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CASE REPORT

How organ care system saved the day during a donation after circulatory death heart transplant: a case of complicated sternal re-entry

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Abstract

Sternal re-entry during left ventricular assist device (LVAD) explant and heart transplantation risks damaging structures including the driveline, LVAD outflow tract, ascending aorta, or heart. Preoperative imaging is vital for planning re-entry. This report highlights a pitfall with CT imaging and an advantage of the Organ Care System (OCS) in minimising ischemic time during complex re-sternotomy. A 56-year-old male with ischemic cardiomyopathy and a LVAD underwent a donation after circulatory death (DCD) heart transplant. A CT scan immediately post-LVAD implantation suggested low re-entry risk. However, during re-sternotomy, a vascular injury occurred between the outflow graft and ascending aorta, causing catastrophic bleeding. Rapid chest proximation using pre-placed Ethibond sutures controlled bleeding whilst obtaining femoral access for cardiopulmonary bypass (CPB). Deep hypothermic circulatory arrest was required whilst the OCS optimally perfused the donor heart, extending preservation time (OCS perfusion time of 241 min). The transplant was performed, following which CPB was weaned. Postoperatively, the patient required a tracheostomy but recovered well, being discharged by day 40. This case illustrates the need to investigate anatomical changes post-LVAD implantation and implement measures to prevent re-entry injuries. CT imaging immediately post-implantation may not reflect evolving anatomy, hence serial imaging could enhance surgical planning. The OCS was vital in allowing extended preservation time to accommodate for unforeseen complications whilst the Ethibond sutures were essential in aiding control of the bleeding. Research in the LVAD subgroup to evaluate the extent of remodelling hence proximity of structures in relation to the sternum is essential to optimise surgical planning.

Key words: re-sternotomy; heart transplantation; preoperative imaging.

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Introduction

A recognised complication of sternal re-opening is inadvertent injury to the heart and major surrounding structures.[1,2] Consequently, preoperative review of the CT chest is mandatory prior to re-entry.[3] In patients with a durable left ventricular assist device (LVAD), the position of the outflow tract is especially important as it may lie in close proximity to the back of the sternum, posing greater risks of damage during re-entry. Injury to the outflow tract during re-entry in a heart transplant can cost valuable ischaemic time which may be unrecoverable. In this report, we illustrate an unexpected event during sternal re-entry for orthotopic cardiac transplantation using an organ care system (OCS) in a donation after circulatory death (DCD) setting.

Case Report

A 56-year-old man with a history of ischaemic cardiomyopathy underwent implantation of a HeartMate III LVAD in 2022 as a bridge to heart transplantation. After approximately 18 months on the transplant waiting list, a suitable heart was identified from a DCD donor. A chest CT performed immediately post-LVAD implantation appeared favourable, showing minimal risk of injury to the LVAD outflow graft, driveline, or heart.

Patient preparation

Once the donor match was found, the patient was consented for the procedure with the risks associated with re-entry discussed. The patient was transferred to the anaesthetic room when the donor reached criteria for DCD heart donation. After induction of anaesthesia, the surgical team began preparing for a standard midline sternotomy. Heavy Ethibond sutures (Ethicon J&J, Bridgewater, NJ, USA; 05 length 75 cm 55 mm needle) were pre-placed on either side of the sternum during re-sternotomy (Figure 1).

Re-entry and unexpected complication

The preparation and re-sternotomy using an oscillating saw were performed as standard. However, just before completion of the sternotomy there was a breach of the junction between the LVAD outflow graft and aorta. Significant haemorrhage occurred but the bleeding was controlled by immediate sternal apposition using the strong pre-placed Ethibond sutures. This provided temporary control while femoral access for cardiopulmonary bypass (CPB) was achieved. The time taken from the start of re-entry to initiating CPB was 35 min. The patient remained haemodynamically stable with minimal requirement for blood transfusion.

The patient was heparinised, and femoral cannulation was achieved *via* the right groin. On CPB the patient was cooled down to 18°C in preparation for deep hypothermic circulatory arrest (DHCA). During this time, the donor heart arrived on OCS.

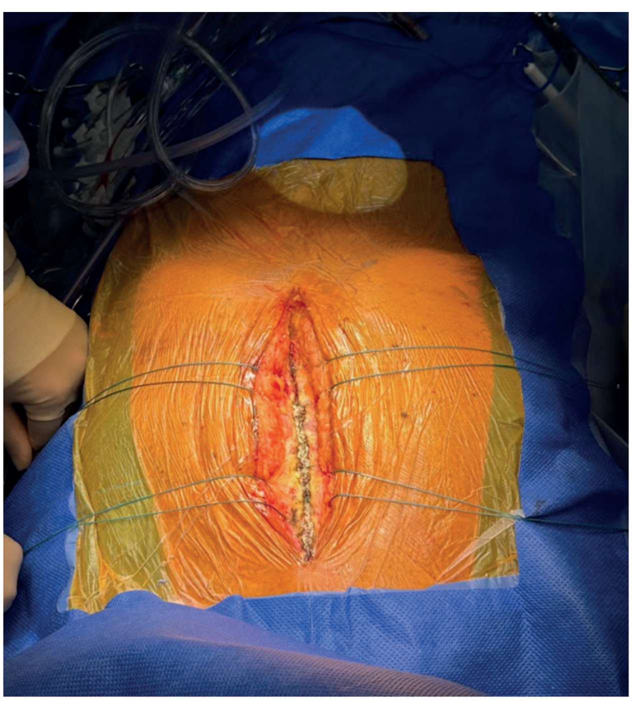

Figure 1. Photograph taken intra-operatively indicating the use of Ethibond sutures placed on either side of the sternum to allow for swift chest closure in high-risk re-sternotomies.

Management of aortic injury and LVAD explantation

Fifteen min was required in DHCA for the sternum to be freed and for the aortic injury to be isolated.

At this point CPB was re-established. The dense adhesions surrounding the heart and LVAD outflow tract were carefully dissected, and the outflow tract tied. The right side of the heart and aorta were freed from adhesions and the superior vena cava (SVC) cannula was inserted for head and neck drainage during transplant. With the CPB fully established and inferior vena cava (IVC) and SVC snared, the aorta was cross clamped and the heart with the device explanted.

Donor heart preparation and implantation

The donor heart was inspected and prepared for implantation. The total time of OCS was just over 4 h. The following sequence of anastomoses was performed using Prolene (Ethicon J&J):

i. Left atrium anastomosis (3/0 Prolene, 120 cm)
ii. IVC anastomosis (4/0 Prolene, 90 cm)
iii. Pulmonary artery anastomosis (5/0 Prolene, 90 cm)
iv. Aortic anastomosis (4/0 Prolene, 90 cm)
v. SVC anastomosis (5/0 Prolene, 90 cm)

The left ventricle was vented through the left atrium to facilitate de-airing. The recipient's ascending aorta was found to be thin and of poor quality. A Teflon sandwich was fashioned at the site of anastomosis with the donor aorta. Following completion of all anastomoses, the patient was rewarmed. A warm blood cardioplegic solution (1000 mL) was administered through the aortic root and the cross-clamp was removed. The donor heart began beating spontaneously and was re-perfused for 30 min on CPB before weaning off. The total warm ischaemic time was 96 min (29 min before reanimation and 67 mins during implantation).

Weaning from bypass

Two atrial and two ventricular pacing wires were placed. The patient was weaned from CPB, following a total of 5 h on CPB,

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with minimal inotropic support (inhaled nitric oxide at 20 PPM, noradrenaline 0.05 µg/kg/min, milrinone 0.2 µg/kg/min, and adrenaline 0.12 µg/kg/min). Backup pacing was initiated in dual-chamber pacing mode at a rate of 90 bpm (upper rate of 100 bpm). Transoesophageal echocardiography showed satisfactory overall function of the heart. A Swan-Ganz catheter was advanced with a measured cardiac index ranging between 2.4 and 2.6 L/min/m².

Closure

Two chest drains were placed, one in the anterior mediastinum and one in the posterior pericardium, to ensure adequate drainage post-operatively. The sternum was closed with double sternal wires and absorbable sutures for skin closure. The LVAD driveline exit site was packed with betadine strips for infection control.

Outcome

Post-operatively, the patient was admitted to the Intensive Care Unit (ICU). He required a tracheostomy seven days post-operatively and was decannulated 10 days later. The patient made a good recovery and was transferred to the ward on day 17 post-operatively, following which he was discharged home at day 40. Currently, the patient is being followed up as per our standard protocol. His immunosuppression regimen included rabbit antithymocyte globulin induction, along with tacrolimus, mycophenolate mofetil, and prednisolone. He has no reported complications since undergoing the transplantation.

Discussion

Heart transplantation is becoming increasingly complex as the number of patients bridged to transplant using LVAD increases. This case highlights the challenges of re-entry during orthotopic heart transplantation.

Preoperative planning is an important aspect of surgical training. The preparation for safe heart and LVAD explantation begins at the point of implantation. During LVAD implantation, the driveline and outflow graft should be positioned away from the back of the sternum and Gore-Tex patches should be used to protect from injury on re-entry.[4] In this case a Gore-Tex patch was not used, possibly due to the presence of a patent LIMA-to-LAD graft during LVAD implantation.

Preoperative imaging is a valuable tool for the assessment of the anatomical relationship between the LVAD outflow tract and surrounding structures, especially regarding the proximity to the back of the sternum.[3-5] Despite preoperative imaging in this case suggesting low anatomical risk, re-sternotomy was complicated. The findings at re-entry differed to what was expected on review of the immediate post-LVAD implant CT scan. On retrospective review of other imaging, anecdotal evidence of remodelling post-LVAD implantation is shown, including changes in geometry and position of the heart and surrounding structures. The discrepancy between imaging and intraoperative events may be attributed to anatomical changes occurring over time following implantation, adhesion formation or the evolution of scar tissue. In earlier post-operative days post-LVAD implantation there is potentially reduced thoracic cavity space due to the lungs being atelectatic and partially inflated. During recovery, full expansion of the lungs is regained, increasing intrathoracic pressure, and pushing the heart and LVAD outflow tract closer to the back of the sternum. Therefore, a singular static CT post-implantation may not adequately reflect the evolving nature of intra-thoracic structures and the increased risks of complications during re-entry. Further investigations are needed to determine the extent of remodelling that may occur in this setting. Three-dimensional reconstruction imaging could offer further insights into the position of vital structures, allowing for more tailored surgical planning.[6]

Another point for discussion is the use of strong Ethibond sutures placed on either side of the sternum during re-entry. This played a crucial role in managing a sudden haemorrhagic event at the time of re-sternotomy. Once an injury occurs, these sternal sutures may be rapidly used to approximate the sternum, reducing blood loss. This technique bought valuable time while femoral exposure was achieved to initiate CPB. The use of femoral access is a well-recognised technique in emergencies when central cannulation is not immediately feasible. This highlights the importance of prior planning to manage potential catastrophic bleeding.

The use of an OCS was vital to ensure successful transplantation. In donation after brain death, the use of cold storage means there is generally less flexibility for preservation due to ischaemic time compared to DCD. In this case, the OCS was vital in facilitating flexibility intra-operatively, addressing the time-sensitive nature of the transplant, especially accounting for the unforeseen complication. This contributed significantly to the transplant success. In the absence of the OCS, the ischaemic time for the donor heart would have possibly been incompatible with survival post-transplantation.

Conclusions

There is a need for stringent preoperative planning as the complexity of heart transplants increases with progressive use of LVADs. The use of the OCS in this case resulted in a positive outcome through extending preservation time of the donor heart allowing flexibility intra-operatively. Intra-operative techniques, including the use of Ethibond sutures should be considered as a routine for re-sternotomy. Further investigation into the anatomic remodelling of intrathoracic structures post-LVAD surgery is required, and preventative means should be used to make LVAD explantation safer.

Contributions

All authors listed have made substantial and direct contribution to the work and approved it for publication. NM and SSM, the

joint first authors, contributed equally to the writing, review and editing of the work. All authors had contribution to the concept and formulation of this report, reviewing it critically for important intellectual content, final approval, and agreement to be accountable for all aspects of this work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately resolved.

Ethics approval

Not applicable.

Conflict of interest

The authors declare no potential conflict of interest.

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