Technical considerations for successful durable left ventricular assist device implantation in a small child

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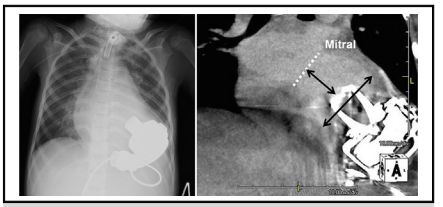


The HeartMate 3 implantation in a child with BSA of 0.72 m².

CENTRAL MESSAGE

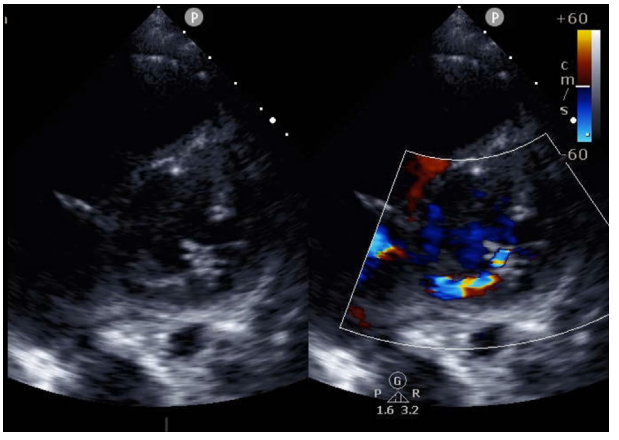
The HeartMate 3 was implanted in a child with BSA of 0.72 m² using "push-in" apex technique.

Video clip is available online.

The HeartMate 3 (HM3; Abbott) left ventricular assist device (LVAD) demonstrates superior clinical outcomes compared with previous LVADs,[1] and its availability is expanding to younger and smaller patients.[2,3] However, the lower limit of patient body size has not yet been determined. Some technical considerations are necessary for safe HM3 implantation in the smaller child. We report the technical issues associated with the successful implantation of the HM3 in a small child. Patient informed consent was orally obtained for publication of data. Institutional review board approval was not required for this case report, as there was no potentially identifiable information in this article.

A 9-year-old girl with refractory left ventricular (LV) noncompaction cardiomyopathy, supported by an extracorporeal LVAD with a centrifugal pump for approximately 3 months, underwent HM3 implantation as a bridge to transplantation (Figure 1, *A*). The patient's body weight and body surface area (BSA) were 15.9 kg and 0.72 m^2, respectively. During HM3 implantation, the LV apex was carefully cored with attention to the location of the papillary muscles, and the inflow minicuff was secured in the usual manner as for adult patients. The inflow cannula was placed in the apical cuff with slight longitudinal pushing of the LV apex, enabling placement of the pump body in the intrapericardial cavity. The position of the inflow cannula tip was confirmed carefully with intraoperative transesophageal echocardiography (Figure 1, *B* and *C*). The outflow graft was anastomosed to the previous outflow graft of extracorporeal LVAD. Chest closure did not compromise the pump position or interfere with the mitral apparatus and the interventricular septum. Postoperative transthoracic echocardiography showed normal mitral valve function and no interference with the LV wall (Figure 1, *D* and *E*, Video 1). Antithrombic therapy included aspirin and warfarin. Two months after implantation, the monitored LVAD flow constantly ranged from 2.8 to 3.5 L/min at 4200 to 4400 rpm, without suction events, low-flow alarms, or hemolysis.

There were several concerns associated with HM3 implantation in this small child. The first was whether the



VIDEO 1. Postoperative transthoracic echocardiography shows normal mitral valve function, reduced degree of mitral regurgitation, and no interference with the LV wall. Video available at: https://www.jtcvs.org/article/S2666-2507(24)00144-5/fulltext.

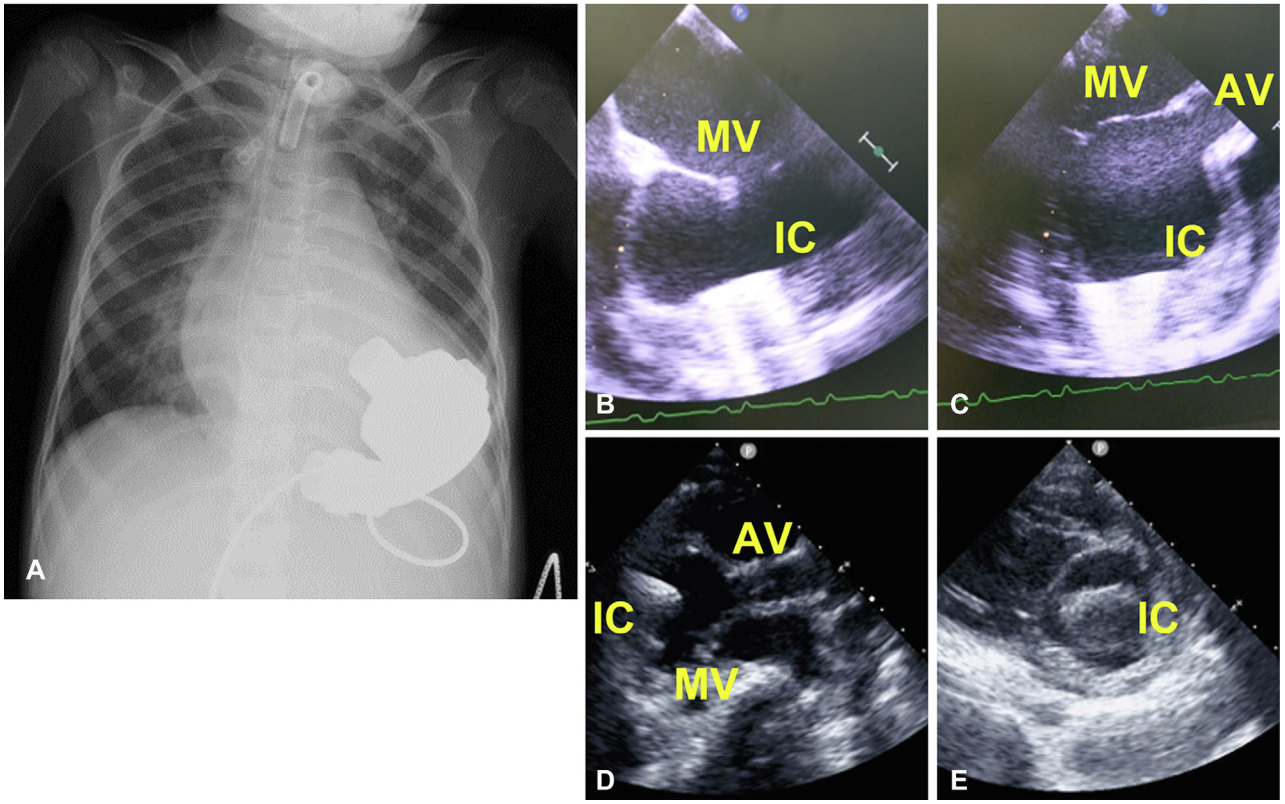


FIGURE 1. A, Postoperative radiography. B and C, Intraoperative transesophageal echocardiography showing that the inflow cannula was directed toward the mitral valve and that there was sufficient distance between the tip of the inflow cannula and the mitral apparatus. D and E, Postoperative transthoracic echocardiography showing normal mitral valve function and no interference with the left ventricular wall. *MV*, Mitral valve; *IC*, inflow cannula; *AV*, aortic valve.

pump could be placed in the limited thoracic cavity without compromising LVAD flow. Although several preoperative virtual simulations have been described,[4] none are conclusive. We focused on the LV morphology. The distance from the LV apex to the mitral valve was 7.8 cm on preoperative computed tomography (Figure 2, *A*) and a pump height was approximately 5.5 cm. We deemed that the HM3 could be implanted by pushing the LV apex without entrapping the mitral valve leaflets. Postoperative computed tomography showed that the distance from the tip of the inflow cannula to the mitral valve was 2.6 cm (Figure 2, *B*), almost matching the preoperative assessment. Intraoperatively, it was also helpful to actually push the LV apex before coring the LV apex. We believe that close

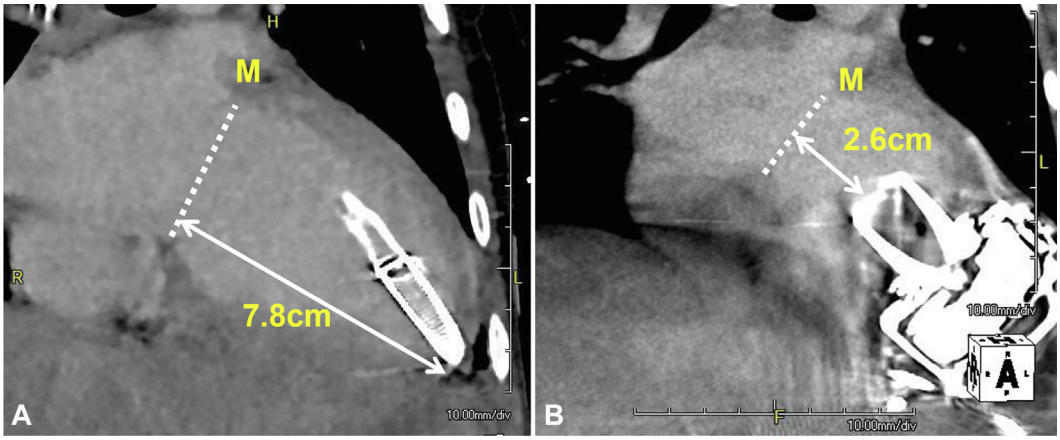


FIGURE 2. A, Preoperative computed tomography showing a distance of 7.8 cm from the left ventricular apex to the mitral valve. B, Postoperative computed tomography showing a distance of 2.6 cm from the tip of the inflow cannula to the mitral valve. *M*, Mitral annulus level.

morphologic assessment of the intracardiac structures, such as the mitral apparatus, papillary muscles, and interventricular septum, allows for appropriate "push-in" of the LV apex without mitral valve dysfunction and collision of the inflow cannula tip with the LV wall and interventricular septum. In addition, with this technique, the inflow tip could be positioned in a wide space at the LV base. Postoperative computed tomography confirmed that there was sufficient apace around the inflow tip (Figure 2, *B*). In other words, by pushing the LV apex, the rugby ball-like LV morphology can be transformed into a spherical shape, possibly allowing sufficient space around the inflow tip, leading to stable pump performance. This tip location may result in less occurrence of suction events, positively affecting less thrombogenicity and stable blood drainage into the pump. If mitral valve function is compromised, mitral valve replacement with a low-profile prosthesis should be considered.[5]

The second concern was the potential for frequent alarms despite pump setting optimization. In this patient, the actual flow level of the extracorporeal LVAD was >3.0 L/min, which contributed to simulating the postimplant flow level. The third concern was the development of late right heart failure and aortic insufficiency. We intend to continue to follow this patient.

This report highlights significant technical considerations impacting the successful implantation of the HM3 in a small child. In a reported multicenter study, the smallest patient weighed 17.7 kg and had a BSA of 0.73 m^2.[3] Our patient weighed 15.9 kg and had a BSA of 0.72 m^2. Although pediatric HM3 implantation is still challenging, sufficient preoperative and intraoperative assessments allow for greater implantability in the population with the smallest body size. Our implantation technique can contribute to expanding use of the HM3 in small children.

Conflict of Interest Statement

The authors reported no conflicts of interest.

The *Journal* policy requires editors and reviewers to disclose conflicts of interest and to decline handling or reviewing manuscripts for which they may have a conflict of interest. The editors and reviewers of this article have no conflicts of interest.

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