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Recurrent Outflow Graft Compression of HeartMate3: When the LVAD Sticks to the Rib

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Glossary:
HM3, HeartMate 3; LVAD - Left Ventricular Assist Device; PTFE, polytetrafluoroethylene tube
Central Message

The HeartMate 3 outflow graft obstruction secondary to accumulation of biodebris is an unexpected complication of left ventricular assist devices therapy, that may require multiple surgical interventions, with meticulous attention to the adjacent bony structures, to prevent recurrence.

Introduction

The HeartMate(HM)3 provides superior mortality and morbidity when compared to prior left ventricular assist devices (LVADs). The new pump design nearly eliminated device thrombosis; a complication that required surgical correction\(^1\). However, extrinsic compression of the outflow graft due to biodebris accumulation between the graft and the external polytetrafluoroethylene tube (PFTE), either intrinsic to the pump such as the outflow bend relief or externally applied to guard against kinking and re-exploration injury, is now recognized as a predominant HM3 complication with a reported incidence of up to 30\(^\%\)\(^2\)–\(^4\). The outflow graft is constructed of a knitted polyethylene terephthalate material that has inherent porosity permitting seepage of blood components that are trapped in-between the graft and bend relief. The gradual enlargement of these biodebris eventually leads to graft compression, and symptoms related to low blood flow and/or congestion. Management strategies with surgical and percutaneous interventions\(^5\) have been reported. However, the recurrence of the graft compression requiring repeated surgical procedures and, eventually, partial rib removal has never been described.

Case Presentation

A seventy-seven-year-old male with a history of dilated non-ischemic cardiomyopathy was implanted with HM3 LVAD in September 2018 as destination therapy via median sternotomy; the left atrial appendage was ligated, and aortic valve was repaired with Park stitch. Post-implant course was uneventful. The LVAD speed was 5400 rpms, flow 4-5 liters per minute
(LPM) at discharge. Two years later he presented with complaints of lightheadedness, new onset exertional dyspnea and multiple low flow alarms. Computed tomography angiography (CTA) revealed a moderate to severe luminal stenosis of the outflow graft at its origin, with 13 mm hypodensity within the bend relief in close proximity to the 7th rib (Figure 1A,B). Biodebris removal was performed using subxiphoid incision. The bend relief and an additional ring reinforced polytetrafluoroethylene graft were incised longitudinally fully evacuating the biodebris. Nine months later, occasional low flow alarms recurred. A repeat CTA revealed 8 mm hypodensity with moderate luminal narrowing at the previous interspace of the outflow graft (Figure 1C). Sixteen months later, low flow alarms occurred daily and were associated with pre-syncopal events. Notably, these low flow alarms were positional, being exacerbated by leaning forward. A CTA showed circumferential and crescentic hypodensity proximally within the bend relief, causing severe narrowing (Figure 1D-F). The surgery was done through a skin incision at the 6th intercostal space exposing the 7th rib (Figure 2A). Over the entire course, the patient was maintained on therapeutic warfarin (INR goal 2.0-2.5) and aspirin 81mg per os daily. Partial removal of the 7th rib was done, with immediate improvement in flow to 4.2 liters per minute (LPM) from 3 LPM (Figure 2B,C). Bend relief was cut to evacuate biodebris, with further improvement in flow to 4.7 LPM (Figure 2D-F). The polytetrafluoroethylene graft around the bend relief was partially removed. The patient was discharged on post-operative day 4 with complete resolution of symptoms. A repeat chest CT was done four months after surgery that showed residual 4 mm peripheral hypodensity in the proximal aspect of the outflow cannula without clinical manifestations (Figure 3). Patient was seen in follow up 9 months after surgery, with no further alarms or symptoms.

Conclusion

External outflow graft compression following HM3 implant is a well-recognized complication, that is associated with longer time on LVAD support and wide clinical presentation from
asymptomatic to potentially lethal. The etiology of this complication relates to seepage of blood components through the endograft material into the aneurysm sac and leads to gradual aneurysm enlargement. This is a well-recognized phenomenon in endovascular surgery and is attributed to the inherent porosity of the endograft. Similarly, with LVADs, the outflow graft is constructed of a knitted polyethylene terephthalate material that has its own inherent porosity permitting seepage of blood components that are then trapped in between the impermeable graft, thereby forming an extravascular thrombus. Gradual enlargement of this thrombus eventually leads to outflow graft impingement. Several potential treatment options are available that include urgent heart transplant listing in transplant eligible patients, endovascular repair in high-risk target population and ultimately surgical decompression. This is the first report illustrating the recurrent nature of the problem following initial surgical decompression and the need for rib removal to potentially prevent future events.

The case presentation was approved by the institutional review board (IRB reference; AAAU2877, 8/1/22) and informed consent was waived.

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**Figure Legends:**

**Central Picture.** Computed tomography angiography (CTA) images in axial view showing obstruction of the outflow graft as a result of biodebris accumulation, leading to significant luminal stenosis (circle)

**Figure 1.** Computed tomography angiography (CTA) images in axial view. A. 2018, patent outflow graft and the bend relief in close proximity to the 7th rib (*solid arrow points to the 7th rib*); B. 2020, severe outflow graft obstruction at its origin with 13mm hypodensity (*dashed arrow*), necessitating surgical evacuation; C. 2021, recurrent moderate luminal stenosis of the outflow graft at its origin with 8mm hypodensity (*dashed arrow*) and posterior hypodensity is no longer appreciated; D. 2022, Recurrent severe outflow graft obstruction with significant luminal narrowing, close proximity to the 7th rib was noted again, necessitating 2nd surgical evacuation and rib removal. E-F, 2020, Maximum intensity projection and volume rendered imaging showing the special relation of the LVAD position (*dashed arrow*), outflow graft (*solid arrow*) within the chest cavity and proximity to the rib cage in coronal views.

**Figure 2.** Intra-operative images during 2nd surgical revision. A. Exposure of the 7th rib (white star); B,C. Partial removal of the 7th rib with immediate improvement in flow to 4.2 liters per minute (LPM) from 3 LPM; D-F. Longitudinal incision of the bend relief and evacuation of biodebris with further improvement in pump flow to 4.7 LPM.

**Figure 3.** Computed tomography angiography (CTA) images before and after surgical biodebris evacuation and 7th rib removal. A. Sagittal view showing the 7th rib (*solid arrow*) before the surgical evacuation of biodebris and rib removal. B-C. Oblique axial and sagittal views at four months follow-up showing the absence of the 7th rib (*solid arrow*) and outflow graft patency.