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REVIEW ARTICLE

How to select a patient for LVAD

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Abstract
Left ventricular assist device (LVAD) implantation leads to improvement in symptoms and survival in patients with advanced heart failure. An important factor in improving outcomes post-LVAD implantation is optimal preoperative patient selection and optimization. In this review, we highlight the latest on the evaluation of patients with advanced heart failure for LVAD candidacy, including discussion of patient selection, implantation timing, laboratory and other testing considerations, and the importance of psychosocial evaluation. Such thorough evaluation by multidisciplinary team can serve to improve the outcomes of a complex group of patients with advanced heart failure being evaluated for LVAD.

Keywords Advanced heart failure · Left ventricular assist device · Patient selection · Psychosocial assessment

Introduction

Left ventricular assist devices (LVADs) are commonly used to improve quality of life and survival in patients with advanced heart failure (HF). Initially developed as pulsatile devices in the 1980s, LVADs have undergone multiple generations of revisions, with the latest generation comprised of continuous flow centrifugal devices. LVADs function by unloading the left ventricle (LV) and propelling the blood into the ascending aorta. In this way, LVADs relieve the symptoms of terminal HF both by reducing central congestion and by improving peripheral perfusion. Approximately 3000 durable LVADs are implanted yearly in the United States (US) [1], a number comparable to yearly adult heart transplantations. Durable LVADs are associated with high implant [2] and long-term costs in the US [3], with overall LVAD expenditures over the first year comparable to those of heart transplant [4]. Financial concerns have limited LVAD utilization worldwide, including in the Asia Pacific region, even though costs of LVADs in the Asia Pacific region have been estimated to be lower than in the US [5]. Due to advances in LVAD technology, particularly with the introduction of the HeartMate III (Abbott Medical), survival over the first and second year after implant is comparable to that of transplant [6], although longer term outcomes among LVAD are lacking and may be less favorable compared to transplantation [7]. Patients with an LVAD also experience an improvement in quality of life and functional capacity post-implant, although their peak functional capacity remains significantly reduced [8]. Despite improvement in quality of life, HF morbidity, and mortality after LVAD implantation, LVAD therapy is complex due to high power requirements necessitating external power as well as potential complications including infections, right ventricular failure, bleeding, and stroke. While transplantation or myocardial recovery leading to explanation remains an option for certain patients who experience LVAD complications, others may require escalation of symptoms management or transition to palliative care. Optimal preoperative evaluation and patient selection therefore require shared decision-making between the treatment team, the patient, and patient's

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caregivers. In this review, we will highlight the latest in the selection of patients for LVAD placement.

Identification of patients with advanced HF

Initial screening for LVAD candidacy involves early identification of advanced HF, as patients who progress to irreversible organ dysfunction may no longer be candidates for LVAD implantation or other advanced therapy options. Table 1 highlights various considerations used to identify HF patients with advanced HF. These include the I-NEED-HELP mnemonic, which is a simple acronym published in 2017 [9]. Available objective scores include the Heart Failure Survival Score (HFSS) and Seattle Heart Failure Model, although the complexity of these scores and modest discrimination in the contemporary [10] era has limited their utilization. While these scores offer some benefit for risk stratification, the authors of this review more so rely on other objective parameters, including metabolic testing and invasive hemodynamics to guide decision-making. Society guidelines have also highlighted key aspects for identification of advanced HF with a focus on symptoms as well as objective criteria including laboratory values, cardiopulmonary stress test results, and hemodynamic parameters [11, 12]. Identification of advanced HF should prompt referral to an advanced HF center, for further patient evaluation and management including consideration for advanced therapies such as LVAD or transplant. Among patients eligible for both LVAD and transplant, shared decision-making about risks and benefits of each is important, though transplant remains the preferred option for most [13]. Direct transplant without LVAD bridging is becoming increasingly common in the US due to the updated heart transplant allocation criteria in 2018[14], though both bridge to transplant and destination therapy LVAD remain important treatment options for unstable or transplant-ineligible patients. While much of the evaluation process for advanced therapies, including indications and contraindications, is similar between LVAD and transplant, important differences remain. For example, patients with recent malignancy but favorable prognosis, irreversible (in the short term) pulmonary hypertension, or obesity above transplant cutoff may be candidates for LVAD, including as a bridge to transplant, but not direct transplantation. The rest of this review will focus predominantly on evaluation of patients for LVAD.

Historically, implantation of LVADs was characterized as bridge to transplantation (BTT) among patients who were considered candidate for transplantation, destination therapy (DT) among those not considered transplant candidates, and bridge to recovery in patients considered good candidates for LV recovery and possible LVAD explantation. However, the clinical relevance of this terminology has been blurred by updated US payor criteria, trials highlighting similar outcomes between DT and BTT cohorts, [15] as well as common changes in patient status leading to transition from one category to another. Therefore, patients with advanced HF who are evaluated for advanced therapies may be candidates for LVADs as a treatment option irrespective of transplant candidacy or in hopes of potential myocardial recovery.

Optimal timing of LVAD implantation in certain patients with advanced HF remains a subject of debate. There is a need to balance the risks associated with late implant in the setting of irreversible end organ dysfunction where outcomes are poor and early implantation where surgical and device-related complications may outweigh benefit. In this regard, the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) has been useful to both evaluate optimal LVAD implantation timing and evaluate post-implant outcomes [16]. In the absence of reversible causes or significant contraindications, patients meeting the INTERMACS 1 and 2 classification should be considered candidates for LVAD implantation. About half of all LVAD implants occur among patients of INTERMACS 1 or 2 profile, though given acute severity of illness, such patients experience worse outcomes compared to less acute INTERMACS profiles [17]. Patients with stable end organ function on inotropic therapy constitute INTERMACS 3 profile and demonstrate significant improvement in outcomes with LVAD compared to patients remaining on inotropic therapy [18]. Those with higher INTERMACS scores constitute a cohort with more individualized decision-making for LVAD implantation, with select patient with INTERMACS profiles 4–7 demonstrating favorable outcomes versus medical management alone [19].

One complicating factor among patients with INTERMACS 1 or 2 profile is the frequent requirement for temporary mechanical circulatory support (tMCS) including extra-corporeal membrane oxygenation (ECMO) either as part of emergent management or optimization prior to LVAD consideration. Preoperative tMCS has been associated with worse outcomes post-LVAD implantation probably due to both patient-related disease severity and tMCS complications which manifest post-LVAD implant. Due to higher associated risks, some have advocated for the addition of an "INTERMACS 0" or specific INTERMACS modifier profile to further highlight the risks in this population [12, 20].

Evaluation of patients for LVAD candidacy

There are no universal guidelines that will categorize which patients are the candidates for LVAD placement and which patients may not derive benefit from this intervention, and multidisciplinary centers are crucial to optimize decision-making. Patients that have comorbidities leading to poor survival limited to 1 year or less from a non-cardiac cause

Table 1 Clinical indicators of advanced heart failure

Clinical indicators of advanced HF	High-risk features
INEEDHELP Mnemonic (2017)[59]	**I** Inotropes- H/o or current use of dobutamine, milrinone, dopamine, or levosimendan **N** NYHA class and/or natriuretic peptides — NYHA class III/IV and/or ↑ BNP or NT-proBNP **E** End-organ dysfunction — deteriorating renal or liver function **E** Ejection fraction less than 25% **D** Defibrillator shocks — recurrent and appropriate shocks **H** Hospitalizations — one or more hospitalization for HF within 1 year **E** Edema/increased use of diuretic agents **L** Low BP — systolic < 90 to 100 mmHg **P** Prognostic medications — unable to ↑ or needing to stop/↓ ACE-I, BBs, ARNIs, or MRAs
Patient profiles per the Interagency Registry for Mechanically Assisted Circulatory Support* (INTERMACS) (2008)[60]	**Profile 1**: Critical cardiogenic shock, other organ hypoperfusion, increased need for inotrope/pressor support **Profile 2**: Progressive decline where patient relies on inotrope support and has signs of worsened organ dysfunction **Profile 3**: Stable, still relies on inotrope support, no signs of clinical deterioration unless weaned from inotropes or temporary circulatory support device **Profile 4**: Symptomatic at rest or with minimal daily living tasks while on appropriate oral medications at home **Profile 5**: Exertion intolerant: no symptoms at rest, remains mostly at home because cannot participate in any activities other than minimal daily living tasks **Profile 6**: Exertion limited: no symptoms at rest or minimal daily living tasks, able to participate in minor activities, develops fatigue quickly, unable to do significant physical exertion **Profile 7**: Advanced NYHA class III: distant history of decompensation (> 1 month) who can participate comfortably in significant physical exertion Modifiers: Temporary Circulatory Support (TCS) — able to modify patients in hospital only (other devices would be INTERMACS devices). Examples of these devices are Levitronix, ECMO, Impella BVS 5000, IABP, AB5000, or TandemHeart. These apply to 1, 2, 3 profiles in the hospital Arrhythmia (A) — able to modify any profile. For example, frequent and recent ventricular tachyarrhythmias contributing to significant clinical deterioration (i.e., frequent ICD shocks or needing an external defibrillator, more than once per week Frequent Flyer (FF) — only modifies outpatients. Patients that require frequent emergency visits and/or hospitalizations needing intravenous vasopressors, diuresis, or ultrafiltration. These apply to profile 3 if at home, 4, 5, 6. Important to mention a Frequent Flyer would rarely be profile 7
Heart Failure Survival Score Criteria (1997)[61]	- Ischemic cardiomyopathy - LVEF as a measure of systolic dysfunction - PCWP as a measure of diastolic dysfunction - Serum sodium as a measure of activation of the RAAS system - Resting heart rate as a measure of activation of the SNS - Intraventricular conduction delay as a measure of myocardial injury/fibrosis - Peak VO_2 and mean blood pressure
Seattle Heart Failure Model Criteria (2006)[62]	- Clinical: age, gender, NYHA class, weight, EF, systolic BP, presence of ischemia, LBBB, QRS > 150 ms - Medications: Ace-I, BBs, ARBs, statins, allopurinol, aldosterone blockers - Diuretics: furosemide, bumetamide, torsemide, metolazone, HCTZ, chlorthalidone - Lab data: Hgb, lymphocyte %, uric acid, sodium, total cholesterol - Devices: Biv Pacer, ICD, BiV ICD, IABP, Vent, UF

Table 1 (continued)

Clinical indicators of advanced HF	High-risk features
Other clinical indicators of advanced HF based on American Heart Association/American College of Cardiology/HeartFailure Society of America[63] as well as European Society of Cardiology criteria[64]	- Increased predicted 1-year mortality (e.g., > 20%) according to HF survival models (e.g., MAGGIC, SHFM) - Repeated hospitalizations or emergency department visits for HF in the past 12 mo - Refractory or recurrent ventricular arrhythmias; frequent ICD shocks - Need for intravenous inotropic therapy - Persistent hyponatremia (serum sodium < than 134 mEq) - Persistent NYHA functional class III to IV symptoms despite therapy - Worsening right HF or secondary pulmonary hypertension - Severely reduced exercise capacity (peak VO_2, < 12–14 mL/kg/min or < 50% predicted, 6-min walk test distance < 300 m, or inability to walk 1 block on level ground because dyspnea or fatigue) - Refractory clinical congestion - Progressive deterioration in renal or hepatic function - Intolerance to RAASi because of hypotension or worsening renal function - Recent need to escalate diuretics to maintain volume status, often reaching daily furosemide equivalent dose > 160 mg/d or use of supplemental metolazone therapy - Intolerance to beta blockers because of worsening HF or hypotension - Frequent SBP < 90 mmHg - Cardiac cachexia

NYHA New York Heart Association, *BNP* brain natriuretic peptide, *NT* natriuretic, *HF* heart failure, *BP* blood pressure, *ACE-I* angiotensin-converting enzyme inhibitor, *BB* beta blockers, *ARNIs* angiotensin receptor-neprilysin inhibitors, *MRA* mineralocorticoid receptor antagonist, *LVEF* left ventricular ejection fraction, *PCWP* pulmonary capillary wedge pressure, *RAAS* renin–angiotensin–aldosterone system, *SNS* systemic nervous system, VO_2 oxygen consumption/oxygen uptake, *EF* ejection fraction, *LBBB* left bundle branch block, *ARBs* aldosterone receptor blockers, *HCTZ* hydrochlorothiazide, *Biv* biventricular, *ICD* implantable cardioverter-defibrillator, *IABP* intraaortic balloon pump, *Vent* ventilator, *UF* ultrafiltration, *MAGGIC* Meta-analysis Global Group in Chronic Heart Failure, *mEg* milliequivalents, *RAASi* renin–angiotensin–aldosterone system inhibitors

*INTERMACS score has been commonly used for both identification of advanced HF severity and prognostic factor for operative outcomes, with lower INTERMACS scores associated with worse outcomes, see text

(i.e., liver cirrhosis, metastatic and/or aggressive forms of cancer, severe connective tissue disease) are usually not candidates for advanced therapies such as LVAD. The following are some of the most common additional factors that need to be addressed and evaluated in patients being evaluated for LVAD.

Laboratory evaluation

Hematological workup

Current LVAD technology requires the use of anticoagulation and potentially antiplatelet therapies and has been associated with hematological complications such as bleeding, pump thrombosis, and thromboembolic events [21]. Bleeding risk post-LVAD implantation is multifactorial and has been tied to fibrinolysis, hepatic dysfunction, renal impairment, anticoagulation, and anti-platelet therapy. LVADs have also been associated with causing platelet dysfunction and impaired von Willebrand factor activity [22], leading to acquired coagulopathy disorders. Preoperative evaluation for hematologic conditions including iron deficiency, thrombocytopenia, hypercoagulable states, and heparin-induced thrombocytopenia is recommended as these have been associated with higher risk of adverse events post-LVAD implantation, although successful implantation despite pre-existing coagulopathy has been reported [22, 23].

Renal dysfunction

Renal dysfunction is common in patients with decompensated HF and among those undergoing evaluation for advanced therapies. Though not consistent across all studies [24] pre-implant renal dysfunction tends to be associated with worse post-implant outcomes [25]. Outcomes in patients with pre-implant glomerular filtration rate (GFR) greater than 30 have been reported to be favorable, while those with GFRs under 30 were noted to have particularly increased risks of early post-implant adverse events [25] Post-LVAD, improvement in renal function is common, although long-term dysfunction remains a concern [26]. High-risk features for post-LVAD renal dysfunction include lack of reversibility of renal dysfunction prior to implantation, diabetes, hepatic dysfunction, and proteinuria, as well as intraoperative blood product use [27, 28]. The possibility

for progression to end-stage renal disease requiring dialysis is of particular concern for LVAD recipients because dialysis has been associated with poor prognosis [29]. Patients with pre-implantation chronic dialysis have generally not been considered candidates for LVAD placement, although feasibility of both hemodialysis and peritoneal dialysis post-implant has been reported with successful outcomes [30]. Careful preoperative evaluation for the etiology of renal dysfunction and preoperative optimization to improve renal function are important components of LVAD patient selection, although no degree of renal dysfunction has universally been considered an absolute contraindication for implant.

Evaluation of liver function

Patients with pre-existing liver dysfunction have poor outcomes post-implantation due to increased rates of neurological events, postoperative major bleeding, and ongoing platelet dysfunction [31]. Although complete metabolic panel to assess for aminotransferases, bilirubin, and albumin as part of other laboratory testing is routine as part of evaluation, the composite Model for End-Stage Liver Disease (MELD) score has also emerged as a valuable screening tool. Specifically, a high MELD score—calculated from creatinine, bilirubin, and international normalized ratio (INR)—has been associated with increased risks of bleeding, renal failure, right ventricular (RV) failure, and device infection post-LVAD implantation [32]. The MELD- XI score, which excludes INR, has emerged as a viable alternative to assess liver function in HF patients on anticoagulation. [33] Scores for MELD and MELD-XI above 17, while not an absolute contraindication, have been associated with poor outcomes post-LVAD implantation [33], and thus can serve as a useful screen to identify preoperative patients who are at high implant risk and may benefit from further optimization or alternative therapies.

Echocardiographic data

Examining cardiac structure and function pre-LVAD implantation serves several key roles. Evaluation of RV dysfunction is of particular importance given that adequate RV function is required to deliver LVAD preload and postoperative RV dysfunction has been associated with significant morbidity and mortality. Echocardiographic predictors of post-LVAD RV dysfunction in combination with invasive right heart catheterization (as described below) can be used for assessment of the risk for RV failure. However, predictive value of current strategies and multiple proposed risk scores utilizing combination of echocardiographic, hemodynamic, laboratory-based parameters [34] remains modest. Therefore, no single measure of RV dysfunction should serve as a contraindication to implantation, and optimizing preoperative comorbidities, end organ function, and hemodynamics may offer the best likelihood of reducing postoperative RV failure risks [35]. Additionally, appreciation of RV failure risk may allow for early implantation of temporary RV assist device, which has been associated with improved outcomes compared to later implantation [36].

Echocardiography is also essential to evaluate the etiology of HF prior to LVAD consideration. For example, hypertrophic or restrictive cardiomyopathy has been associated with worse outcomes post-LVAD implantation when compared to dilated and ischemic cardiomyopathy [37]. Approximately 12% of durable LVAD implants in the US occur among patients with restrictive cardiomyopathy, including patients with amyloid, sarcoid, or radiation-induced HF, and these patients experience higher short-term as well as long-term adverse events [37]. Evaluation of left ventricular dimension is also important because smaller pre-implant ventricular size has been associated with worsened post-LVAD outcomes [38].

A thorough evaluation of preoperative valve function is also important. There is mixed data on concomitant surgical repair of mitral and tricuspid regurgitation during LVAD implantation [39, 40], and practice remains largely center specific. Aortic regurgitation and significant stenotic lesions of the tricuspid, mitral, or pulmonic valves generally require surgical intervention at the time of LVAD placement, as aortic regurgitation can worsen postoperatively and lead to significant hemodynamic consequences. Limited data suggests feasibility for not replacing functioning mechanical valves, including aortic valves, at the time of implant [41] while others favor patch closure or replacement of mechanical aortic valves to reduce thrombotic risk [42]. Additionally, evaluation for atrial shunts is important as they can be fixed intraoperatively to decrease the risk of paradoxical embolism or severe hypoxemia due to increased venous return.

Invasive hemodynamic data

While hemodynamics obtained by echocardiography can help guide decision-making, a key part of patient assessment requires invasive hemodynamics with a right heart catheterization. Invasive evaluation of filling pressures can serve an important role in evaluation of RV function, with high right atrial pressure (≈ 10–15 mmHg or greater), high right atrial to wedge pressure ratio (≈ 0.6 or greater), and low RV stroke work index all being important predictors of post-LVAD RV dysfunction [35]. Elevated pulmonary artery pressures in the setting of elevated wedge pressure are not a contraindication for LVAD and may be

predictive of lower risk of postoperative RV failure. However, optimization of volume status which in turn may lead to reduced pulmonary artery pressures remains important pre-implant. In this regard, Swan-Ganz catheters or implantable pulmonary artery monitoring systems (CardioMEMS, Abbott Medical, Inc) have been successfully used to evaluate volume status and pulmonary pressures as part of preoperative optimization [43]. Post-implant, both pulmonary hypertension and pulmonary vascular resistance tend to improve significantly [44].

Additional patient evaluation considerations

Ventricular arrhythmias

After implant, LVAD patients may develop ventricular arrhythmias which can be particularly significant in those with pre-existing ventricular arrhythmias. Preoperative or intraoperative ablation may be considered in select cases [45]. Alternatively, patients with a high preoperative burden of ventricular arrhythmia may be better served by alternate management options such as heart transplantation to avoid the consequences of postoperative RV failure and abnormal LVAD flows which may occur in the setting of recurrent ventricular arrhythmias.

Other preoperative testing

Depending on patient risk factors, multiple other testing may be needed prior to LVAD candidacy. Chest computed tomography (CT) is often performed to evaluate for cardiac structure proximity to the sternum (especially in patients with a prior history of sternotomy) as well as to evaluate calcification of the aorta and potential outflow cannula implant site. Age-appropriate cancer screening may be needed based on risk factors, including screening for sources of bleeding from the gastrointestinal tract with endoscopic procedures. Studies have demonstrated that although a history of malignancy is associated with increased mortality risk post-implant, short-term survival remained acceptable and therefore LVAD can be considered in appropriate patients with recent history of malignancy [46]. Pulmonary function testing is also important prior to surgical consideration, especially since LVAD implantation has been associated with postoperative decline in lung capacity [47].

Age

Age is a key non-modifiable factor meriting consideration as part of patient evaluation for LVAD. Advanced age may be associated with increased comorbidity burden as well as lower physiological reserve, which may affect patient candidacy and decision-making. While advanced age (> 65 years old) has been identified as a risk factor for adverse events in some risk scores (see Table 2) and other analyses [48], LVAD placement remains feasible with studies demonstrating good outcomes among well-selected older patients. One cohort of well-selected patients aged ≥ 70 (range 70–87 years old) demonstrated similar short-term outcomes compared to younger patients [49]. Given the growth of the elderly HF population over time, the role of age in LVAD decision-making will require additional evaluation and age itself should not serve as an exclusion criterion for appropriately selected patients.

Obesity

Obesity is common among patients with advanced HF, and obese patients may have favorable outcomes in the presence of HF, the so-called obesity paradox. Although obesity with body mass index (BMI) > 35 kg/m^2 is often considered a contraindication to heart transplant due to worse post-transplant outcomes [50], obesity within similar range is generally not considered a contraindication for LVAD therapy with favorable outcomes reported in select patients even above BMI of 40 kg/m^2 [51] Weight gain is common post-LVAD, and concomitant bariatric surgery has been utilized in this population to both improve quality of life and increase transplant candidacy in obese patients undergoing LVAD [52].

Frailty

In the evaluation and careful consideration for LVAD, frailty has emerged as a crucial factor in selecting patients who may benefit from LVAD. Frailty has been traditionally characterized as increased physiological vulnerability, reduced resilience to stressors, and loss of physiological function which is broad and can include risks of mortality associated with HF. Several common models of frailty have been described in patients undergoing LVAD evaluation, and measures of frailty and sarcopenia have been associated with adverse outcomes. In a study comparing multiple preoperative assessments of frailty, CT-assessed muscle mass and bioelectrical impedance analysis, which measures body composition and sarcopenia, were the only frailty assessment measures associated with adverse outcomes [53]. Importantly, many other commonly used measures of frailty including walk distance and grip strength are not consistently associated with adverse outcomes, partly because these parameters may have limited ability to discriminate intrinsic frailty from HF symptomatology that may be reversible with LVAD implantation.

Table 2 Risk scores and models used to identify patients for high-risk post-LVAD implantation

Select LVAD outcomes risk score	High-risk features	Select RV failure risk scores[6]	High-risk features
Destination Therapy Risk Score (DTRS[65]) (2007)	Mean PAP ≤ 25 mmHg Platelet count ≤ 148 × 103 μL AST > 45 U/mL, BUN > 51 U/dL INR > 1.1, Hct ≤ 34% Serum albumin ≤ 3.3 g/dL No IV inotropes Vasodilator therapy	Utah RVF risk score (2010)	ACEi and/or ARB use (− 2.5 points) Beta blocker use (2 points) Pulmonary vascular resistance: ≤ 1.7 Wood units (1 points) 1.8–2.7 Wood units (2 points) 2.8–4.2 Wood units (3 points) ≥ 4.3 Wood units (4 points) Destination therapy (3.5 points) Inotrope dependency (2.5 points) IABP (4 points) Obesity (2 points) *The subgroup with a risk score of ≥ 12.5 had substantially lower survival at 1 year compared to the subgroup with a risk score of 8.5 to 12
Heart Mate Risk Score (HMRS[66]) (2012)	Albumin (g/dL) INR units Age (per 10 years) Creatinine (mg/dL) Center volume < 15	Michigan RVF risk score (2008)	Vasopressor requirement (4 points) AST ≥ 80 IU/L (2 points) Bilirubin ≥ 2.0 mg/dL (2.5 points) Creatinine ≥ 2.3 mg/dL (3 points) ≥ 5.5 points — high risk 4.0 to 5.0 — medium risk ≤ 3.0 — low risk
IMACS-RS (2021)[67]	Age BMI INTERMACS 1/2 at implant Pre-implant dialysis Major infection pre-implant Small LV size Moderate to severe TR BUN Bilirubin Low hemoglobin Low albumin Female Ischemic etiology Low platelet count	EUROMACS-RHF risk score (2017)	Use of multiple inotropes Severe RV dysfunction on echo Hemoglobin INTERMACS class Right atrial/PCWP ratio
Penn-Columbia Risk score (2018) [68]	Age Creatinine Bilirubin BMI RV dysfunction Aortic Insufficiency	Pittsburgh Decision Tree (2012)	Right atrial pressure Heart rate White blood cell count International normalized ratio ALT Transpulmonary gradient Number of inotropic agents Age
Bayesian model from INTERMACS (2016)[69]	Most prominent predictors of 1-year mortality: Age BUN Hemoglobin Device strategy RVAD need Platelet count Numerous other predictors		

PAP pulmonary arterial pressure, *AST* aspartate aminotransferase, *ALT* alanine transaminase, *BUN* blood urea nitrogen, *INR* international normalized ratio, *IV* intravenous, *BMI* body mass index, *LV* left ventricle, *RV* right ventricle, *TR* tricuspid regurgitation, *RVAD* right ventricular assist device, *ACE-I* angiotensin-converting enzyme inhibitor, *ARB* aldosterone receptor blockers, *IABP* intraaortic balloon pump, *PCWP* pulmonary capillary wedge pressure.

Family and psychosocial considerations

Standardized approaches to psychosocial evaluation involve screening for caregiver availability, substance use, and other factors that are critical for optimal patient selection [54]. Evaluation of social support (from a family member, close friend, or caregiver) is routine among patients being considered for LVAD and lack of social support is considered a strong relative or absolute contraindication to LVAD placement. Caregivers play several crucial roles in the management and long-term care of LVAD patients [55]. A study by Bruce et al. in 2017 showed the risk of death was over three times higher in LVAD patients that lived alone compared with those who did not [55] implying an important caregiver role in medication and other medical care compliance including transportation, driveline care, and emotional support.

Other components of psychosocial evaluation are also important for candidacy consideration. Patients with ongoing substance abuse including alcoholism are not candidates for LVAD therapy, and smoking at the time of implantation has been associated with adverse events [13]. Assessing history and barriers to compliance with care is likewise important, and a history of limited cognition, psychiatric comorbidities, limited social support, and noncompliance has been associated with adverse post-implant events [56].

Importance of palliative care evaluation

Palliative care consultation is a critical component of patient assessment and serves to improve patient and family understanding of the critical nature surrounding LVAD consideration. Advance directive planning, goals of care discussions, and consideration for potential withdrawal of LVAD in absence of future capacity also warrant preoperative consideration. In addition to these, palliative care intervention as part of a multidisciplinary team can help facilitate shared decision-making [57] and address symptoms in complimentary manner to that of the remaining treatment team. While decisional regret post-LVAD implantation remains low, post-implant satisfaction is not universal and many patients express concern about both the evaluation process and quality of life post-implant [58]. Therefore, a focus on goals of care as part of a thorough patient evaluation is critical for optimizing both patient and family decision-making.

Conclusion

Although LVAD is a viable option for patients with advanced HF to improve quality of life and survival, patient selection and optimization prior to implant considerations can be complex. A multidisciplinary team evaluation can identify patients who may be expected to derive benefit from implantation and guide patients towards mutual decision-making. An ongoing focus on early identification of advanced HF, optimization of end organ function and risk stratification prior to implantation, and focus on patient and family quality of life remain crucial for long-term success in the management of potential LVAD candidates.

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