Anesthetic management in heart transplantation for a patient with a pre-existing left ventricular assist device: A case report

Dinh Thi Thu Trang*, Nguyen Minh Ly, Tong Xuan Hung, Tran Duc Hung, An Hai Toan, Nguyen Van Kien, Nguyen Quoc Khanh, Ngo Van Dinh, Doan Ngoc Thieu, and Dang Hoang Hai

108 Military Central Hopstal

Summary

Background: Heart transplantation in patients with a pre-existing left ventricular assist device (LVAD) poses significant anesthetic and surgical challenges, especially in centers with limited prior experience. We report the first successful case in Vietnam of anesthetic management for heart transplantation in a patient supported by a LVAD. *Case Presentation:* A 39-year-old woman with end-stage dilated cardiomyopathy had undergone HeartMate LVAD implantation in 2019. She was admitted multiple times for LVAD-related infections and subsequently listed for heart transplantation. *Intervention & Outcome:* Anesthesia included fentanyl, ketamine, low-dose propofol, and rocuronium, with advanced monitoring with FloTrac and trans-esophageal echocardiograph (TEE). Prophylactic femoral cannulation was performed prior to sternotomy to mitigate serious complications. Surgery lasted 420 minutes with 321 minutes of cardiopulmonary bypass. Transfusion requirements: 2000 mL of red blood cells, 1500mL of plasma, 400mL of cryoprecipitate, and 3 units of platelets. Inotropes and inhaled nitric oxide were used to support right ventricular function. Postoperatively, the cardiac index improved from 1.4 to 2.8L/min/m^2, ejection fraction was 51%, and the patient was extubated on postoperative day one without anesthetic complications.

Keywords: Heart transplantation; LVAD; Anesthesia; Case report; Hemodynamic monitoring.

I. BACKGROUND

Heart transplantation represents the ultimate therapeutic option for patients with end-stage heart failure. However, this is a highly complex surgical procedure that requires multidisciplinary coordination throughout all stages, including preoperative care, surgical intervention, anesthesia, and postoperative intensive care. By 2013, global statistics reported a 1-year survival rate after heart transplantation of 90% and a 5-year survival rate of 70%[1]. To date, a substantial number of patients remain on the waiting list for heart transplantation. The shortage of donor organs remains a pressing issue in many countries, particularly in Asia. Recently, the advent of Mechanical circulatory support has provided a bridge-to-transplant strategy, allowing patients with advanced heart failure additional time while waiting for a suitable donor organ.

In Vietnam, heart transplantation remains a challenging procedure and has only been performed in a few central hospitals, with a relatively limited number of cases. Notably, the technique of ventricular assist device implantation has only been attempted in a small number of

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Correspondence to: *Dttrang108@gmail.com*
108 Military Central Hopstal

patients. The introduction of mechanical circulatory support (MCS) has also changed the clinical characteristics of transplant candidates[1]. Anesthesia and intensive care management in heart transplantation for patients with a pre-existing ventricular assist device present unique challenges. We report the anesthetic and perioperative management of the first heart transplantation performed in Vietnam in a patient with a previously implanted left ventricular assist device.

Contributors**:** All Authors were involved in the conception and production of the initial manuscript as well as secondary drafts and production of figures

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II. PRESENTATION

2.1. Preoperative status

The patient was a 39-year-old female, Vi Thi T., weight: 51 kg, height: 1.60 m. She had been diagnosed with dilated cardiomyopathy for many years, which progressed to end-stage heart failure, and underwent implantation of a left ventricular assist device (LVAD) at Vinmec Times City International Hospital in 2019. Following LVAD implantation, she was maintained on anticoagulation therapy with a vitamin K antagonist. Since 2023, she required multiple hospital admissions due to LVAD-related infections, which were stabilized with medical management. The patient was listed for heart transplantation.

Clinical examination

General condition: Average, BMI 19.9.

Heart rate: 70-80 beats/min; Blood pressure: 90/60 - 110/70mmHg

LVAD-supported circulation: Flow: 4.4L/min; Pump speed: 4500 RPM; power: 5.0 W; pulsatility index (PI): 2.5.

Lungs: Clear bilateral breath sounds, no rales, SpO_2 100%

Other systems: Normal.

Laboratory and imaging investigations

Preoperative echocardiography:

EF(%)	Dd(ml)	Ds(ml)	EDV(ml)	ESV(ml)	PAP(mmHg)
16	66	61	251	188	27

Other tests:

Coagulation: PT 64%; APTT 33.7 sec; INR 1.32; Fibrinogen 2.6 g/L.

CBC: RBC 5.4 $\times$ 10^6/µL; Hematocrit 42.4%; Platelets 214 $\times 10^3$/µL.

Liver, renal function, and electrolytes: Normal.

2.2. Results of Anesthesia

In the operating room, the patient was prepared according to the standard protocol for heart transplantation anesthesia. She received oxygen at 2 L/min, and monitoring included heart rate, blood pressure, SpO_2, BIS, TOF-Guard, and rSO_2. Pre-medication was administered, followed by local anesthesia for insertion of a left radial arterial line for continuous blood pressure monitoring which was connected to the FloTrac system to measure CI, SVV, and SVR. An 8.5 F central venous catheter was inserted into the right internal jugular vein.

Upon confirmation of donor organ availability, general anesthesia was induced, followed by endotracheal intubation and controlled ventilation. Agents included fentanyl, ketamine, and low-dose propofol. Depth of anesthesia was guided by BIS, while neuromuscular blockade was titrated according to TOF monitoring. Anesthesia was maintained with TCI propofol, analgesics, and muscle relaxants, adjusted based on BIS, TOF, and rSO_2. A trans-esophageal echocardiography (TEE) probe was placed for intraoperative cardiac monitoring.

Due to prior LVAD implantation, the anesthesiology and surgical teams elected to insert

a femoral cannula prior to chest opening. After initiation of cardiopulmonary bypass (CPB), the surgical team proceeded with removal of the native heart, implantation of the donor heart, and completion of atrial and vascular anastomoses. During this stage, hemodynamic and respiratory parameters were fully supported by CPB, with advanced monitoring: blood pressure, SpO_2, rSO_2, BIS, fluid balance, electrolytes, and acid–base status.

Following aortic cross-clamp release, the donor heart resumed effective contractile activity under support with moderate doses of inotropic and vasopressor agents. Inhaled nitric oxide (NO) was administered immediately after reperfusion of the graft to reduce right ventricular afterload and mitigate the risk of right ventricular failure, a frequent complication in post-transplant patients. Graft function was assessed by TEE. Once adequate conditions were confirmed, CPB was discontinued, and electrolyte, acid–base, and coagulation balance were restored before transfer to the ICU for continued management.

The patient was successfully extubated on postoperative day one.

Table 1. Anesthesia and surgery time

Duration	Time of surgery	Time of anesthesia	Time of aortic clamp	Time of CPB	CPB support duration	Ischemic time
Time (minutes)	420	560	147	321	55	50

Table 2. Patient hemodynamic parameters

Time / Value	T1	T2	T3	T4	T5	T6
MAP (mmHg)	62	58	64	68	72	64
CVP (mmHg)	8	9	7	8	10	9
Heart Rate (beats/min)	77	82	88	101	110	100
CI(l/min/m^2)	1.4		2.1	2.8	2.5	2.8
SVV(%)			12	14	9	
SVR (dynes x sec/cm^3)			980	1065	1268	
PAP (mmHg)	30	28	31	35	32	35

Chart 1. Peripheral capillary Oxygen Saturation

Table 3. Arterial blood gases

Time / Value	To	T1	T2	T3	T4	T5	T6
pH	7.38	7.4	7.32	7.25	7.23	7.32	7.46
$PaCO_2$	39	31.4	34	36.2	36	37	35
PaO_2	94	140.6	163.5	177	85	88	115
HCO_3	23.7	24	18.2	16.2	15.1	22.3	24.9
BEecf	2.4	-1.2	-8.5	-11.4	-12.7	-5.4	-2.7
Lactate	0.9	1.0	2.13	2.4	8.4	7.8	8.4
Hct	42	40	31	25	24	26	32

Table 4. Drugs during surgery

Drugs / Dose	Propofol	Fentanyl	Esmeron	Tranexamic acid	Solu-Medrol	Ketamine
Total dose (mg)	3200	1.4	250	4500	500	20

Table 5. inotrope and vasotropic administration

Drugs / Dose	Adrenalin (mg)	Noradrenalin (mg)	Dobutamin (mg)	NO (L)
Total dose	4	8	250	10

Table 6. ROTEM test results

Value	EXTEM		APTEM		INTEM		FIBTEM		HEPTEM	
	T4	T5	T4	T5	T4	T5	T4	T5	T4	T5
A5	20	43	18	28	18	42	7	14	30	40
CT	54	49	70	75	190	276	53	59	218	268
A10	57	54	12	12	61	53	14	16	55	52

Table 7. Blood and fluid transfused during surgery

V(ml)	Crystalloid	Red blood	Plasma	Platelets	Cryo
Volume (ml)	1000	2000	1500	300	400

Table 8. Echocardiogram results

Value	EF(%)	Dd(mm)	Ds(mm)	Vd(ml)	Vs(ml)	TAPSE	IVT	PAP (mmhg)
Pre-operation	16	66	61	251	188	17	12.5	27
Postoperative day 1	51	37	26	57	24	19	14.7	35

Table 9. Measurement of cardiac biomarkers

Value		CK-MB(U/l)	Troponin Ths (ng/ml)	NT-proBNP (ng/ml)
Pre-operation		4.6	21.2	
Postoperative day 1		111		
	Pre-operation	4.6	21.2	1334
	Postoperative day 1	111	1910.0	466.1

T0 : Pre-operation	T4 : After CPB stop
T1 : After induction 15 minutes	T5 : Before to ICU
T2 : Before CPB	T6 : Postoperative day 1
T3 : After aortic clamp release 15 minutes	

III. DISCUSSION

This was a particularly unique clinical case, both in terms of surgery and anesthetic management. The patient had undergone implantation of a left ventricular assist device (LVAD) for five years prior to transplantation at Vinmec International General Hospital. This was also the first LVAD implantation performed in Vietnam. The LVAD had been in place for five years, and preoperative echocardiography (Table 8) demonstrated an EF of 16%, left ventricular end-diastolic diameter (Dd) of 66 mm, end-systolic diameter (Ds) of 61 mm, and pulmonary artery pressure of 27 mmHg. The patient was indicated for heart transplantation once a suitable donor became available.

Induction of anesthesia is one of the most critical phases in heart transplantation. Because these patients invariably present with severe end-stage heart failure, induction carries a high risk of profound hemodynamic instability and even cardiac arrest[2]. In this case, invasive arterial pressure monitoring, central venous access, and comprehensive intraoperative monitoring were established before induction. Induction was relatively favorable, as the presence of the LVAD provided circulatory support, thereby reducing the risk of circulatory collapse compared to other transplant cases. Anesthetic agents with minimal cardiovascular depression were chosen, including: Fentanyl 3mcg/kg, Ketamine 0.5 mg/kg, Propofol 1mg/kg, rocuronium 1mg/kg. Depth of anesthesia was guided by BIS, and neuromuscular blockade was monitored using TOF. In Table 2, blood pressure and heart rate remained stable throughout the induction.

The phase from induction to initiation of cardiopulmonary bypass (CPB) is particularly demanding, as the native heart and circulatory system are subject to significant surgical stress. The goals of anesthetic management in this period include balancing myocardial oxygen supply and demand, monitoring for myocardial ischemia, optimizing preload and afterload, maintaining contractility and ejection fraction in the failing heart, and ensuring stable rhythm and conduction to avoid arrhythmias. Advanced hemodynamic monitoring is indispensable in this setting, with intraoperative transesophageal echocardiography (TEE) considered the "gold standard" for assessment of cardiac function, right ventricular performance, and intravascular volume status. Both Edwards[3] and ISHLT guidelines[4,5] strongly recommend its routine use.

In this patient, TEE combined with the FloTrac system was used to monitor hemodynamic parameters including CI, SVV, and SVR. This minimally invasive monitoring system enabled timely detection and correction of hemodynamic disturbances. Additional vasoactive and inotropic agents such as dobutamine, adrenaline, and

norepinephrine (Table 5) were used to maintain arterial pressure within target ranges. Anesthesia was maintained under BIS-guided depth and TOF-monitored neuromuscular blockade (Table 4).

The first difficulty in this patient was severe adhesions due to prior sternotomy for LVAD implantation five years earlier, compounded by the risk of infection. Several authors have emphasized that such cases require a specific anesthetic plan, advanced hemodynamic monitoring, and close multidisciplinary coordination[3-5]. In our case, these challenges were particularly evident during re-sternotomy and the transition from LVAD support to cardiopulmonary bypass (CPB).

During surgery, the heart was adherent to the posterior sternum, creating a high risk of cardiac chamber perforation and massive bleeding during sternotomy. Therefore, the surgical and anesthetic teams elected to preemptively place femoral cannulation prior to re-entry, to mitigate potential catastrophic hemodynamic compromise during adhesiolysis. Re-sternotomy significantly increases intraoperative risk, and several studies have shown its association with primary graft dysfunction (PGD) and higher early mortality after heart transplantation[6-10]. In a study comparing heart transplant outcomes in 72 patients who had LVADs showed that: surgery time, cardiopulmonary bypass time, blood transfusion requirement, time to extubation, intensive care unit length of stay were longer in LVAD group, however there was no difference in short- or long-term survival[9].

The second major challenge was the establishment of CPB and the gradual transition from LVAD support to full CPB. At the moment of discontinuing LVAD and initiating CPB, poor synchronization can easily lead to hemodynamic collapse, as the patient's circulation was entirely LVAD-dependent. During this transition, circulation is supported by two pumps-LVAD and CPB-making the patient vulnerable to hemodynamic instability and hemolysis if the flow is not smoothly shifted from LVAD to CPB. As this was our first experience with transplantation in a patient supported by LVAD, our anesthetic team worked closely with the surgical and perfusion teams to gradually taper LVAD flow while increasing CPB support. Initial LVAD settings were as follows: flow rate 4.4 L/min, pump speed 4500 RPM, and power consumption 5.0 Watts; PI:2.5 Cardiopulmonary bypass (CPB) was initiated gradually, with a progressive increase in CPB flow while the LVAD output was concomitantly reduced. The CPB flow was incrementally raised until reaching the target cardiac index (CI: 2.2 - 2.4 L/min/m^2), at which point the LVAD was completely turned off. At this stage, the patient's circulation was fully supported by CPB. Hemodynamics remained stable throughout (Table 2). Arterial blood gases prior to CPB were within normal ranges, with lactate < 2.5mmol/L (Table 3), confirming adequate cardiac output and tissue oxygen delivery.

After completion of anastomoses, aortic cross-clamp was released, and ventricular fibrillation occurred, which was successfully cardioverted with a single 10J shock. The new heart resumed sinus rhythm at 50 bpm, gradually increasing to 95-110 bpm. Vasoactive support included norepinephrine at 0.2mcg/kg/min and adrenaline at 0.1mcg/kg/min. As shown in Table 2, the patient maintained stable hemodynamics; including CI, SVV, and SVR, were kept within acceptable limits. CPB duration was prolonged at 321 minutes, with aortic cross-clamp time of 147 minutes and 55 minutes of partial CPB support prior to weaning (Table 1). Prolonged CPB was associated with increased lactate after reperfusion (Table 3). TEE confirmed satisfactory graft function: EF 51%, IVT 14.7, CO 4.2 L/min, CI 2.8L/min/m^2, RV/LV ratio 0.8 (Table 8).

The global prevalence of end-stage heart failure continues to rise. Despite therapeutic advances, the disease inevitably progresses, reducing both survival and quality of life. Heart transplantation remains the only effective treatment for end-stage heart failure. Mortality in such patients reaches 44% at 6 months and 64% at 12 months, whereas 1-year survival after transplantation is approximately 90%[11]. Unfortunately, the number of patients awaiting transplantation far exceeds the supply of donor organs.

Mechanical circulatory support (MCS) devices were first used at the Texas Heart Institute in 1968, 1978, and 1981; however, all patients died of infection before donor hearts became available. The first successful bridge to transplantation was achieved by Oyer in 1985 using the Novacor LVAD (Baxter Healthcare, Oakland, CA). In 2019, there were 3,198 LVAD implantations in the United States, half as destination therapy and one-quarter as a bridge to transplantation. Anubodh S. recommended earlier LVAD implantation in patients with advanced heart failure[12].

Although LVAD implantation and maintenance are costly, they remain less expensive than sustaining a patient on the transplant waiting list for 75 days. One-year survival following LVAD is approximately 70%. Patients bridged to transplantation with LVAD face specific complications that affect postoperative survival13. Most data suggest no significant decrement in survival among recipients bridged to transplant with durable LVAD compared to recipients medically managed before transplant. However, LVAD complications convey higher risk, particularly those with device-related infection showing significantly higher mortality risk post-transplant4. In our case, despite multiple prior LVAD infections, no early post-transplant infection was observed, underscoring the importance of meticulous infection control. In Vietnam, LVAD bridging to transplantation is still nascent, requiring multidisciplinary expertise and remains limited by high cost.

For patients undergoing cardiac surgery with CPB, coagulopathy risk is substantial. In our case, coagulation was managed with ROTEM guidance. Due to prolonged surgery, severe adhesions, and extended CPB time (321 minutes, Table 1), blood loss was considerable. ROTEM revealed deficiencies requiring supplementation of coagulation factors (Table 6). The patient received 2,000 ml packed red blood cells, 1,500 ml plasma, 700 ml salvaged blood, 2 platelet units, and 4 cryoprecipitate units (Table 7). ROTEM after replacement confirmed stable coagulation (Table 6). Despite the extended procedure, no coagulopathy occurred, and postoperative drainage remained <100 ml/h. In a study of 44 patients, Matsumoto reported significantly higher blood loss in VAD patients compared to non-VAD during the first 48 hours after transplantation (6.7 ± 3.5 L vs. 1.8 ± 0.75 L, p=0.004)[1]4.

Right heart failure remains a frequent complication after transplantation and significantly contributes to mortality. It is commonly associated with secondary graft dysfunction, surgical complications, and pulmonary hypertension[2],[1]4. Aska, in a study of 175 VAD patients, reported 67 deaths (38%), with infection and right heart failure as leading causes[2]. Several studies have shown that immediate postoperative inhaled nitric oxide (NO) reduces the incidence of right heart failure[2],[1]4. Inhaled NO selectively dilates pulmonary vasculature and effectively decreases right ventricular afterload. In Aska's study, 21% of post-VAD patients received inhaled NO[2]. In our patient, NO was administered at 20 ppm after reperfusion. Pulmonary artery pressure slightly increased post-CPB and on postoperative day one (35mmHg) (Table 2).

The patient underwent safe anesthesia and perioperative management. Postoperatively, she was transferred to the ICU for continued mechanical ventilation and intensive care. She was extubated on postoperative day one, with only mild transient elevations in cardiac enzymes (Table 9). No anesthesia-related complications were observed.

IV. CONCLUSION

Heart transplantation is a major procedure that requires meticulous preparation across infrastructure, equipment, personnel, and multidisciplinary collaboration, encompassing preoperative, intraoperative, and postoperative care. Mechanical circulatory support provides a bridge to transplantation, prolonging survival for end-stage heart failure patients. However, this remains a novel field in Vietnam, requiring further clinical experience to develop appropriate protocols, enhance professional expertise, and establish transplantation as a feasible and effective

treatment option for advanced heart disease. Prolonged surgery, risk of massive blood loss, coagulopathy, and the need for precise coordination during the synchronization of the LVAD with CPB are major considerations that require particular attention in this patient.

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