Minimally invasive direct left ventricular assist device implantation

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An institutional review board (Ethics Committee, Witten/Herdecke University) approved the study protocol and publication of data (Institutional Review Board No.: S-164/2022; September 9, 2022). The patients provided informed written consent for the publication of the study data.

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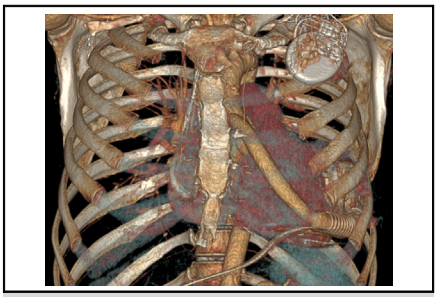


3D reconstruction from CT images after MIDVAD implantation.

CENTRAL MESSAGE

A single-incision, minimally invasive LVAD implantation with outflow graft anastomosed to the ascending aorta is feasible. Prior experience with less-invasive procedures is inevitable.

See Commentary on page XXX.

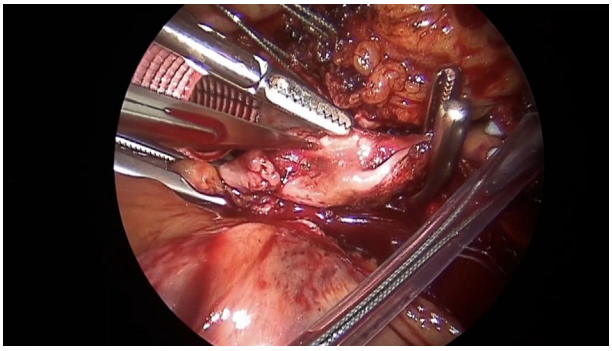
Video clip is available online.

Less-invasive or minimally invasive implant strategies for left ventricular assist devices (LVADs) usually involve minimizing or completely avoiding sternal trauma, avoiding heart luxation while simultaneously leaving the major part of pericardium intact. The current literature supports the advantages of less-invasive LVAD implantations that include less re-exploration for bleeding, blood product utilization, and postoperative right ventricle failure as well as shorter length of hospital stay.[1-4] Most surgeons use a left minithoracotomy for implantation of the pump combined with a hemisternotomy or right-sided minithoracotomy to attach the outflow graft to the ascending aorta.[1,5-7] In this report, we introduce a novel technique for LVAD implantation whereby the pump implantation is performed through a single minithoracotomy incision. We call this procedure the minimally invasive direct left ventricular assist device (MIDVAD) implantation (see Video 1). The advantage of this technique is that antegrade blood flow in the ascending aorta is maintained and the sternum remains intact without additional skin incision for the outflow graft anastomosis.

PATIENT SELECTION

The MIDVAD technique is only feasible if no additional procedure is necessary and the patient has no history of previous cardiac procedures. There are several other procedure-related caveats that require close attention. For instance, similar to other minimally invasive procedures, this technique is more challenging in patients with higher body mass index. In addition, single lung ventilation is necessary for this procedure and may be a limiting factor in patients with compromised lung function. Finally, preoperative computed tomography scanning is inevitable to exclude calcification of the ascending aorta and subsequent stroke risk.

A total of 3 50- to 66-year-old patients in New York Heart Association functional class III and IV and Interagency Registry for Mechanically Assisted Circulatory Support class 4 were supported with the HeartMate 3 pump (Abbott) using this technique. The patients were free from procedure-related adverse events. The institutional review board at Witten/Herdecke University approved this study (approval No. S-164/2022; September 9, 2022). Written



VIDEO 1. The video displays the MIDVAD procedure, including the placement of the HeartMate 3 pump (Abbott) into the left apex and the attachment of the outflow graft to the proximal ascending aorta. Video available at: https://www.jtcvs.org/article/S2666-2507(23)00061-5/fulltext.

informed consent for the publication of the study data was obtained from all patients.

TECHNICAL WORKFLOW

The patients were put on cardiopulmonary bypass via the femoral vessels (or the right axillary artery if the femoral artery was calcified) during the preoperative computed tomography scan. Single lung ventilation was used and the right lung was continuously ventilated. An anterolateral left-sided minithoracotomy was performed through the fifth or sixth intercostal space with an incision length of 7 to 12 cm. An endoscopy was set through the fourth intercostal space and the chest cavity was flooded with carbon dioxide. The pericardium was incised longitudinally from the left ventricular apex to the aorta. Afterward, a minimally invasive direct coronary artery bypass retractor was used and the ascending aorta was exposed to insert a vent catheter in the distal ascending aorta for de-airing. The technique for exposing the aorta is based on the Ottawa procedure, which is known from minimally invasive cardiac surgery coronary artery bypass (MICs-CABG)[8]: the ventilation pressure and positive end-expiratory pressure to the right lung was increased (to move the mediastinum to the left); serial traction sutures on the right side of the pericardium were placed (to pull up the aorta); wet gauze was applied to the right-lateral aspect of the aorta (displacing it medially); a coronary tissue stabilizer was used (to lightly press the pulmonary artery dorsally and medially), if necessary; and an additional, upper intercostal space was opened through the same left sided minithoracotomy to facilitate access to the ascending aorta.

Next, the apex was exposed and the HeartMate 3 device was inserted into the ventricle as described previously.[1] Great care was given to properly de-air the pump through the graft and aorta. The driveline was tunneled in the usual manner. The outflow graft was sized appropriately to avoid kinking and right ventricle compression and was tunneled within the pericardium. Partial aortic clamping was placed and the outflow graft was attached to the anterior part of the proximal ascending aorta. Cardiopulmonary bypass was weaned and the pump was started. Finally, the chest and groin cannulation sites were closed. Figure 1 shows the 3-dimensional computed tomography scan of the pump position and the course of the outflow graft.

CAVEATS

Major issues include bleeding from the aortic anastomosis site and the management of secondary right heart failure. In the case of bleeding, a direct view of the suture line is mandatory. A bailout sternotomy may be necessary to control bleeding complications. This was not necessary in our cases.

In case of secondary right heart failure requiring mechanical support, we advocate for less-invasive percutaneous approaches (eg, using ProtekDuo cannulae [LivaNova]). Alternatively, a graft is attached to the pulmonary artery (as outflow cannula) and exteriorized using the same incision and the venous cannula in the groin used as inflow for the right VAD. Our experience with this technique of right VAD implantation has been described before.[9]

COMMENT

To our knowledge, these are the first patients receiving HeartMate 3 implantation and outflow graft anastomoses to the proximal ascending aorta through a single minithoracotomy incision (Figure 2). Apart from minimization of the surgical trauma (a potential advantage for future surgeries), the MIDVAD approach offers the advantage of keeping the sternum intact while physiological antegrade blood flow in the ascending aorta is maintained. The technique to perform a handsewn proximal anastomosis onto

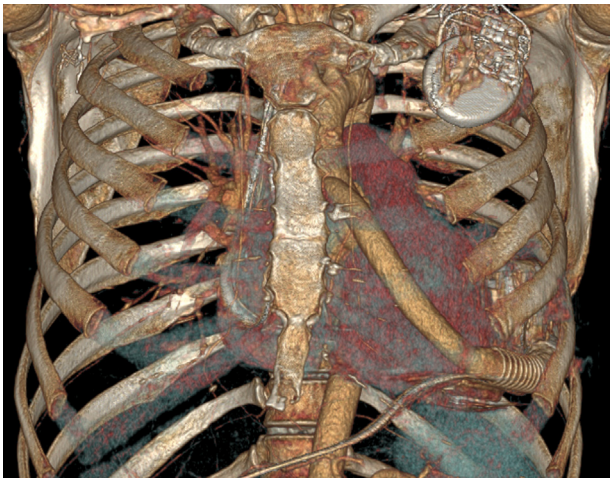


FIGURE 1. Three-dimensional reconstruction from computed tomography images to show HeartMate 3 pump (Abbott) in place after a single lateral thoracotomy.

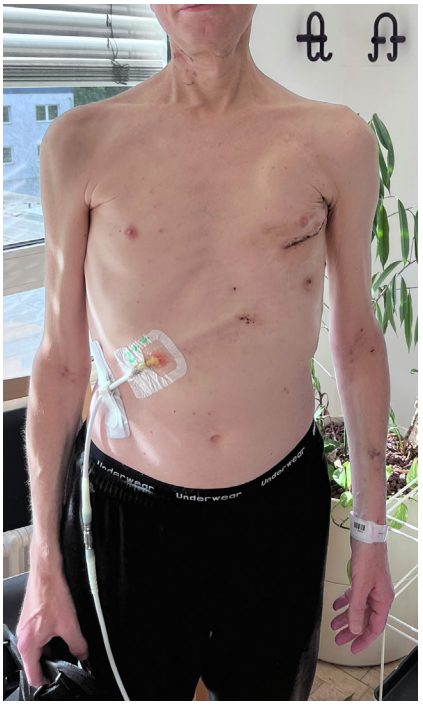


FIGURE 2. Postoperative scar.

the ascending aorta through a small left thoracotomy is well known in MICs-CABG procedures.[8] By applying this MICs-CABG technique to the known less-invasive LVAD implantation technique, the safety and feasibility are maintained. As previously described, optimal patient selection and prior experience with less-invasive LVAD implantation is mandatory to achieve excellent results. Further studies are necessary to evaluate the possible benefits and the applicability of this technique in a broader patient population.

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References

1. Al-Naamani A, Fahr F, Khan A, Bireta C, Nozdrzykowski M, Feder S, et al. Minimally invasive ventricular assist device implantation. *J Thorac Dis*. 2021;13:2010-7.
2. Jawad K, Sipahi F, Koziarz A, Huhn S, Kalampokas N, Albert A, et al. Less-invasive ventricular assist device implantation: a multicenter study. *J Thorac Cardiovasc Surg*. 2022;164:1910-8.e4.
3. Potapov E, Loforte A, Pappalardo F, Morshuis M, Schibilsky D, Zimpfer D, et al. Impact of a surgical approach for implantation of durable left ventricular assist devices in patients on extracorporeal life support. *J Card Surg*. 2021;36:1344-51.
4. Saeed D, Muslem R, Rasheed M, Caliskan K, Kalampokas N, Sipahi F, et al. Less invasive surgical implant strategy and right heart failure after LVAD implantation. *J Heart Lung Transplant*. 2021;40:289-97.
5. Schmitto JD, Mariani S, Abicht TO, Couper GS, Danter MR, Itoh A, et al. Expert consensus paper: lateral thoracotomy for ccentrifugal ventricular assist device implant. *Ann Thorac Surg*. 2021;112:1687-97.
6. Popov AF, Mohite PN, Sabashnikov A, Weymann A, Patil NP, Sáez DG, et al. Minimally invasive HeartWare LVAD implantation through single left thoracotomy. *J Artif Organs*. 2015;18:170-2.
7. Saeed D, Sixt S, Albert A, Lichtenberg A. Minimally invasive off-pump implantation of HeartMate 3 left ventricular assist device. *J Thorac Cardiovasc Surg*. 2016;152:1446-7.
8. Chan V, Lapierre H, Sohmer B, Mesana TG, Ruel M. Handsewn proximal anastomoses onto the ascending aorta through a small left thoracotomy during minimally invasive multivessel coronary artery bypass grafting: a stepwise approach to safety and reproducibility. *Semin Thorac Cardiovasc Surg*. 2012;24:79-83.
9. Saeed D, Maxhera B, Kamiya H, Lichtenberg A, Albert A. Alternative right ventricular assist device implantation technique for patients with perioperative right ventricular failure. *J Thorac Cardiovasc Surg*. 2015;149:927-32.