative mobility. These devices not only save lives but, in some long-term bridge-to-transplant cases, permit hospital discharge and cardiac rehabilitation. Cardiac assist devices are entering a new developmental phase that focuses on patient independence, quality of life and long-term durability. Eventually, as cardiac support or replacement devices become smaller, more durable, and less obtrusive, they may become as conventional and commonplace as pacemakers are today.

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