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Surgical Correction of Spontaneous Outflow Graft Twisting of HeartMate 3 LVAD via a Subcostal Approach

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ABSTRACT

We present two cases of successful surgical correction of a HeartMate 3 left ventricular assist device (LVAD) outflow graft twisting through a subcostal approach. These twistings were diagnosed with computed tomography or pull back pressure measurement. Technically, a subcostal approach allowed us to access directly the twisted outflow graft and the device connector in a less invasive fashion as compared with a re-sternotomy. Diagnostic modality and surgical tips that address graft twisting are presented within the discussion of these two case studies. The institutional review board of our institution approved this study and waived the requirement for informed consent.

INTRODUCTION

The HeartMate 3 is a centrifugal-flow left ventricular assist device (LVAD) and the most updated version of a durable circulatory support device. It has been reported that this particular device provides less incidences of device-related complications compared with the previous version of the HeartMate device [Mehra 2019]. However, there are a number of reports describing late spontaneous outflow graft twisting events that are exclusive to the HeartMate 3 [Mehra 2018; Potapov 2018].

CASE REPORTS

Case 1: A 54-year-old female was hospitalized due to shortness of breath and persistent LVAD low flow alarms. Her initial surgery, HeartMate 3 insertion with mitral and tricuspid valve repair, took place 30 months prior to this presentation. The LVAD pump flow was 1.4 L/minute with 5400 rpm on admission, which was significantly lower than the baseline (i.e. 4.0L/minute with 5400 rpm). Echocardiography revealed that the aortic valve was open with every heart beat along with a dilated left ventricle. While the lactate dehydrogenase (LDH) level was slightly elevated (256U/l), serum haptoglobin (145mg/dl) and indirect bilirubin (0.2mg/dl) were within normal range. A computed tomography angiography (CTA) showed significant outflow graft narrowing at the vicinity of the LVAD pump (Figure 1A, 1B). (Figure 1)

Case 2: A 38-year-old male presented with shortness of breath, abdominal distension, nausea, and vomiting. He underwent the initial HeartMate 3 implantation, following mitral valve repair 18 months previous to device placement. His pump flow was slightly lower than his baseline, specifically 4.0L/minute with 6200 rpm on admission and 5.1L/minute with 6200 rpm as baseline. Echocardiography demonstrated that the aortic valve was open with every heart beat. Lab data showed that lactate dehydrogenase (LDH) level was elevated (425U/l), serum haptoglobin was low (36 mg/dl), and indirect bilirubin was elevated (3.1mg/dl). Due to a concern of rising creatinine (2.4 mg/dl), an outflow graft angiography was chosen for a diagnostic test, which required less amount of contrast compared with a CTA. This test revealed an apparent outflow graft twisting at the proximal portion of the outflow graft (Figure 1C) with a significant pressure gradient about 100mmHg at the twisting by a pull back pressure measurement (Figure 1D, 1E).

Both cases were taken to the operating room with a diagnosis of outflow graft twisting/kinking. A subcostal approach was utilized to directly access the proximal portion of the outflow graft. A reverse-J shape incision was made in the subcostal area, and the outflow graft was exposed enough to access the connection between the outflow graft and the device body. A Rultract retractor (Rultract Inc., Ohio) was used to lift the rib to obtain reasonable exposure (Figure 2A). (Figure 2) The bend relief was identified, followed by the plastic frames of it partially removed. The bend relief was then longitudinally opened to reveal the outflow graft. It was discovered that the outflow graft was twisted about 3-4 cm from the device connector (Figure 2B). While ascertaining the bend relief, it was adhered to the surrounding tissue and detached from the connector using the HeartMate accessory instrument. Then, the connector was rotated in a direction for untwisting the outflow graft. A curved-up Rongeur forceps was helpful to rotate. In both cases, it required rotating in a counter-clockwise fashion 120 degrees to fix the twisting (Figure 2C, 2D).

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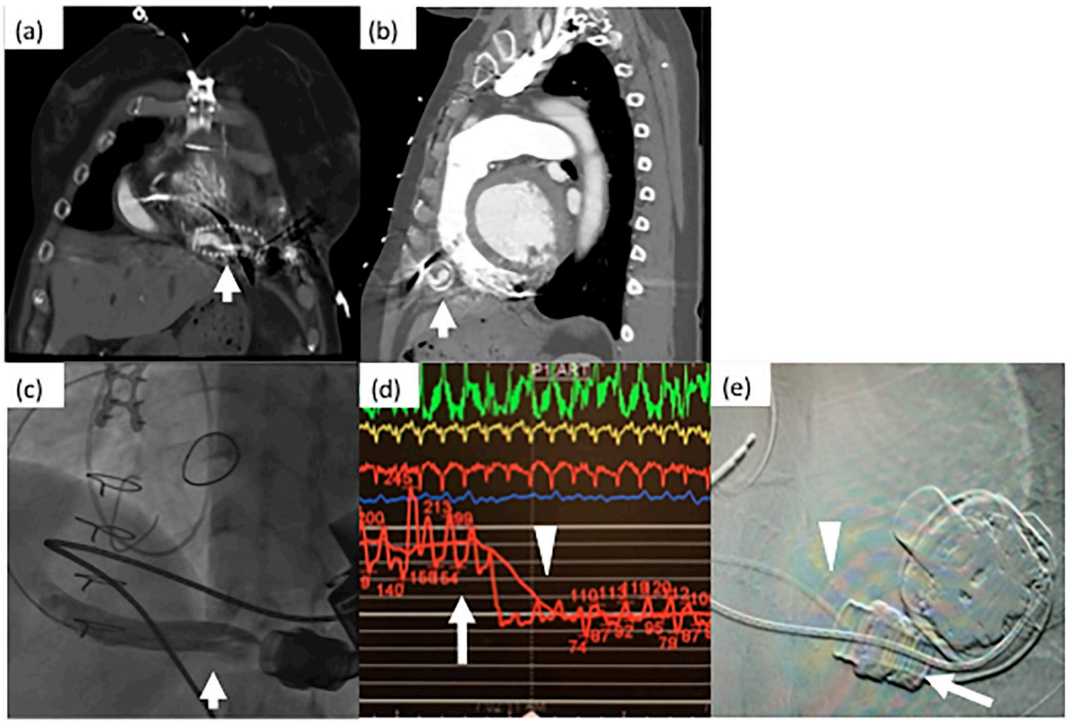

Figure 1. A, B) Computed tomography showed an outflow graft twist (white arrow); C) The graft angiography showed a graft twisting (white arrow); D, E) A pull back pressure measurement showed a significant gradient before (white arrow) and after (white arrow head) the twisting.

Hemodynamics and LVAD parameters were immediately improved. We did not place an outflow graft clip, given the risks to injure the surrounding structures during a dissection with a relatively limited exposure. The opening of the bend relief was covered with a Gore-Tex soft tissue patch (WL Gore & Assoc Inc, Flagstaff, Ariz). The connector between the bend relief and the device body was left exposed to the surrounding tissues to facilitate adhesions growing so as to prevent a recurrence. After decent hemostasis, the incision was closed in layers in the routine fashion. The postoperative course was uneventful. No recurrent issue has been noted for four months of the follow-up period.

DISCUSSION

The first clinical trial for the HeartMate 3 was initiated in 2014 [Schmitto 2015]; subsequently, it was approved by the Food and Drug Administration (FDA) for commercial use in 2017. It was reported that the HeartMate 3 pump showed either comparable or more favorable outcomes compared with the HeartMate II, in terms of device-related complications such as a remarkable reduction in stroke rates [Mehra 2019]. However, there has been a device-related complication exclusive to the HeartMate 3, which is spontaneous outflow graft twisting in a long-term phase. Although the mechanism of late graft twist has not clearly been understood, the helical heart motion, ventricular remodeling, and/or metallic swivel joint configuration have been considered to lead to this issue [Mehra 2018; Potapov 2018]. According to the MOMENTUM3 trial report, the incidence of late outflow graft twisting was 1.6%, and the median duration from the index surgery was 544 days [Mehra 2018]. In our case series, the incidence was 2.4% (2/84), and its median duration from the index implantation was 495 days. As for diagnostic modality, it generally is recommended to obtain a CTA to detect the outflow graft twisting. In our first case, a CTA revealed a narrowing of the outflow graft, and the final diagnosis of twisting was confirmed during surgery. Thrombus formation inside the outflow graft would be an important differential diagnosis because it would need a different surgical strategy to avoid embolic events. However, it is sometimes difficult to differentiate those diagnoses only with a CTA, although it is known that most of late outflow graft twisting occurred at a proximal portion of the graft near the device connection [Mehra 2018; Potapov 2018]. In our second case, we performed an outflow graft angiography and found this test to be very helpful with confirming outflow graft twisting as it was clearly shown. Along with this, the pressure measurement demonstrated significant pressure gradients at the twisted point. Ultimately, our team recommends an outflow graft angiography in patients with a suspicious outflow graft twisting.

In terms of surgical approaches, a full resternotomy is one option. However, it would require a full dissection of the heart and the device to fix the problem, which likely needs cardiopulmonary bypass. A left thoracotomy is another option; it provides reasonable access to the device body. However, it would suffer from limited exposure to access the main target;

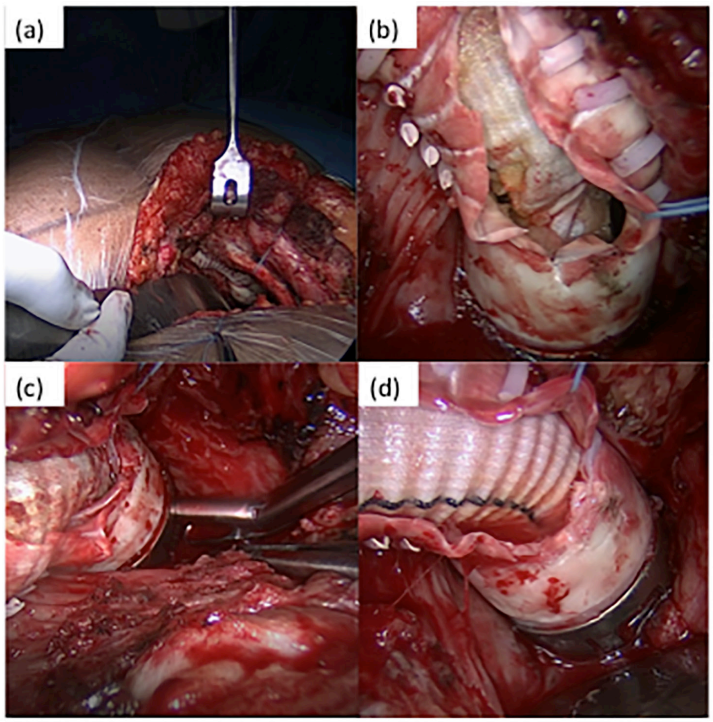

Figure 2. A) Subcostal approach. A Rultruck retractor was useful to lift the rib and expose the surgical field. B) Graft twisting; C) The graft is untwisted with curved-up Rongeur forceps; D) The graft was untwisted and fixed.

specifically, the outflow graft that lies down anterior/medial side of the chest. We utilized a subcostal approach, which allowed direct access to the target area (i.e. the outflow graft and the device connector) in a less invasive fashion.

A number of these issues are reported in the literature, specifically, outflow graft connector clips' role in avoidance of twisting were released in October 15, 2018 by Abbott (Abbott Park, IL). Eventually, an integrated pump cover was released on November 11, 2019. Index implantations for both of our cases took place before the clip was released for use. It is important to note, we did not place a clip during the surgery due to anatomical reasons. We believe that the connector will not rotate again due to severe adhesions. However, this could be a trade-off in a subcostal approach and close follow up for our patients is necessary.

CONCLUSION

We experienced two cases of spontaneous outflow graft twisting in patients supported with a HeartMate 3, and successfully treated with a surgical repair using a subcostal approach.

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