JARVIK 2000 Implantation in Adolescent Heart: A Transesophageal Echo Experience

Abstract

Left ventricular assist devices (LVAD) have gained widespread use as an effective clinical therapy for patients with heart failure (INTERMACS 1-5) and are the standard of care for bridging patients to cardiac transplantation. Pre-implantation transesophageal echocardiography (TEE) allows interrogation of all cardiac structures and identifies potential problems such as intracardiac shunts, thrombi, aortic insufficiency, and right ventricular dysfunction that need palliation. Post-implantation exam helps in weaning from cardiopulmonary bypass (CPB) and successful LVAD initiation. ICU monitoring with TEE guides optimal intervention and should be considered in selected patients. TEE will continue to remain vital to successful outcomes in LVAD patients.

Keywords: *Cardiopulmonary bypass, hemodynamic transesophageal echo ImaCor., interagency registry for mechanically assisted circulatory support,left ventricular assist device, transesophageal echocardiography*

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Introduction

Heart transplantation has become the standard of care for children with end-stage heart disease secondary to cardiomyopathy or congenital heart disease. A national shortage of organ donors limits the availability of pediatric heart transplants and results in longer waiting times and unacceptably high waiting list mortality.[1] Expanded use of pediatric ventricular assist devices (VADs) has decreased mortality in children awaiting heart transplantation.[2] In older children and adolescents, median age at implantation (15 years) VADs are commonly utilized with excellent survival rates and serious adverse event rates were low.[3] Jarvik 2000 as a bridge to transplantation has overall survival proportions at 1 and 2 years of 85% and 79.3%, respectively.[4]

With the increasing use of left ventricular assist devices (LVAD), state of the art echocardiography has become vital in assessing device performance and overall cardiovascular hemodynamic variables. Here, we summarize our echo findings in a patient enrolled in Bridge to Transplantation protocol at our institution.

Case Report

A 13-year-old female patient (height 153 cm, weight 37 kg, body surface area 1.21 m^2) with a history of dilated cardiomyopathy who was on home Milrinone presented with increasing shortness of breath. Her worsening heart failure led to a planned LVAD (Jarvik 2000) implantation as a bridge to transplantation. Preoperative evaluation showed her hematological and biochemical values were within normal limits. Cardiac magnetic resonance imaging confirmed dilation of all cardiac chambers with left ventricle end diastolic volume 181 ml, end systolic volume 136 ml, stroke volume 45.2 ml, and ejection fraction 25%. Cardiac catheterization reports revealed: Cardiac output 2.5 l/min, systemic vascular resistance 2045 dynes s/cm^5, pulmonary vascular resistance 384 dynes s/cm^5, transpulmonary gradient 12 mmHg, and pulmonary artery pulsatility index 2.63.

Conventional monitors and a radial arterial catheter for blood pressure monitoring were applied while the patient was awake. Anesthetic induction was performed with fentanyl (5 mcg/kg), etomidate (0.2 mg/kg), and vecuronium (0.1 mg/kg). Isoflurane (0.4% to 1%) was used for maintenance supplemented by midazolam (5 to 10 mg) and fentanyl (5 mcg/kg). Other monitors

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were inserted after anesthetic induction including a pulmonary arterial catheter and a TEE probe.

A TEE assessment was performed before initiation of CPB. Left and right ventricular function was evaluated, and the cardiac chambers were examined for thrombus, particularly at the apex of the left ventricle, which is the insertion site for the Jarvik 2000. Aortic valve function was assessed because the presence of moderate to severe insufficiency results in regurgitation of blood into the left ventricle when the device is activated. The atrial septum was inspected for a patent foramen ovale, which can lead to decreased systemic oxygenation as a result of right to left shunting with the lower left-sided pressure resulting from LVAD activation. The aorta was assessed for calcification, plaque, or dilatation.

After an uneventful operative placement of Jarvik 2000, the device was deaired and cardiopulmonary bypass was weaned. During weaning, TEE was used to verify that the pump was correctly centered at the apex of the left ventricle, with the inlet positioned in axial alignment with the mitral valve opening. This is best accomplished in the midesophageal four chamber and two chamber TEE views. When the LVAD support was slowly increased from 8000 to 10000 rotations per minute, patient developed hypotension with reduced LVAD flows, Mean arterial pressure in the 30s and an elevated central venous pressure. TEE midesophageal 4 chamber view demonstrated severe suck down of the left ventricle as shown in Figure 1. After volume loading and bolus injection of phenylephrine, the size of left ventricle expanded. Inhaled nitric oxide was started at 40 parts per million and ionotropes Milrinone (0.5 mcg/kg/min), Adrenaline (0.05 mcg/kg/min) were added to augment right ventricular function. At the conclusion of the procedure, LVAD flows ranged 2–3 l/min with the mean arterial pressure in the 60s. The patient was then transported to critical care unit with open chest to avoid trivial tamponade effect in the scenario of recovering right ventricular dysfunction.

Post operatively hTEE was used in addition to conventional monitors and LVAD parameters. Midesophageal four chamber view and transgastric short axis view were used to assess volume status, guide LVAD flows, and monitor right ventricular function. Chest closure was done on postoperative day 2 and patient was extubated on postoperative day 4.

Discussion

TEE is essential in the perioperative management of patients undergoing placement of LVADs. We report the use of TEE in the diagnosis and management of hemodynamic distress during weaning off CPB and as a supplementary monitor in the ICU.

Jarvik 2000 is an axial flow, rotary blood pump system. Jarvik lacks a real inflow conduit. The impeller is implanted directly in the LV apex with outflow conduit anastomosed to either ascending or descending aorta. Based on settings impeller speed varies from 8000 to 12000 rotations per minute with maximum output up to 8.5 l/min. Jarvik 2000 is indicated for use in patients with late-stage heart failure who may be either bridge to transplant candidates or life time recipients.

Hemodynamic compromise in LVAD patients can be due to hypovolemia, inflow or outflow cannula obstruction, right ventricular dysfunction, and cardiac tamponade, all of which can be easily identified by TEE.

This report demonstrates the suction cascade seen when patients are initially weaned from CPB and on to support from axial flow LVAD. The transition must be slow with meticulous attention to left ventricular filling and LVAD speed adjustments. If the left ventricle is under filled and speed of the device is increased too quickly suck down effect occurs whereby part of the left ventricle wall is sucked over and covers the pump inflow leading to obstruction and reduced LVAD output. The ventricular septum bows into the left ventricle and right ventricle assumes an unfavorable geometry leading to right ventricular dysfunction. Septal shift also deforms the tricuspid annulus worsening the Tricuspid regurgitation as shown in Figure 2.[5,6]

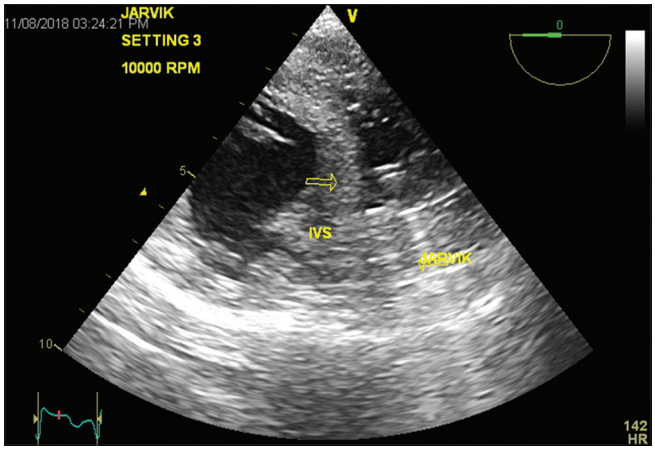

Figure 1: TEE ME 4 CH view demonstrating suck down

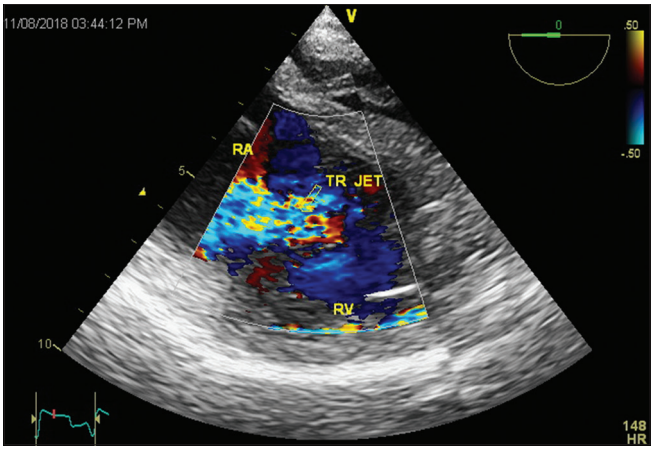

Figure 2: TEE ME 4 CH view demonstrating RV Ddysfunction and TR

M mode and 2D measurements	
Left atrium	40 mm
Aortic root	22 mm
Left ventricle end diastolic diameter	56 mm
Left ventricle end systolic diameter	50 mm
Septum (diastole)	5 mm
Left ventricle posterior wall (diastole)	5 mm
End diastolic volume	151 ml
End systolic volume	120 ml
Ejection fraction	21.00%
Right ventricle	
Fractional area change	26.00%
Tricuspid annular plane systolic excursion	13 mm
Tricuspid annulus S'	15 cm/s
Doppler	
Parameters	Velocity m/s
Aortic valve	1
Mitral valve	E/A 0.5/0.4
	E/E` 13
Pulmonary valve	0.8
Tricuspid valve	0.4

When a patient with LVAD becomes hemodynamically unstable, the natural tendency is to increase device speed in an effort to increase LVAD support. However, in suck down this will worsen the situation by causing further inflow obstruction, worsening tricuspid regurgitation and right ventricular dysfunction. The correct manoeuvre is reducing the device speed while restoring the intravascular volume. If there is evidence of right ventricular dysfunction adding ionotropes, inhaled nitric oxide, adjusting LVAD flows to avoid over pumping the right ventricle would be helpful.

The ability to assess volume status, right ventricle function (by looking at the contractility, TAPSE, tissue Doppler, tricuspid regurgitation) as well as examine the left ventricle size to guide LVAD flows make TEE incredibly useful in the post LVAD implantation period.

Current monitoring standards in the ICU after LVAD implantation is based on clinical hemodynamic variables and LVAD parameters. Use of TEE as a continuous hemodynamic monitor as an adjunct to conventional monitoring would be ideal because it can provide specific information, such as evidence of suck down events, right ventricle size and function that would affect the management approach. It is useful in sicker LVAD recipients with open chest with an impact on decision making.[7]

Conclusion

TEE will remain the imaging modality of choice for perioperative assessment, hemodynamic optimisation, and troubleshooting of complications in the rapidly growing population of LVADs.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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