Case Report

Left Ventricular Assist Device Implantation via Dual Left Thoracotomy in an Adult Patient with Congenitally Corrected Transposition of the Great Arteries

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A 59-year-old man presented for possible durable ventricular assist device (VAD) implantation. He had previously been diagnosed with congenitally corrected transposition of the great arteries, a ventricular septal defect, an atrial septal defect, pulmonary valve stenosis, and aortic valve regurgitation. In the previous 22 years, he had undergone palliative cardiac surgery 3 times. VAD implantation as a bridge to transplantation was planned. Owing to severe adhesions, mesocardia, a left ascending aorta, and moderate aortic regurgitation, we performed VAD implantation and aortic valve closure via a dual left thoracotomy and partial sternotomy.

Keywords: Congenitally corrected transposition of the great arteries, Left ventricular assist device, Heart failure

Case report

A 59-year-old man presented for possible durable ventricular assist device (VAD) implantation. At 37 years of age, he was diagnosed with congenitally corrected transposition of the great arteries (CCTGA) with a ventricular septal defect (VSD), an atrial septal defect (ASD), pulmonary valve stenosis, and aortic valve regurgitation (AR). In his first cardiac surgery at another hospital, he underwent morphologic left ventricle (mLV)-to-pulmonary artery (PA) conduit placement, ASD/VSD closure, and postoperative bleeding control. At 46 years of age, he underwent a second heart surgery at our institution consisting of mLV-to-PA conduit change, tricuspid valve replacement with a mechanical valve, residual VSD closure, aortic valve repair, left PA angioplasty, and postoperative bleeding control. At 55 years of age, he underwent heart surgery a third time (mLV-to-PA conduit change with mechanical valved conduit). After the third operation, he took heart failure medications for systemic ventricle (morphologic right ventricle [mRV]) failure. He was admitted to the hospital 3 times within the 6 months prior to the VAD consultation. Heart failure led to renal insufficiency (estimated glomerular filtration rate: 34.0 mL/min/1.73 m^2) and liver cirrhosis (Child-Pugh class B). During his most recent admission, he developed cardiogenic shock and was admitted to the intensive care unit multiple times. Echocardiography revealed severe mRV dysfunction (ejection fraction, 20%) and moderate aortic regurgitation. We referred him for cardiac transplantation; however, his condition deteriorated rapidly. Owing to the aortic valve regurgitation and previous cardiac pathologies, venoarterial extracorporeal membrane oxygenation was not possible. As he had type O blood, his wait time for transplantation was expected to be relatively long. Thus, we planned to implant a HeartWare VAD (HVAD; HeartWare International Inc., Framingham, MA, USA) as a bridge to transplantation.

We decided to perform a dual left thoracotomy instead of the standard sternotomy. Through a left anterolateral thoracotomy via the fifth intercostal space using a 15-cm incision, the apex of the mRV was confirmed and the surrounding tissue was dissected to allow for implantation. Owing to the left aortic arch, an anterolateral thoracotomy via the second intercostal space (10-cm incision) was per-

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formed for aortic valve closure. An unplanned partial sternotomy was performed to improve visualization of the anterior and medial sides of the ascending aorta because the sternum and aorta were tightly adhered. Despite the upper sternotomy, the mLV-to-PA conduit and ascending aorta could not be completely divided because of severe adhesions. Thus, the right femoral artery and vein were cannulated for cardiopulmonary bypass. Aortic cross-clamping was performed through a thoracotomy, and an aortotomy was created. The cross-clamping was insufficient and blood leakage occurred. A 12F urinary balloon catheter was inserted in the gap to block the blood leakage from the medial side of the aortic cross-clamp. A single dose of cold-blood cardioplegia was delivered via a direct cardioplegic infusion catheter. The aortic valve was closed using a modified Park stitch and commissuroplasty [1]. After the aortic

cross-clamping was released, we sought a suitable site for the inflow cannula by manual palpation and insertion of a 16F Foley catheter under transesophageal echocardiography guidance. The inflow cannula axis in this patient was from the anterior to the posterior and from left to right on the horizontal plane (Fig. 1A, B). The sewing ring was placed using multiple pledged horizontal mattress sutures. After adequate length of the outflow graft was ensured, it was trimmed for aortic anastomosis. The outflow graft was installed on the left lateral side of the ascending aorta using partial aortic clamping (Fig. 2A, B). The driveline was placed using the single tunnel technique. Cardiopulmonary bypass was smoothly transitioned to the HVAD. The HVAD speed was set at 2,400 rpm, flow at 3.4 L/min, and power at 2.7 W. Intraoperative transesophageal echocardiography confirmed good inflow position. The incisions
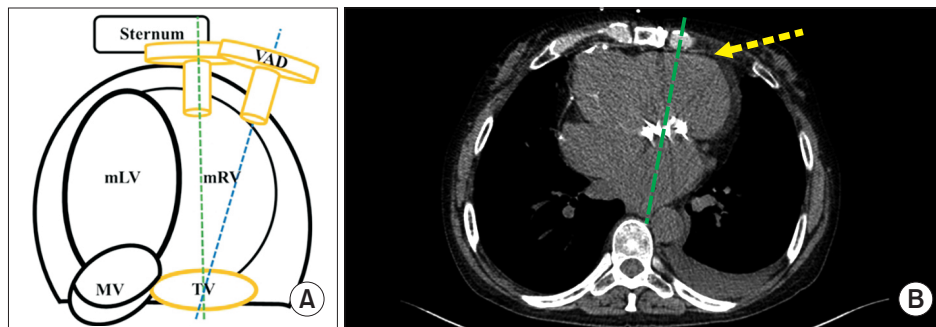
Fig. 1. (A) Diagram of the patient's heart. The green dotted line is the conventional implantation axis; insufficient space for the device was expected. The blue dotted line is the alternative axis applied in this case. (B) The green dotted line shows the conventional implantation axis. A chest computed tomography scan shows the longitudinal axis of the heart lying in the mid-sagittal plane (i.e., mesocardia). The TV was replaced with a mechanical valve in this patient. If the VAD had been inserted along the green dotted line, the space would have been expected to be very narrow (yellow dashed arrow). VAD, ventricular assist device; mLV, morphologic left ventricle; mRV, morphologic right ventricle; MV, mitral valve; TV, tricuspid valve.
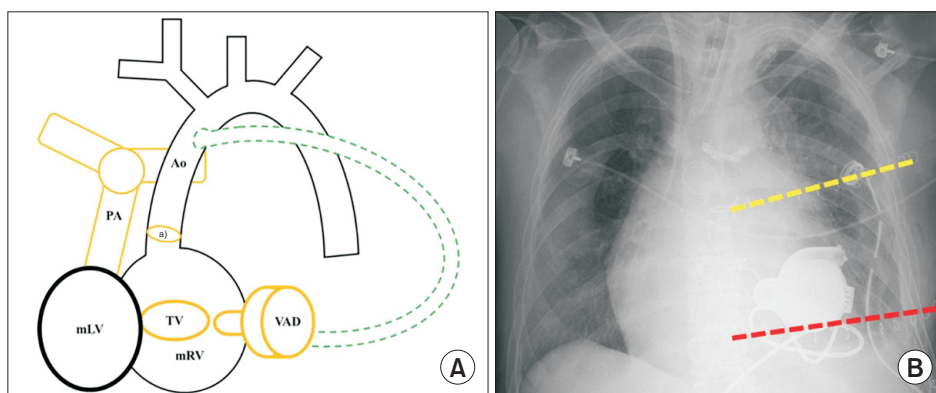
Fig. 2. (A) Diagram of the patient's postoperative status. The green dotted line is the outflow tract, which was inserted on the left side of the ascending aorta. (B) Chest radiograph taken immediately after surgery. Thoracotomy incisions for aortic valve repair and outflow anastomosis (yellow dashed line) and inflow of the pump insertion (red dashed line) are shown. VAD, ventricular assist device; mLV, morphologic left ventricle; mRV, morphologic right ventricle; TV, tricuspid valve; mLV-to-PA conduit, morphologic left ventricle-to-pulmonary artery conduit. a)Repaired aortic valve.

were closed as usual.

The patient was transferred to the intensive care unit, and extubation proceeded at 24 hours postoperatively. Due to a postoperative acute kidney injury, continuous renal replacement therapy was performed for oliguria on the second postoperative day and converted to hemodialysis on the sixth postoperative day. He was then transferred to the general ward on the seventh postoperative day. Pre-discharge echocardiography confirmed that the inflow cannula was well positioned without any obstructions. Minimal aortic regurgitation through the repaired aortic valve was observed. On the 28th postoperative day, a wound infection developed at the femoral cannulation site, but it was successfully managed with wound revision and antibiotics. He was discharged home on the 48th day after VAD implantation. The HVAD speed was set at 2,500 rpm, flow at 5.2 L/min, and power at 3.6 W. The total postoperative hospital stay was 48 days. Postoperative echocardiography confirmed that the aortic valve closed during every cardiac cycle, and no aortic regurgitation was observed. Unfortunately, the patient developed a traumatic subdural hemorrhage after falling in his bathroom and he lost consciousness during transportation to the hospital. A craniotomy with subdural hematoma removal was performed, but he did not regain consciousness. The family opted to turn off the VAD because the patient had stated in the ambulance that he would not want any further management. He died 81 days after VAD implantation, immediately after the VAD was turned off.

The study was approved by the Institutional Review Board of Samsung Medical Center (IRB approval no., 2020-09-058). The patient provided written informed consent for the publication of clinical details and images.

Discussion

CCTGA, a rare disorder accounting for only approximately 0.5% of all congenital heart diseases, is characterized by atrioventricular and ventriculoarterial discordance [2]. Graham et al. [3] showed that congestive heart failure and systemic ventricular dysfunction were common in patients with CCTGA. Among patients in their mid-40s, 67% with associated cardiac defects and 25% without associated cardiac defects had congestive heart failure [3]. For CCTGA, corrective surgery may be considered in young patients before the systemic ventricle function becomes impaired, but heart transplantation is the only remaining option thereafter, although it is limited by a shortage of donor hearts. Furthermore, heart failure symptoms must be controlled once they occur. Therefore, VAD implantation is playing an increasingly important role as a bridge to transplantation for congenital heart diseases.

Unlike conventional VAD implantation procedures, the following problems were found in our patient. First, serious cardiac injury during re-sternotomy was expected, as he had already undergone 3 sternotomies. The pulmonary valved conduit was too close to the sternum, meaning that it could be severely damaged during sternotomy (Fig. 3A). Second, moderate AR occurred, which required repair or closure during surgery. As the ascending aorta and main PA were tightly fused, as seen on a computed tomography (CT) scan, aortic cross-clamping would be difficult (Fig. 3B). Finally, the VAD implantation axis was difficult to achieve due to mesocardia. If the VAD is inserted parallel to the septum, it is likely to be installed just below the sternum, with insufficient space (Fig. 1A, B). After much consideration, we decided to use an HVAD, which can be inserted via thoracotomy. An HVAD can be small enough to enable insertion in the pericardium. Due to this characteristic, safe and effective alternatives such as lateral thoracotomy have been developed to replace median sternotomy [4]. Ozbaran et al. [5] inserted HVADs via lateral thoracotomy in patients who had previously undergone median sternotomy with a high risk of postoperative complications due to adhesions and found no significant difference from the
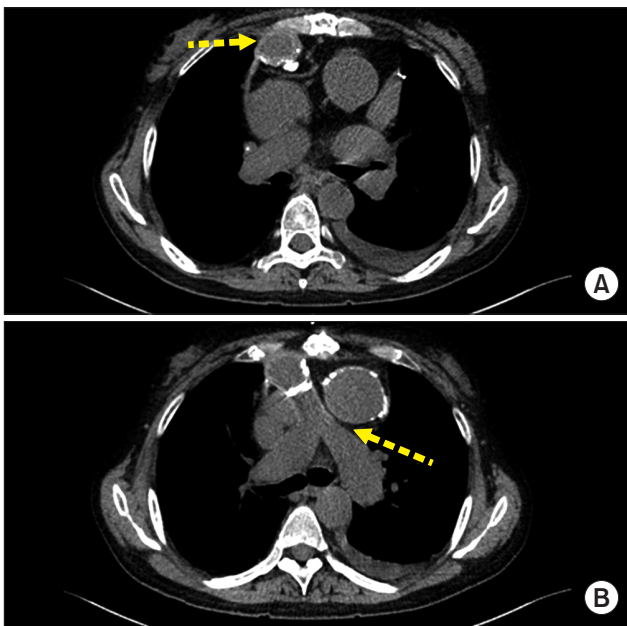
Fig. 3. (A) Chest CT scan showing that the conduit and sternum were closely attached (yellow dashed arrow). (B) Chest CT scan showing insufficient space for aortic cross-clamping (yellow dashed arrow). CT, computed tomography.

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standard median sternotomy results. The insertion position of the inflow cannula was determined under intraoperative transesophageal echocardiography guidance, which enabled real-time viewing. For the present patient, a left lateral thoracotomy was planned due to severe adhesions to the sternum in the mLV-to-PA conduit as described earlier. However, virtual reality technology may facilitate preoperative surgical planning in such complex cases [6].

Riggs et al. [7] confirmed 19 cases of VAD implantation in patients with heart failure due to CCTGA between 2002 and 2018, half of which were reported within the last 5 years. In all cited cases, a conventional median sternotomy was used [7]. To our knowledge, this is the first reported case of using thoracotomy as an approach for VAD implantation in a patient with CCTGA and end-stage heart failure. The detailed anatomy of patients with CCTGA may vary. However, among patients with an anatomy similar to that of the present patient, a dual left thoracotomy with or without upper sternotomy would be beneficial. Our approach may avoid possible catastrophic injury of the valved conduit, aorta, and mLV. Our case demonstrates that aortic valve closure is also possible using this approach.

In summary, VAD implantation as a bridge to transplantation is a viable option for patients with CCTGA. The issues posed by multiple previous cardiac operations, mesocardia, and aortic regurgitation were overcome by HVAD implantation via a dual left anterolateral thoracotomy. Preoperative CT and intraoperative transesophageal echocardiography findings are important factors in the formulation of a good surgical plan.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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