

# Ten-Year Survival With a Continuous-Flow Left Ventricular Assist Device and Aortic Valve Closure

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We report the long-term survival of a 46-year-old man supported with a HeartMate II continuous-flow left ventricular assist device after complex repair of a bicuspid aortic valve, anomalous left main coronary artery, and dilated aorta. He has been maintained on an anticoagulation regimen of warfarin and low-dose aspirin without problems for 10 years, during which he has worked continuously and productively. Device flow has been kept at 10,000 rpm. Possible contributors to this long-term success include proper alignment of the device inflow cannula, pericardial patch closure of the left ventricular outflow tract, and, notably, the remarkable freedom from mechanical failure of the continuous-flow left ventricular assist device. Whether the higher flow rate produced by the pericardial patch closure contributes to pump longevity is unknown and merits further investigation. (*Tex Heart Inst J* 2020;47(4):325-8)

**Key words:** Heart-assist devices; heart failure/therapy; treatment outcome; ventricle-assist devices; ventricular dysfunction, left/therapy

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Left ventricular assist devices (LVADs) are often considered to be intermediate-term support devices that last months or even several years. However, continuous-flow LVADs have proved to be remarkably free from mechanical failure. We report a case of mechanical cardiac support for more than 10 years with a continuous-flow LVAD.

## Case Report

A 46-year-old man presented for evaluation in 2008. He had a 5.5-cm dilated aortic root and severe aortic insufficiency due to a bicuspid (but not substantially stenotic) aortic valve. His left ventricular (LV) ejection fraction was preserved at 60%. The left main coronary artery anomalously arose superior to the sinotubular junction. Surgical repair with a Bentall procedure was initiated. The ascending aorta was replaced with a 32-mm prosthetic graft, the aortic valve and root were repaired with a 23-mm bi-prosthetic aortic valve (Freestyle; Medtronic, Inc.), and the left main coronary artery was reimplanted with use of an 8-mm prosthetic graft.

Weaning from cardiopulmonary bypass (CPB) was complicated by biventricular failure. Placement of a CentriMag LVAD (Levitronix LLC) and an intra-aortic balloon pump was necessary to wean the patient from CPB. The CentriMag LVAD's inflow cannula was placed in the left atrium through the right superior pulmonary vein. The outflow cannula was anastomosed to a right axillary artery graft that had been used for antegrade perfusion during ascending aortic aneurysm repair. Subsequent right-sided cardiac function was adequate; therefore, no right-sided mechanical support was necessary. The sternum was left open, and the skin was closed. Postoperatively, the patient developed hepatic failure, acute renal failure that necessitated continuous renal replacement therapy, ileus that necessitated total parenteral nutrition,

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and respiratory failure that necessitated tracheostomy and continuous ventilator support.

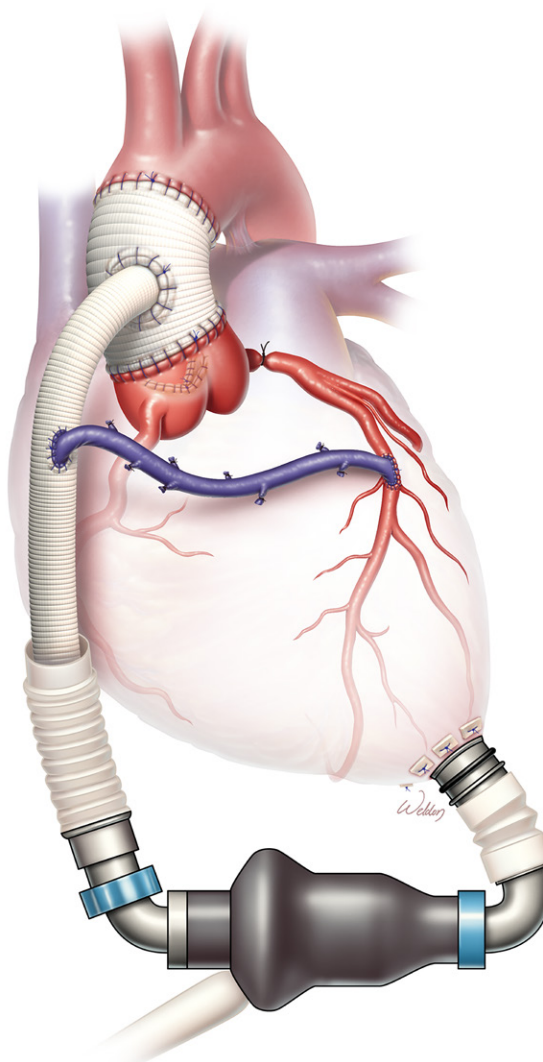
Weaning from the CentriMag LVAD was unsuccessful, and after 10 days a HeartMate II LVAD (Thoratec, an Abbott company) was implanted. Cardiopulmonary bypass was established with a venous cannula in the right atrium; aortic perfusion was established through the right axillary graft after the CentriMag LVAD was removed. Inflow to the HeartMate II was established from the LV cardiac apex while the heart was beating and the patient was on CPB. Particular attention was paid to properly orienting the HeartMate II inflow cannula; alignment with the septum was confirmed by means of transesophageal echocardiography (TEE). The HeartMate II outflow graft was attached to the ascending aortic graft with an end-to-side anastomosis. A pump flow rate of 8,000 rpm enabled weaning from CPB. Once again, the sternum was left open, and the skin was closed. Despite successful weaning from CPB, the patient remained in borderline cardiogenic shock with hepatic, renal, and pulmonary failure.

The day after HeartMate II implantation, TEE was performed to evaluate possible reasons for the patient's continued multiorgan insufficiency. Although LV recovery had been anticipated, TEE revealed hypokinesis of the anterior LV wall, right ventricular failure, no opening of the prosthetic aortic valve, a large thrombus in the aortic root, and substantial left atrial thrombus. Therefore, 48 hours after HeartMate II implantation, the patient was returned to the operating room.

Cardiopulmonary bypass was established through the right femoral artery and vein. After the chest was reopened, additional venous drainage was established through the superior vena cava. The prosthetic ascending aortic graft was cross-clamped, and hypothermic cardioplegia was administered. The ascending aortic graft was opened transversely. Fresh thrombus with smooth edges covered the bioprosthetic valve, and it was completely removed. The thrombus was attributed to stasis in the ascending aorta proximal to the LVAD inflow graft, secondary to poor LV function and the Bentall configuration for coronary artery perfusion. Therefore, the valve was removed, and the LV aortic outflow tract was occluded with a pericardial patch. Thrombus had extended into the 8-mm prosthetic graft to the reimplemented left anterior descending coronary artery (LAD). Thrombectomy of the prosthetic graft and reimplemented LAD reestablished graft patency; acceptable back-bleeding was noted. To ensure adequate perfusion of the LAD, a saphenous vein graft was anastomosed end-to-side proximally to the HeartMate II outflow graft and distally to the native LAD (Fig. 1). The right atrium was opened, and the left atrium was explored through the atrial septum. Thrombus within the left atrium, possibly related to stasis, was removed. The patient was again weaned from CPB with the HeartMate II set at 8,000 rpm.

Thereafter, acceptable cardiac function returned, and hepatic, renal, and pulmonary function recovered. Four days after the operation, the chest was closed. Chest radiographs (Fig. 2) and echocardiograms confirmed appropriate position of the HeartMate II inflow cannula over time. During the next year, the patient steadily recovered, and he returned to work.

The patient declined cardiac transplantation. He has been maintained on an anticoagulation regimen of warfarin (international normalized ratio [INR], 2.0–2.5) and aspirin (81 mg/d) without problems for 10 years, during which he has worked continuously and productively. Initially, his INR levels were monitored in the hospital. Since discharge, they have been monitored by his local physician.



**Fig. 1** Illustration shows the surgical anatomy after left ventricular assist device implantation, including aortic occlusion and bypass of left anterior descending coronary artery with its origin off the outflow graft.

Illustration by Scott A. Weldon, MA, CMI, FAMI; used with permission of Baylor College of Medicine.

The patient has received annual follow-up care in our outpatient clinic. HeartMate II flow has been carefully monitored and is optimized at 10,000 rpm. Cardiac catheterization after 7 years of nonpulsatile flow support revealed excellent cardiac function and a patent saphenous vein graft off the LVAD outflow graft. An echocardiogram obtained one year later revealed continued occlusion of the LV outflow tract by the intact pericardial patch, mild mitral and tricuspid regurgitation, a widely patent LVAD inflow cannula appropriately aligned with the ventricular septum and free from thrombus, and a widely patent outflow conduit with no substantial thrombus. Internal LV dimensions were normal (end-diastolic diameter, 4.8 cm; end-systolic diameter, 4.0 cm) with the LVAD set at 10,000 rpm.

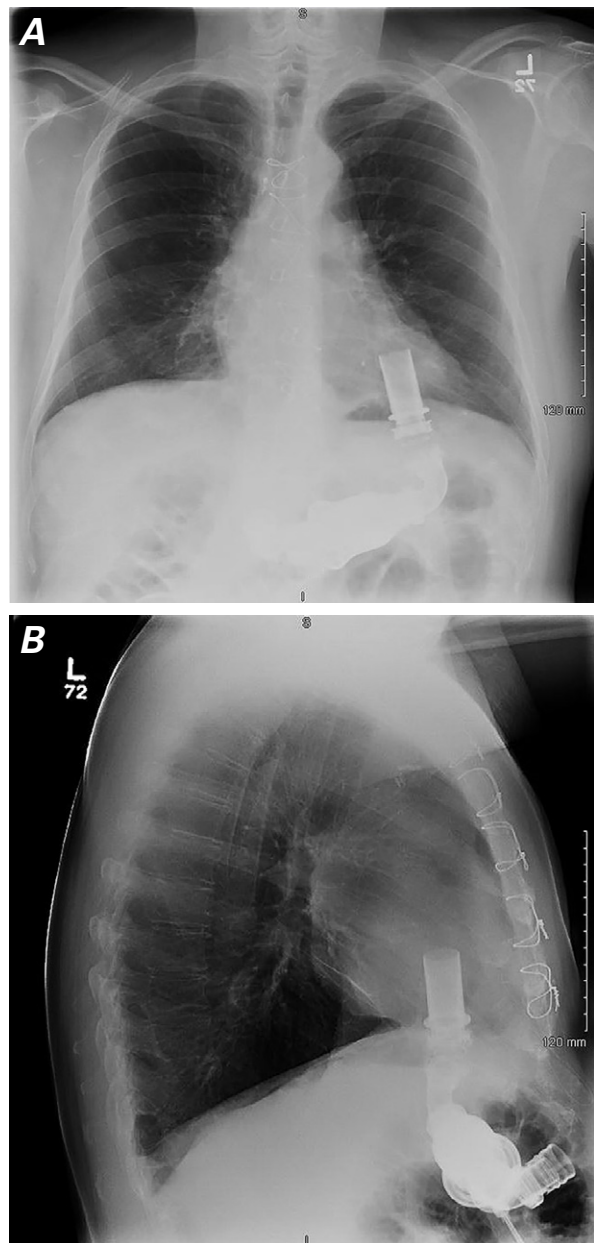
After 9 years of LVAD support, the patient had presyncopal episodes associated with slowing of the HeartMate II pump speed and activation of controller alarms. An echocardiogram showed no clinically important thrombus in the LVAD. However, a defect in the external portion of the driveline was found and repaired, and the controller was replaced. Presyncopal episodes and slowing of the HeartMate II pump resolved after driveline repair. The patient returned to work and has continued to do well for the 10 years that he has been receiving continuous-flow LVAD support. Other than the driveline problem, the LVAD has remained free from mechanical failure.

## Discussion

Although continuous-flow LVADs are usually regarded as intermediate-term assist devices, they can be extremely durable when placed properly and can provide cardiac support for years.<sup>1,3</sup> In our patient's case, a continuous-flow pump implanted under challenging conditions has remained in place and continued to function with minimal problems for more than 10 years. Important factors that may have contributed to this promising longevity are proper alignment of the inflow cannula and occlusion of the outflow tract with a pericardial patch, which directs all cardiac output through the LVAD.

Continuous-flow pumps have proved to be remarkably free of mechanical problems over time. Malfunction of the actual pump, its bearings, or its rotor (excluding thrombosis) is unusual, occurring in less than 5% of cases.<sup>4,5</sup> The most common causes of pump failure are pump infection, driveline infection, and turbulent flow at the inflow cannula. Improper alignment of the inflow cannula predisposes the pump to turbulent flow and thrombosis and is thus a potential reason for revising the LVAD implant. We meticulously align the LVAD inflow cannula parallel to the septum, which we confirm by means of TEE during surgery.

Pericardial patch closures have been used to occlude the LV outflow tract, thus directing all cardiac output



**Fig. 2** A) Anteroposterior and B) lateral chest radiographs show the inlet cannula of the HeartMate II left ventricular assist device aligned parallel to the cardiac septum.

through the continuous-flow device, usually when there is substantial aortic valve regurgitation or stasis in the aortic root. Our patient has tolerated such a closure for many years, and the flow through his HeartMate II LVAD has probably been higher than that for most LVADs. Whether this higher flow rate plays a role in pump longevity is unknown and would be an interesting issue to investigate in the future.

One novel aspect of this case was bypass of the LAD with a saphenous vein graft, anastomosed proximal to the LVAD's outflow graft. The graft was still patent after 7 years of nonpulsatile flow, supporting the use of this anatomic arrangement.

Continuous-flow LVADs are remarkably durable. Our patient's device still functions extremely well 10 years after implantation, without any evidence of pump malfunction. Left ventricular outflow tract occlusion with a pericardial patch has also been well tolerated in this case.

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