Operative Techniques in Thoracic and Cardiovascular Surgery

Total Artificial Heart Replacement With 2 Centrifugal Blood Pumps

Carmelo A. Milano, MD, Jacob Schroder, MD, and Mani Daneshmand, MD

Abstract

A total of 2 small, electrical, centrifugal pumps can be implanted as a total artificial heart replacement. This type of mechanical support may be advantageous in the setting of severe biventricular failure when cannulation of the native ventricles is complicated. Postinfarct ventricular septal rupture with inability to reconstruct the defect is an example in which we have successfully applied this strategy. The technique for ventriculectomy and pump attachment to the mitral and tricuspid annuli is presented.
Operative Techniques in Thoracic and Cardiovasculary Surgery 20:306-321

KEYWORDS artificial heart, ventricular assist device, heart failure

Introduction

Patients with advanced heart failure may require mechanical circulatory support most commonly with isolated left ventricular assist devices (LVADs). Approximately 5%-10% of this advanced heart failure cohort would also have severe right ventricular (RV) failure necessitating mechanical support. Historically, a variety of temporary extracorporeal RV assist devices (RVADs) have been be used. Limitations for these temporary RVADs include the need to exit 2 large cannulas from the chest. Furthermore, these systems limit mobility since the cannulas are attached with blood tubing to the external pumps. Patients with extracorporeal RVADs may be unable to leave the intensive care unit setting and may not be discharged from the hospital. Another strategy for these patients with severe biventricular failure is total artificial heart (TAH) replacement with intracorporeal pneumatic pumps that have inflow and outflow valves. The Syncardia TAH (Syncardia Systems, Inc, Tucson, AZ) is Food and Drug Administration approved as a bridge to transplant. However, these pumps are large implants which cannot be used for smaller patients. In addition, while the Syncardia TAH pneumatic drivers have enabled discharge from the hospital, these units are sizable and also limit mobility.

There has been recent success with small electrically driven, implanted centrifugal pumps as LVADs and the HeartWare ventricular assist device (HVAD) pump (HeartWare Inc, Framingham, MA) and the Heartmate III pump (St. Jude Medical Inc, Pleasanton, CA) are examples of this technology. The HVAD pump has been Food and Drug Administration approved as a bridge-to-transplant device. Given its small size, an increasing experience is also developing with the HVAD pump for RV support or replacement.[1] More than 100 patients worldwide have been supported with 2 HVAD pumps as biventricular replacement.[2] The HVAD pump sewing ring can be affixed with interrupted or running sutures to the diaphragmatic surface of the RV (Fig. 1) or to the body of the right atrium (RA) (Fig. 2). The inflow cannula is then installed through the sewing ring into the RV or RA (Figs. 1 and 2). We have used this approach successfully in several cases, however, there are limitations: first, the HVAD inflow cannula, which was designed for the left ventricular apex, has a length that is not ideal for either RA or RV cannulation. To reduce the length of cannula insertion into the RA or RV, the sewing ring can be built up with felt washers that are positioned between the surface of the heart and the sewing ring (Fig. 2). Typically, this buildup raises the sewing ring off of the heart by 5-10 mm. With this modification, 5-10 mm less of the cannula is inserted into the RA or RV. Reduced cannula insertion avoids obstruction, which can result from the cannula abutting the septum or tricuspid valve apparatus. Without the felt washer buildup, the HVAD cannulation of the RA can lead to cannula obstruction with the interatrial septum or tricuspid valve leaflets. Similarly, without the felt washer buildup, the HVAD cannulation of the RV can lead to cannula obstruction with the interventricular septum or subvalvular apparatus of the tricuspid valve. Additional concerns with the RV cannulation include difficulty with sternal closure due to the anterior projection of the pump. For this reason, attempts to cannulate the diaphragmatic surface of the RV may help to avoid problems with sternal closure.

Duke University Medical Center, Durham, NC

Address reprint requests to Carmelo A. Milano, MD, Duke University Medical Center, Box 3043, Durham, NC 27710. E-mail: milan002@mc.duke.edu

 1522-2942/$-see front matter
http://dx.doi.org/10.1053/j.optechstcvs.2016.02.001

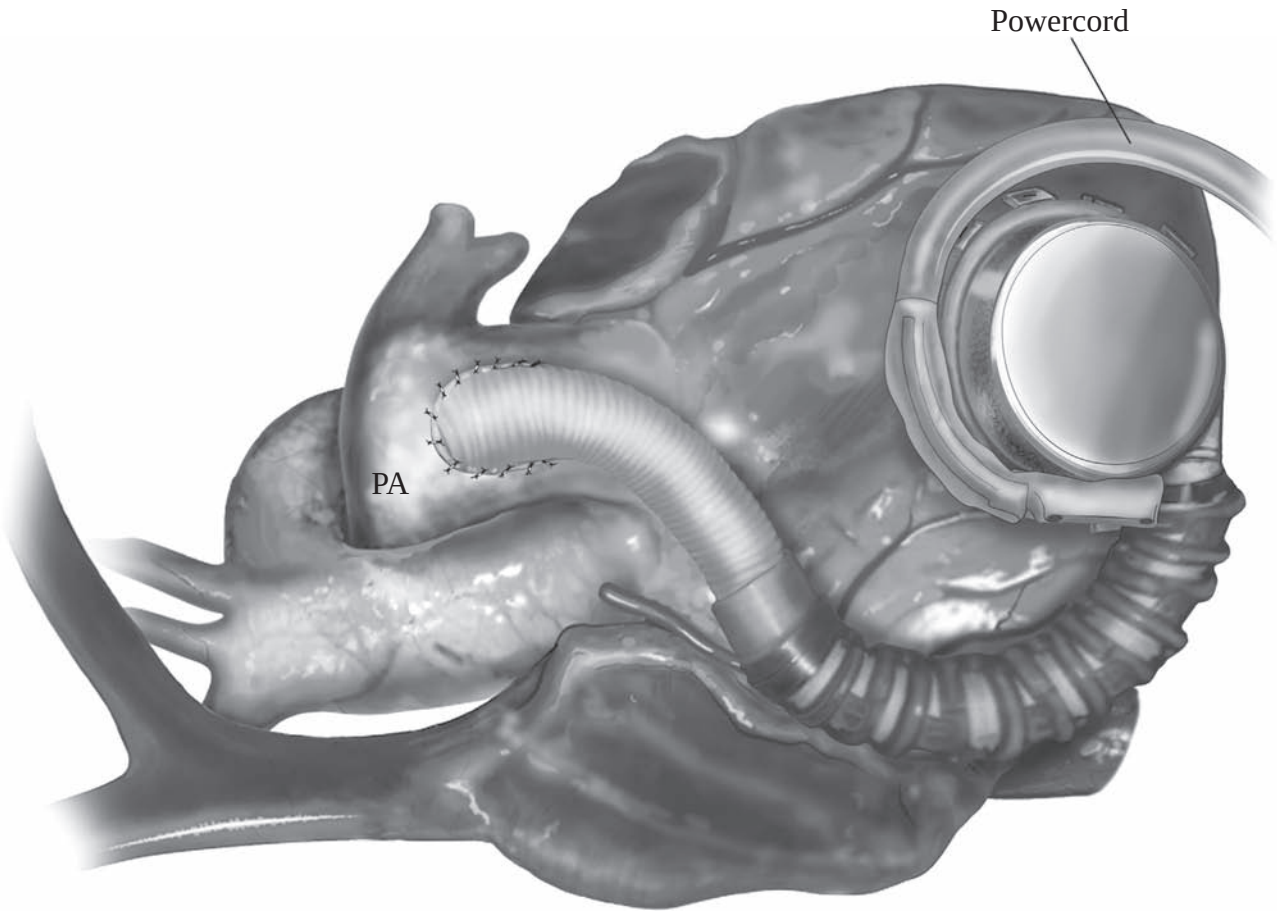

Figure 1 Cannulation of the diaphragmatic surface of the right ventricle is shown with the outflow attached to the main pulmonary artery (PA).