Continuous-Flow Left Ventricular Assist Device Explantation After More Than 5 Years of Circulatory Support and Ventricular Reconditioning

George V. Letsou, MD1; Andrew C.W. Baldwin, MD1; Andrew B. Civitello, MD1; William E. Cohn, MD1; O.H. Frazier, MD1

1Center for Cardiac Support, Texas Heart Institute, Houston, Texas

Continuous-flow left ventricular assist devices have proved to be effective, durable, lifesaving tools in patients with end-stage heart failure. However, because of the risks associated with mechanical circulatory support (including stroke, infection, gastrointestinal bleeding, and device malfunction), the optimal goal of device therapy is myocardial recovery and device removal. Ventricular reconditioning and pump explantation after continuous-flow support have been reported; however, little is known about variables that govern the pace and degree of myocardial response in patients who experience such recovery. We describe our long-term pump-weaning strategy for a 25-year-old man who had a continuous-flow device implanted and then needed more than 5 years of support from it before developing cardiac reserve sufficient to enable pump explantation. To our knowledge, this is the longest period of uninterrupted continuous-flow device support to end in successful pump deactivation and a return to medical therapy. This case highlights the importance of actively and persistently pursuing a device-weaning strategy in all patients who need left ventricular assist device therapy. (Tex Heart Inst J 2021;48(2):e207266)

Ventricular reconditioning after continuous-flow left ventricular assist device (CF-LVAD) support has been described1–4; however, little is known about variables that affect the progress of myocardial response. We describe our successful weaning strategy that enabled a young man to undergo explantation of a CF-LVAD after more than 5 years of circulatory support.

Case Report

A 25-year-old man who had idiopathic cardiomyopathy was admitted to our institution with progressive dyspnea that had worsened over the preceding months. Previously, he had been active and physically robust, and he used a range of nutritional supplements. He originally attributed his symptoms to overexertion during an alpine vacation earlier that year. He could not recall an acute event but had become increasingly concerned when his shortness of breath failed to resolve over several months despite an outpatient trial of antibiotics and prednisone therapy. His family had no heart disease or genetic abnormalities.

Physical examination at hospital presentation revealed severe tachycardia (heart rate, 127 beats/min) and hypoxemia necessitating high-flow oxygen support. Diagnostic images revealed diffuse pulmonary infiltrates and bilateral pleural effusions. Electrocardiograms showed a left ventricular (LV) ejection fraction <20%, an internal LV end-diastolic dimension (LVEDD) of 6 cm, and mild mitral regurgitation. Cardiac catheterization revealed a pulmonary capillary wedge pressure of 45 mmHg and a cardiac index of 1.51 L/min/m².

Because of profound cardiogenic shock, the patient underwent placement of a TandemHeart percutaneous ventricular assist device (CardiacAssist, Inc.) for temporary hemodynamic support. He was then admitted to the cardiac intensive care
Continuous-Flow LVAD Explantation After 5 Years

After 1,938 days (5.3 yr), the patient underwent elective ligation of the pump outflow graft through a subxiphoid incision, and external transection of the driveline at the level of the skin. He was extubated the same day and was discharged from the hospital 7 days later, after an uneventful postoperative course. He was doing well at his most recent follow-up examination, 5 years after LVAD explantation. An echocardiogram showed an LV ejection fraction of 35% and an internal LVEDD at end-diastole of 7.16 cm. His right ventricular function was moderately reduced, and the chamber size was normal. The patient remained active, well, and employed in lawn maintenance. He continues to undergo close monitoring as a New York Heart Association functional class II outpatient whose medical regimen includes lisinopril, carvedilol, bumetanide, metolazone, and spironolactone.

Discussion

Ventricular reconditioning through mechanical offloading and device support was first demonstrated after treatment with pulsatile LVADs and more recently with CF pumps. Although this observation and the potential for device removal have been reported, the variables affecting pace and degree of myocardial response are unclear. Our patient needed more than 5 years of active reconditioning efforts before device removal was possible. To our knowledge, this is the longest reported period of uninterrupted CF device support before successful weaning and pump removal.

The principle of ventricular reconditioning is based on the dynamic relationship between the device and LV preload. The extracardiac positioning of the HeartMate II intrinsically restricts inflow to the pump, enabling the LV to serve as a reservoir. Sufficiently reduced pump speed will raise the LV end-diastolic volume to a point on the Frank-Starling curve that enables ejection through the aortic valve. This state of parallel flow, in which the heart and device both contribute to total cardiac output, is essential to the process of ventricular reconditioning. When parallel flow is ensured, the progression of myocardial rehabilitation can be evaluated during brief periods of reduced pump speed, with use of AoVT and LVEDD as markers of ventricular condition. Any device-weaning plan must account for several mechanical and procedural limitations. Although the HeartMate II can produce flows of up to 12 L/min, most patients never need such generous cardiac output (few patients at our institution are managed at speeds >10,000 rpm). However, the controllers are manufactured with preset speed restrictions that prevent device operation below 8,000 rpm without triggering alarms. Thus, although many patients need slower pump speeds for sufficient ventricular filling, such individualized therapy is not always possible with current device
specifications. Active weaning is further complicated by the need for frequent outpatient follow-up visits and imaging for ongoing ventricular evaluation. The presence of an echocardiography machine in our outpatient clinic has proved valuable, enabling clinicians to efficiently optimize pump flows in real time and to facilitate ventricular reconditioning.

The success of LVAD weaning may also depend on the underlying cause of heart failure. In our case, pathologic analysis of the LV plug removed at the time of LVAD implantation suggested that an acute ischemic event had occurred and that myocardial remodeling and eventual recovery were likely.

The eventual outcome of LVAD explantation in our patient is unclear. To date, he has tolerated explantation well; however, his LV ejection fraction is still somewhat depressed at 35%, and his LV is dilated. Careful medical management of heart failure is mandatory after LVAD explantation or deactivation. Birks and colleagues reported a 5-year survival rate of 74% after LVAD explantation in appropriately selected patients. In a series of 30 patients who underwent long-term CF-LVAD support at our institution, 27 underwent LVAD explantation. There were 2 late deaths after explantation; another patient needed LVAD reimplantation and eventually underwent cardiac transplantation.

Dividing the outflow graft is less invasive than complete explantation, and it reduces the risk of morbidity. Our patient tolerated surgery well and had no complications or thrombotic events.

Continuous-flow LVADs have proved to be life-saving, durable, and capable of providing reliable long-term hemodynamic support for patients in end-stage heart failure. Despite the advantages of these pumps, the risk of complications such as infection, stroke, and malfunction is constant. Therefore, the optimal outcome of therapy is myocardial recovery and device removal. Younger patients, in particular, typically face 2 undesirable alternatives: prolonged exposure to the risk of LVAD-associated complications, and the statistical improbability of having an average lifespan after undergoing heart transplant at an early age. The opportunity to avoid or delay either outcome warrants an aggressive approach to cardiac reconditioning.

Finally, the time necessary for ventricular reconditioning and weaning from device support can be prolonged. Although some patients at our institution have been able to undergo explantation within months of starting device support, the current patient needed more than 5 years of support before he had sufficient myocardial recovery. This delayed response suggests that actively and persistently pursuing a weaning plan is essential to identifying an opportunity for device removal.

Published: 10 June 2021

References

1. Frazier OH, Benedict CR, Radovancevic B, Bick RJ, Capek P, Springer WE, et al. Improved left ventricular function after chronic left ventricular unloading. Ann Thorac Surg 1996;62(3):675-82.
2. Birks EJ, George RS, Hedger M, Bahrami T, Wilton P, Bowles CT, et al. Reversal of severe heart failure with a continuous-flow left ventricular assist device and pharmacological therapy: a prospective study. Circulation 2011;123(4):381-90.
3. Birks EJ, George RS, Firouzi A, Wright G, Bahrami T, Yacoub MH, Khaghani A. Long-term outcomes of patients bridged to recovery versus patients bridged to transplantation. J Thorac Cardiovasc Surg 2012;144(1):190-6.
4. Frazier OH, Baldwin ACW, Demirozu ZT, Segura AM, Hernandez R, Taegtmeyer H, et al. Ventricular reconditioning and pump explantation in patients supported by continuous-flow left ventricular assist devices. J Heart Lung Transplant 2015;34(6):766-72.