Chapter 28
Mechanical Circulatory Support

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ABSTRACT

An increasingly important component of the therapeutic armamentarium in the treatment of cardiac and cardiopulmonary pathology, utilization of mechanical circulatory support allows clinicians to help sicker patients with more advanced disease states. A plethora of options exist, each with multiple implant techniques and management strategies. To optimize patient care in a cost-conscious environment, one must understand the advantages and disadvantages of each permutation, and have an algorithmic approach for the selection and application of available technologies. This chapter aims to provide such an understanding by reviewing surgical implant techniques and peri-operative management strategies for a number of commonly used short-term and durable devices.

INTRODUCTION

Iterative refinements in cardiac surgical techniques and patient care have improved surgical outcomes in the preceding decades, which has led to sicker patients with more advanced disease states being submitted for cardiac surgical treatment. Patients with advanced cardiac and cardiopulmonary pathology, including ischemic and non-ischemic cardiomyopathies, advanced valvulopathy, de novo or failing congenital heart disease with treated or palliated lesions, pulmonary and pulmonary vascular disease, and multiple re-do cardiac surgical procedures are at an increased risk of cardiac and pulmonary failure in the peri-operative period. An understanding of Mechanical Circulatory Support (MCS) options provides cardiac surgeons and cardiac surgical intensivists a safety net with which to improve patient outcomes in such high-risk scenarios.

Many MCS techniques and management strategies have been described; each may have advantages and disadvantages, but all are expected to evolve over time with increasing collective experience and cumulative published data. Although consistent success is being achieved with the techniques and strategies described in this chapter, the constant progression of MCS options, surgical techniques, and post-operative management dictates that at some point in the future, this chapter will be obsolete. The latter notwithstanding, objectives for the reader of this chapter are to: (i) distinguish between a number

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of common MCS options; (ii) rationalize a stepwise approach to the application of MCS options; (iii) review the most common surgical implant techniques; (iv) identify pertinent peri-operative management issues including weaning of MCS devices; and (v) recognize common complications of each device.

BACKGROUND

Historically, the advancement of cardiac surgery has paralleled the development of MCS. The earliest available device was ECMO, in the form of cardiopulmonary bypass, which allowed the development of safer surgical treatment of a wide range of cardiac pathology. Numerous heart and/or lung function replacement or assist devices have been developed over the past 60 years, which in turn has allowed the continual refinement of therapy in increasingly older and more sick patients.

Current common MCS devices may be categorized into cardiac and cardiopulmonary support systems, the latter comprised of ECMO. Cardiac support systems may be divided into short-term and durable devices, which may be further subcategorized by a number of characteristics including uni- or bi-ventricular assistance, partial or full support capability, and percutaneous or surgical implantation.

Device Selection

A step-wise, algorithmic approach for the selection of MCS based on the patient's physiologic derangement (i.e. expected time course of MCS requirement, level of support required, presence of oxygenation/ventilation insufficiency, left and/or right ventricular failure), and anatomical considerations (if the patient has recently undergone a sternotomy / partial sternotomy or right anterior mini-thoractomy, this may support the selection of particular centrally cannulated devices; if the patient has had a mechanical aortic valve replacement, this renders the cardiac anatomy unsuitable for trans-aortic valve devices; if there is significant peripheral vascular disease, this makes peripherally inserted devices less attractive). In general, one selects the device most likely to optimize patient recovery. This seemingly obvious statement encompasses many factors, including not only the support requirements and the risk of implanting the MCS device, but also the ability to progress the patient in other domains while on MCS. As such, a cannulation strategy that potentially allows extubation and mobilization would be preferable if possible in a patient expected to require greater than 72 hours of support.

Institutional resources play a role in device selection. In centers mandating a perfusionist at the bedside for certain devices, one may lean against such devices in consideration of cost and/or elective cardiac surgery cancellation. Centers with larger MCS volume are able to train intensive care nurses or respiratory therapists to care for patients with their range of devices, allowing improved resource efficiency for the care of these sick patients.

As a general rule, our first tier of MCS for mild persistent hemodynamic instability or cardiogenic shock after pharmacologic optimization is an Intra-Aortic Balloon Pump (IABP). If greater hemodynamic support is required and is emergent, or if respiratory compromise exists or is expected, ECMO is placed. If not, a more nuanced approach for the selection of MCS is possible. Generally speaking, a post-cardiotomy patient still in the operating room will receive a centrally cannulated short-term uni- or