

# Simple Felt-Plug Closure Technique

## for Minimally Invasive Removal of a Centrifugal-Flow Left Ventricular Assist Device

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*As the indications for implanting left ventricular assist devices have expanded, some patients are qualifying for device removal after myocardial recovery. Whereas explantation has been described for previous generations of devices, no standard procedures have been developed. Removal of centrifugal-flow devices has created the need for a plug to seal the apical ventriculotomy after pump removal. However, no commercially available products are available in the United States. We used a novel technique to fashion a plug from Teflon felt and a Dacron graft to enable minimally invasive explantation of a current-generation centrifugal-flow device in a 33-year-old woman. (Tex Heart Inst J 2020;47(4):322-4)*

Less than 5% of patients who undergo left ventricular assist device (LVAD) implantation qualify for device removal. Those who do recover can benefit from minimally invasive surgical approaches. Several methods to remove devices have been described for earlier-generation devices, but none has become standard.<sup>1-3</sup> Furthermore, no devices to plug the ventricular opening are commercially available in the United States. We describe our back-table creation of a plug and a safe, minimally invasive technique that we used to explant an adult patient's centrifugal-flow LVAD.

### Case Report

Four weeks after giving birth, a 33-year-old woman presented with new-onset fatigue and ankle swelling. A transthoracic echocardiogram showed global left ventricular (LV) dysfunction (ejection fraction, 20%). The patient underwent implantation of a centrifugal-flow LVAD (HeartWare HVAD; Thoratec, part of Medtronic) to treat postpartum nonischemic cardiomyopathy. The device was initially intended as a bridge to transplant; however, 31 months later, the patient's heart failure symptoms had improved to New York Heart Association functional class I. Results of right-sided heart catheterization showed a sustainable cardiac index of 2.2 L/min/m<sup>2</sup> when device flow was reduced to a weaning rate of 1,900 rpm. We decided to remove the HVAD.

**Key words:** Cardiac surgical procedures/methods; device removal/instrumentation/methods; heart-assist devices; minimally invasive surgical procedures/methods; recovery of function; treatment outcome

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### Surgical Technique

At operation, a dual-lumen endotracheal tube was used to isolate the patient's lungs. We performed a left anterior minithoracotomy through the 7th intercostal space, using transthoracic ultrasound guidance to identify the device and the ventricular apex along the left chest wall to ensure an optimal incision.

To seal the apical ventriculotomy after pump removal, we used a back-table technique to create a felt plug. A spare sewing ring with the same diameter as the existing one was used as a template. Care was taken at each step to ensure that the plug would achieve hemostasis.

A strip of thick Teflon felt (1 × 12 in) was rolled tightly to create a cylinder that fit snugly within the spare sewing ring (Fig. 1A). The end of the strip was then sewn to the roll to preserve the shape. To minimize the risk of thrombosis, a Dacron graft was wrapped around the roll, thus providing a smooth interventricular surface. The wrapped end of the roll was then pushed through the spare ring to form a bullet-shaped plug, which was secured by placing a polypropylene purse-string suture along its base (Fig. 1B). The Dacron skirt was trimmed along the circumference of the ring.

Finally, to cover the bottom of the plug, we used the ring as a guide to cut a circular patch from a remnant of the Dacron graft. The patch was secured to the skirt with

several sutures, and then completed with a running suture around the edge (Fig. 1C).

The right common femoral artery and vein were cannulated for cardiopulmonary bypass (CPB) by means of a direct cutdown incision, and CPB was started. The HVAD outflow graft was clamped and divided, and the driveline was cut and fully excised. With the patient in the Trendelenburg position and the operative field flooded with carbon dioxide, the HVAD was detached from the inflow collar and removed from the ventricular apex. After removing the device and ensuring that the LV was free of thrombus, we inserted the plug into the apical ventriculotomy (Fig. 1D) and secured it to the existing sewing ring. The HVAD outflow graft served as an aortic root vent to de-air the heart when CPB was discontinued, then was ligated with a vascular stapler and left in situ—a technique that reportedly does not increase risks of postoperative stroke or thrombotic events.<sup>4</sup> Finally, we weaned the patient from CPB without pressor or inotropic requirements (CPB time, 53 min).

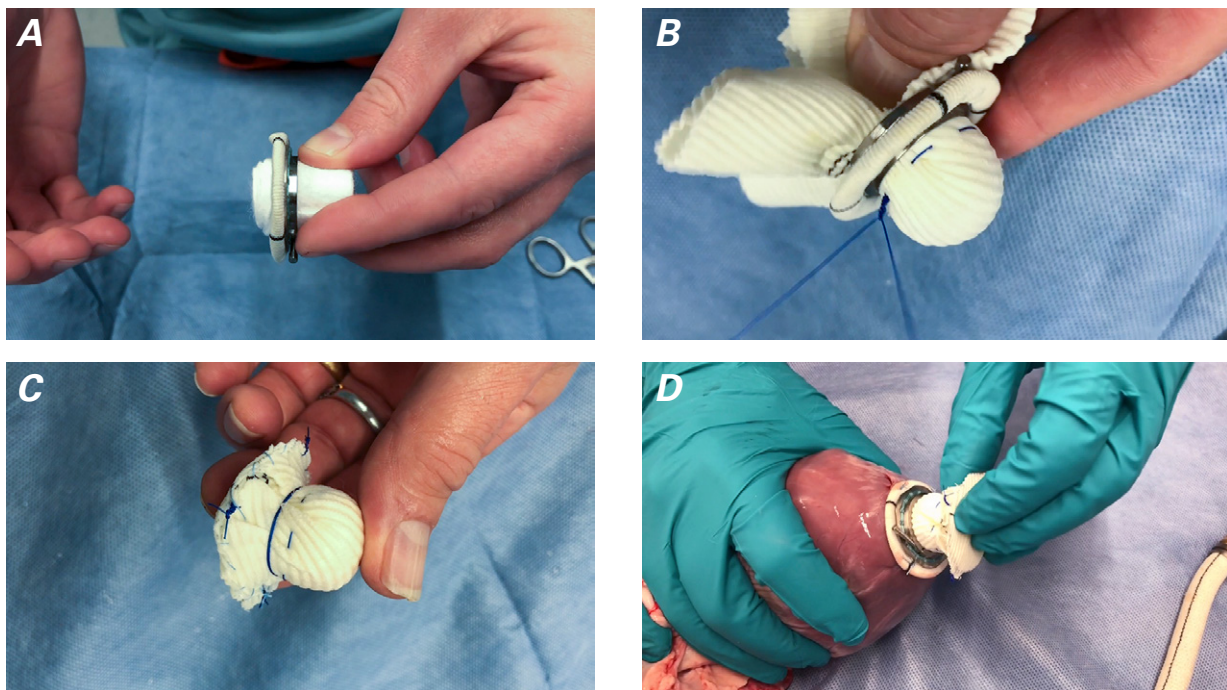
The patient recovered uneventfully and was discharged from the hospital on postoperative day 5. At her follow-up examination 2 months later, she was in New York Heart Association functional class I. A transthoracic echocardiogram revealed mildly reduced global LV systolic function (ejection fraction, 40%–45%) and

normal right ventricular systolic function. The LV apex was akinetic, but the mild hypokinesis elsewhere suggested minimal distortion of LV geometry after plug implantation. No thrombus was seen. The patient was lost to follow-up less than one year after device removal.

## Discussion

As surgical indications for mechanical circulatory support continue to expand, some patients with improved heart failure can undergo LVAD explantation. There are no standard techniques for this procedure, and most descriptions in the medical literature are case reports involving older-generation devices.<sup>1-3</sup> We report a safe, effective, minimally invasive felt-plug technique for sealing the apical ventriculotomy after removal of a centrifugal-flow device. Although felt plugs have been used before, we think that we are first to report covering the plug with a Dacron patch to improve the fit and hemostatic seal at the ventriculotomy site. To remove our patient's LVAD through a minithoracotomy, we left most of the outflow graft in situ after ligation.

Few relevant data on long-term patient outcomes are available; to date, the largest case series describing complications affecting in situ outflow-graft segments included 18 patients.<sup>4</sup> The grafts were anastomosed to



**Fig. 1** Photographs show the process for fashioning a felt plug to seal the apical ventriculotomy after removal of a left ventricular assist device. **A)** A strip of Teflon felt is rolled together to form the plug and is inserted in the spare sewing ring to ensure proper fit. **B)** The roll is covered with a Dacron graft and is inserted into the sewing ring to create a bullet-shaped plug, which is secured with a purse-string suture along its base. **C)** The Dacron skirt is trimmed, and the base of the roll is covered with a Dacron patch to complete the plug. **D)** After pump removal, the plug is inserted into the existing sewing ring.

Supplemental motion image is available for [Figure 1](#).

the descending aorta after a Jarvik 2000 (Jarvik Heart, Inc.) had been removed. No thrombotic complications were observed during a mean follow-up time of 53.6 months (range, 21.6–76.9 mo) in 14 surviving patients.<sup>4</sup> For current-generation devices, even fewer data are available.

In 2010, European authors reported their use of a commercial titanium plug (Steffan Fittkau GmbH) in 4 patients after explanting a 2nd-generation LVAD, the HeartMate II (Thoratec, part of Abbott).<sup>5</sup> That plug has not been approved by the U.S. Food and Drug Administration, and we found only one report of its use in the U.S. after LVAD removal.<sup>6</sup> No other plugs are commercially available.

This challenge can be overcome with use of our technique for fashioning a felt plug. The only associated costs are for the Teflon felt, the extra sewing ring used as a template, the Dacron graft, and the sutures. Our felt-plug method can be readily customized for any device type, including the latest centrifugal-flow devices. Finally, our minimally invasive approach enables patients to recover and to be discharged from the hospital only a short time after operation.

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