Imaging Essentials before Ventricular Assist Device (VAD) Placement: What Does the Surgeon Need to Know?

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At the conclusion of this lecture, the participant should be able to:

1. Identify the essential components of an intraoperative TEE examination in a patient who presents for VAD placement.
2. Review the importance of detecting intra-cardiac shunting in patients undergoing VAD placement.
3. Discuss the clinical significance of valvular regurgitation in patients undergoing VAD placement.

Left ventricular assist devices (LVADs), have emerged as a relevant option for improving quality of life and survival in patients with end-stage heart failure. The most common indications include bridge to transplant (BTT), destination therapy (DT) and bridge to recovery (BTR). Technological advancements have led to the use of continuous flow devices which are improved compared to previous pulsatile models as far as efficiency, size, implantability, extended support, and overall patient outcomes are concerned. LVAD implantation improves exercise tolerance and end-organ dysfunction and can improve hemodynamics. Echocardiography is an important imaging modality used not only in the diagnosis of heart failure, but in the intraoperative implantation and management of LVADs. Echocardiographers must develop a systematic approach to echocardiographic assessment of LVAD implantation.

Pre-Implantation Exam

Prior to beginning the procedure, certain conditions must be addressed that would hinder proper device function. Since the pump simply pulls blood from whatever chamber where the inflow
cannula is placed, any obstruction to flow into that chamber must be prevented. In the case of an LVAD, mitral stenosis must be ruled out. Because of the vacuum-like effect, conditions that would cause the pump to pull in unwanted blood must also be addressed. Intracardiac shunts, for example, are accentuated and can cause mixing of deoxygenated blood and hypoxemia. Similarly, aortic insufficiency can cause the LVAD to pull blood from the ascending aorta, compromising forward flow. Analogous situations can occur with RVADs on the right side of the heart. In addition to conditions compromising pump flow, the pre-implantation TEE should identify any thrombus, particularly at the site of inflow cannula implantation. Similarly, atherosclerotic plaques at the site of outflow cannula placement should be avoided.

Right ventricular failure is a significant concern when an LVAD is being implanted, and may complicate management in up to 50% of cases. For this reason, the pre-implantation TEE should thoroughly evaluate RV function, as well as the severity of tricuspid regurgitation. Several scoring systems have been developed in order to predict the need for an RVAD following LVAD implantation. Among them, the “CRITT” score has been shown useful and easy for the intraoperative echocardiographer to apply. (5)

Cardiac Shunts

Assessment for cardiac shunting prior to VAD insertion is performed to evaluate the risk of significant right to left shunting and to determine the risk of paradoxical embolization. These shunts may be at two levels, atrial or ventricular. A ventricular shunt occurs if there is a ventricular septal defect and these may occur following an acute myocardial infarction. It is important to detect these prior to VAD insertion, as they would require closure at the time of VAD insertion. A more frequent cardiac shunt is at the atrial level, due to either a patent foramen ovale (PFO) or atrial septal defect (ASD). Both these defects have the risk of intracardiac shunting which may cause hypoxia or paradoxical emboli. A PFO or
ASD can be detected and assessed using transesophageal echocardiography, with direct visualization of the defect on 2D imaging. Color Doppler imaging aids in determining the direction of flow. However, an atrial shunt is a function of the pressure differential between the right and left atria and this can be a dynamic parameter. A PFO with right to left shunting may not become apparent until after LVAD insertion because the LVAD reduces left heart pressures and hence promotes right to left shunting; particularly in the setting of pulmonary hypertension, which may be common in this subset of patients.

Valvular Dysfunction

Aortic valvular dysfunction is clinically important in the setting of VAD insertion. Uncorrected aortic regurgitation has a negative impact on forward flow provided by an LVAD due to regurgitation of VAD flow back into the left ventricular cavity. It is generally recommended that moderate and greater levels of severity of aortic regurgitation should be corrected at the time of VAD insertion (13). However, questions still remain as to which intervention is most appropriate. This choice in part depends upon whether recovery is expected or not, and whether a continuous or pulsatile device is being considered. Options include over-sewing the valve, repairing the valve or replacing the valve (13, 14). Aortic stenosis is usually not of such clinical significance compared to aortic regurgitation. However in continuous flow devices, depending upon the configuration, aortic stenosis may limit forward flow and may need surgical replacement at the time of VAD insertion.

Tricuspid regurgitation is a relatively common condition in patients being assessed for mechanical support. This is typically due to right heart failure secondary to chronic elevation of the pulmonary pressures due to left heart failure. There are numerous complex factors that can influence the degree of tricuspid regurgitation post LVAD insertion. The decision to correct tricuspid regurgitation at the time of VAD insertion is a complex one. If significant tricuspid regurgitation is present and it is expected that improvement of this would result in improved RV function, then intervention on the tricuspid valve may be warranted (13).
References


