Archives of Cardiovascular Disease (2012) 105, 114—121

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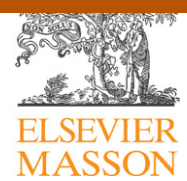

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REVIEW

Left ventricle assist device: When and which patients should we refer?

Jean-Noël Trochu[a,*], Pascal Leprince[b], Marie Bielefeld-Gomez[c], Olivier Bastien[d], Florence Beauvais[e], Jean-Pierre Gueffet[a], Damien Logeart[e], Richard Isnard[f], Marie-Christine Iliou[g], Christophe Leclercq[h], Claude Girard[c]

[a] *Inserm, UMR915, université de Nantes, l'institut du thorax, CHU de Nantes, boulevard Jacques-Monod, 44093 Nantes, France*
[b] *Service de chirurgie cardiaque, hôpital Pitié—Salpêtrière, AP—HP, université Pierre-et-Marie-Curie, 75013 Paris, France*
[c] *Service d'anesthésie-réanimation, hôpital du Bocage, CHU de Dijon, université de Dijon, 21000 Dijon, France*
[d] *Hôpital cardiologique et pneumologique Louis-Pradel, université Claude-Bernard Lyon-I, 69000 Lyon, France*
[e] *UMRS-956, Inserm U942, AP—HP, hôpital Lariboisière, Cardiology Department, université Paris Diderot, 75475 Paris, France*
[f] *UMRS-956, institut de cardiologie, CHU Pitié-Salpêtrière, AP—HP, institut ICAN, université Pierre-et-Marie-Curie, 75013 Paris, France*
[g] *Cardiac Rehabilitation Department, Broussais-HEGP hôpital, 75908 Paris, France*
[h] *CIC-IT 804, LTSI Inserm U 642, service de cardiologie, hôpital Pontchaillou-CHU, 35033 Rennes, France*

Received 28 September 2011; received in revised form 6 November 2011; accepted 8 November 2011
Available online 9 February 2012

KEYWORDS
Heart failure;
Systolic dysfunction;
Left ventricular assist device

Summary Progress in the medical treatment of patients with heart failure with systolic dysfunction, cardiac resynchronization therapy, internal cardiac defibrillators and multidisciplinary management programmes has resulted in dramatic improvements in survival and quality of life; however, this progress has led to an increase in the prevalence of advanced heart failure. In the context of organ shortage for cardiac transplantation, the technological developments in left ventricular assist devices, shown in recent positive clinical studies, provide real hope for

Abbreviations: ACE, angiotensin-converting enzyme; ARB, angiotensin II receptor antagonist; CRT, cardiac resynchronization therapy; ECMO, extracorporeal membrane oxygenation; HF, heart failure; ICD, internal cardiac defibrillator; INTERMACS, Interagency Registry for Mechanically Assisted Circulatory Support; LVAD, left ventricular assist device; RV, right ventricular.

* Corresponding author.
E-mail address: jeannoel.trochu@chu-nantes.fr (J.-N. Trochu).

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doi:10.1016/j.acvd.2011.11.004

patients with advanced heart failure. This article summarizes the most recent clinical studies concerning left ventricular assist devices and discusses for whom and when a left ventricular assist device should be proposed.
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MOTS CLÉS
Insuffisance cardiaque avancée ;
Assistance circulatoire monoventriculaire gauche ;
Transplantation cardiaque ;
Ventricule droit ;
Hypertension artérielle pulmonaire

Résumé Les progrès du traitement médicamenteux, la resynchronisation cardiaque, l'utilisation des défibrillateurs implantables, l'éducation du patient et l'organisation du suivi ont permis d'améliorer la qualité de vie et la survie des patients insuffisants cardiaques avec dysfonction systolique, mais ces progrès se sont aussi traduits par une augmentation de la prévalence des patients en insuffisance cardiaque avancée. Dans le contexte de pénurie d'organes pour la greffe cardiaque, les progrès technologiques des assistances monoventriculaires gauches apportent des résultats cliniques très encourageants et constituent un réel espoir pour la prise en charge des patients insuffisants cardiaques sévères. Cet article fait le point sur les données les plus récentes concernant l'assistance monoventriculaire gauche et discute quand et pour quels patients l'envisager.
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Background

Progress over the past 20 years in the medical management of patients with HF with systolic dysfunction has been accompanied by a significant improvement in survival and quality of life due to the prescription of ACE inhibitors, ARBs, beta-blockers and anti-aldosterones, CRT and ICDs, in addition to multidisciplinary management programmes based on education of the patient and coordination of care [1,2]. These strategies have also resulted in changes in the clinical profile as well as an increase in the number of patients with advanced HF.

The prevalence of HF in Europe is estimated to be between 2 and 3% of the general population, with 15 million patients having symptomatic HF. Patients with advanced HF represent approximately 0.4% of the population, i.e. 60,000 patients. If we estimate that around 50% of these patients have altered systolic function and that 30—50% are < 75 years of age, then 10—15,000 patients should require a heart transplant, a total artificial heart, a biventricular assist device or a LVAD.

Cardiologists should learn to recognize these patients because there has been remarkable progress in cardiac assist devices over the past few years, while access to transplantation remains very limited. An LVAD can be used as a bridge to heart transplantation, until possible recovery, or can be used long term or even permanently (destination therapy). During the past 10 years, 1-year survival rates for destination therapy have increased from 52% with pulsatile devices [3] to 68% with continuous flow devices [4] and to 94% in bridge-to-transplant indications [5]. Moreover, the incidence of complications has dramatically decreased with the use of continuous flow devices. Their reliability, longevity (> 5 years) and battery autonomy (up to 10 h) are continuously improving and consequently have contributed to an improvement in quality of life [6].

The aims of this article are to describe the profiles and management of patients with advanced HF for whom an LVAD should be proposed and to consider when an LVAD should be proposed, on the basis of the most recent clinical studies.

When should a heart failure (HF) patient be referred to an HF centre?

The majority of HF patients with left ventricular systolic dysfunction are followed in an ambulatory setting and should receive optimal therapy based on the use of recommended medications, CRT/ICD devices when indicated and an organized care plan as defined by the international guidelines [7]. It is crucial to take time to titrate the medications up to the maximal tolerated doses and to optimize CRT stimulation during the initial phase and follow-up. At the advanced stages of HF, particular attention should be paid to deciding if the time for heart transplantation or LVAD implantation has occurred. The decision to recommend cardiac replacement or LVAD implantation remains difficult and concerns a small proportion of patients, a large majority of whom are currently referred too late. The paradox is that these patients, for whom the prognosis is worse than most cancers, are referred late, while the level of intervention and quality of management should at least equal what is given to cancer patients. Hence, patients with severe HF should be directed earlier to experienced HF teams in order to discuss therapy, evaluate prognosis and organize a care plan, allowing elective implantation of an LVAD if necessary and pre-empting the evolution of clinical situations. Several clinical and biological variables should alert the primary care physicians to refer the patient to the HF team. Pertinent indicators of severity can be: very symptomatic (e.g. unable to climb a flight of stairs without dyspnoea); intolerant to ACE inhibitors, ARBs or beta-blockers; natraemia < 135 mmol/L; hospitalized repeatedly during the past 6 months; and persistent elevation of natriuretic peptides. Beyond these simple indicators, HF risk scores should be used more often. The HF Survival Score [8] and the Seattle HF Score [9] seem to be relevant in these patients, even if they can underevaluate prognosis in the most severe patients; their routine use is not frequent in Europe but the severity of the patients should justify broader utilization of these scores to facilitate the best treatment strategies. Earlier referral has to be

preferred to improve patient selection for LVAD implantation or heart transplantation.

The HF team will ensure that all conventional medical strategies have been optimally implemented and will accurately evaluate right heart function as well as other factors that can influence the therapeutic decision (see below). Based on this evaluation, a strategy of management and outpatient follow-up will be proposed in collaboration with the cardiologist and general practitioner. This period of time provides a good opportunity to implement patient education and give information about LVADs and heart transplantation. Heart transplantation currently offers the best quality of life, autonomy and chance of socioprofessional reintegration and the longest survival. However, the shortage of organ donors dramatically limits the probability of transplantation in ambulatory waiting patients and emergency transplantation is given priority in industrialized countries. In this context, during consultations where heart transplantation is discussed, the possible requirement for a period of bridge assistance until transplantation should be systematically mentioned.

For which patients should a left ventricular assist device be proposed?

Patients with chronic heart failure

As recommended by the European Society of Cardiology, an LVAD may be considered as a destination therapy to reduce mortality in patients in New York Heart Association class 3B to 4, who remain symptomatic despite optimization of the recommended HF medications (Fig. 1) [10]. As described by the European working group on advanced heart failure these patients complain of major limitations in their daily life, with dyspnoea and fatigue present at rest or during minimum effort, which confines them to bed or at home. For ambulatory patients, excursions outside are feared and rare, and walking is limited. These patients have repeated episodes of salt and water retention or low cardiac output episodes and are often rehospitalized, with more than one hospitalization during the previous 6 months. All these signs appear despite optimization of (or attempts to optimize) their medications [11]. These patients do not respond to cardiac resynchronization therapy or respond only transiently and inverse left ventricular remodeling is not observed. Above all, drug titration is often impossible and at the most advanced stages, drug treatments (ACE inhibitors, ARBs, beta-blockers, antialdosterones) have to be decreased due to hypotension, renal insufficiency and profound weakness. At this stage of advanced HF, the main objective becomes optimization of volaemia and high doses and combinations of diuretics have to be used. The classification of the INTERMACS registry proposes seven clinical scenarios that allow better definition of the functional limitations and degree of severity of patients with advanced HF (Table 1) [12]. Although this classification does not take into account the arrhythmic risk, it is extremely useful in daily clinical practice for the management of patients and for making decisions regarding therapeutic strategies. Community cardiologists should know this classification since it also has a prognostic value [13]. These patients have a profound alteration of left ventricular ejection fraction (< 25%). The alteration of systolic function should not be underestimated, and higher values may be found in cases of significant mitral insufficiency. Echocardiography shows marked anomalies in the mitral profile and an increase in filling pressure concordant with the level of natriuretic peptides, which remain increased between congestive episodes [11]. An increase in central venous pressure despite haemodynamic optimization indicates an alteration of RV function. It is crucial to perform a comprehensive evaluation of RV function and to identify RV dysfunction because this is a determining prognostic factor. During follow-up of ambulatory HF patients, an increase in pulmonary pressure and/or pulmonary resistance should direct the patient to a HF reference centre because this indicates advanced disease and an increased risk of RV dysfunction. RV dysfunction is one of the main determinants of operative risk and may preclude the possibility of LVAD implantation. The patient's age is not a formal contraindication and depending on the general state of the patient and the presence of comorbidities, implantation of mechanical assistance may be proposed in patients > 65 years of age [14].

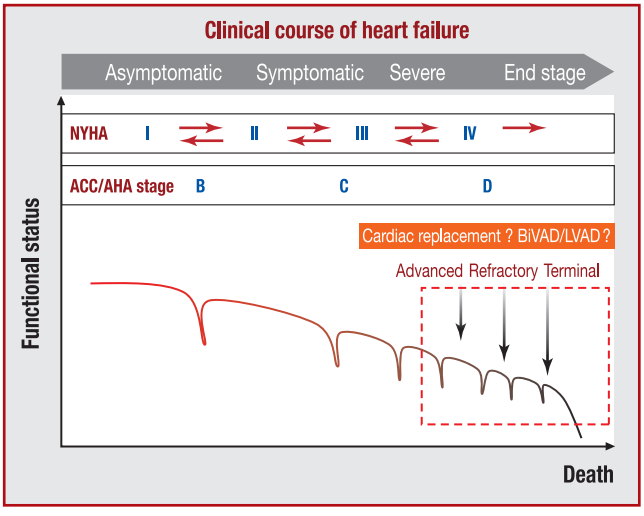

Figure 1. Clinical course of heart failure. ACC: American College of Cardiology; AHA: American Heart Association; BiVAD: biventricular assist device; LVAD: left ventricular assist device; NYHA: New York Heart Association.

Patients with acute heart failure

The sickest patients experiencing profound cardiogenic shock are contraindicated for long-term circulatory support and should be first stabilized with peripheral transitory circulatory systems, such as ECMO or others, but this topic will not be discussed in this article. Hence, patients with multiple organ failure are not an indication for an LVAD, except for an extremely limited number of patients in whom a bridging strategy may be implemented until the decision is made. Only teams with wide experience in this type of management should take this decision, and patients with cardiogenic shock have to be transferred as soon as possible to experienced centres. Patients who are type 1 or 2 in the INTERMACS classification are currently the main indication. The need to increase doses of inotropes, vasopressors and the development of signs of multiple organ failure are deter-

Table 1 Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) classification.

Classification	Description	Time frame for definitive intervention
1	Patient with life-threatening hypotension despite rapidly escalating inotropic support, critical organ hypoperfusion with increasing lactate levels and/or systemic acidosis. ''Crash and burn''	Needed within hours
2	Patient with declining function despite intravenous inotropic support, may be manifested by worsening renal function, nutritional depletion, inability to restore volume balance. ''Sliding on inotropes''	Needed within a few days
3	Patient with stable blood pressure, organ function, nutrition and symptoms on continuous intravenous inotropic support, but demonstrating repeated failure to wean owing to recurrent symptomatic hypotension or renal dysfunction. ''Dependent stability''	Elective over a few weeks
4	Patient can be stabilized close to normal volume status but experiences frequent relapses into fluid retention, generally with high diuretic doses. Symptoms are recurrent rather than refractory. More intensive management strategies should be considered, which in some cases reveal poor compliance. ''Frequent flyer''	Elective over weeks to months as long as treatment of episodes restores stable baseline, including nutrition
5	Patient is living predominantly within the house, performing activities of daily living and walking from room to room with some difficulty. Patient is comfortable at rest without congestive symptoms but may have underlying refractory elevated volume status, often with renal dysfunction. ''Housebound''	Variable, depends upon nutrition, organ function, and activity
6	Patient without evidence of fluid overload is comfortable at rest and with activities of daily living and minor activities outside the home, but fatigues after the first minutes of any meaningful activity. ''Walking wounded''	Variable, depends upon nutrition, organ function, and activity
7	A placeholder for future specification, patients without recent unstable fluid balance, living comfortably with meaningful activity limited to mild exertion	Transplantation or circulatory support not currently indicated

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mining factors that should make clinicians consider urgent LVAD implantation [15]. Low SvO_2 or high lactate levels are useful criteria for assessing oxygen dependence and multiple organ failure at an early stage. Under these conditions, this usually takes place as rescue therapy in a patient who is a candidate for transplantation, while in the case of destination therapy, LVADs should be reserved for stabilized patients only. Level 3 patients are dependent on intravenous perfusion of positive inotropes. Multiple attempts to withdraw inotropes should be avoided in favour of LVAD implantation in the current context of a shortage of grafts [15]. In France, the national regulations on the distribution of grafts determined by the Biomedicine Agency restricts the possibility of a patient being given national priority to two 48-hour periods and the shortage of grafts should encourage clinicians to use LVADs (Fig. 2).

Main contraindications

A preassistance assessment is necessary and is similar to the pretransplantation assessment, with general examinations to look for temporary or permanent contraindications. A number of contraindications should rule out an LVAD: severe chronic respiratory failure; severe liver failure; major problem in the clotting test; uncontrolled haemorrhage; uncontrolled septic or inflammatory syndrome; multiple organ failure; recent cerebrovascular accident; psychiatric disorder compromising compliance with treatment; and life-expectancy < 2 years. A number of comorbidities may be tolerated and individually should not contraindicate an LVAD on a case-by-case basis. Reversible and disproportionate postcapillary pulmonary arterial hypertension is not a contraindication if RV function is preserved or only altered slightly. Moderate renal failure in relation to an acute or chronic cardiorenal syndrome should recover in line with the improvement in peripheral blood flow [16]. A history of cancer considered as cured and a slowly evolving cancer that is well controlled by specific treatment are not contraindications for an LVAD. A history of thoracotomy does not contraindicate LVAD surgery but may affect the route of access for the intervention and the model of assistance. The presence of a mechanical mitral valve is associated with a high risk of embolism and a replacement by a bioprothesis should be discussed. Aortic regurgitation is a contraindication if it is not cured during the procedure. An apical thrombosis has to be tracked before implantation. Clinicians should be particularly vigilant for denutrition, which should be corrected before surgery. The presence of

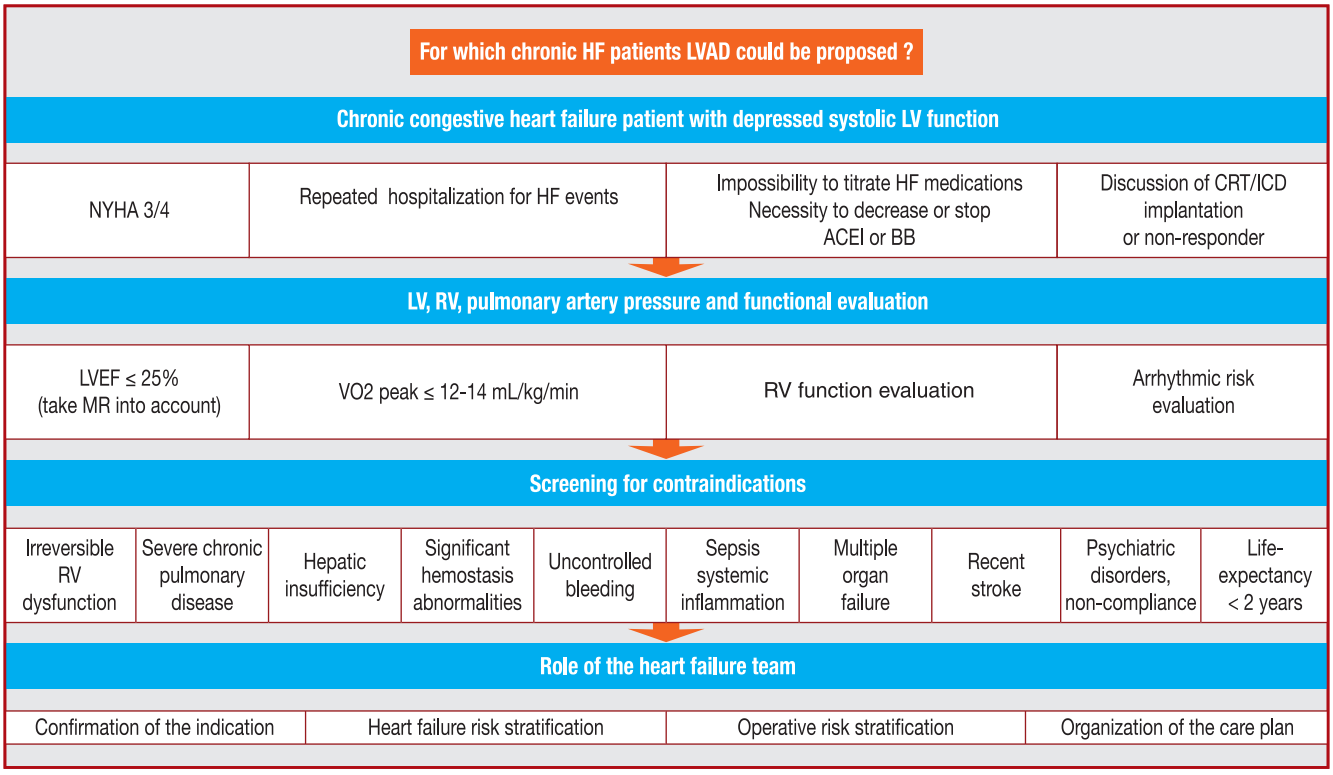

Figure 2. For which heart failure patients could left ventricular assist device be proposed? ACE-I: angiotensin-converting enzyme inhibitor; BB: beta-blocker; CRT: cardiac resynchronization therapy; ICD: internal cardiac defibrillator; LVEF: left ventricular ejection fraction; MR: mitral regurgitation; NYHA: New York Heart Association; RV: right ventricle.

well-controlled and uncomplicated diabetes is not a contraindication. However, a combination of several relative contraindications will lead to a definitive contraindication; for example, age, poorly controlled diabetes, renal failure and arteriopathy together in the same patient will strongly affect the operative risk and should contraindicate the patient.

Confirmation of the cardiological indication

Assessment of right ventricular function

One priority of the cardiovascular assessment is a thorough evaluation of right heart function [17]. Evaluation of RV function should always take into account pulmonary pressure values and vice versa. Slightly raised or normal pulmonary pressure in the presence of indicators of RV systolic dysfunction does not rule out the presence of increased pulmonary resistance and should raise the possibility of postoperative right HF. RV dysfunction is one of the complications that significantly increases morbidity and mortality after an LVAD implantation [18]. The frequency of this complication ranges from 20—30% depending on the severity of preoperative dysfunction and the type of assistance. However, the frequency has decreased since the use of continuous flow LVADs [4] and a transient RV assist device is not always necessary. Before elective surgery, RV dysfunction can be decreased by optimization of volaemia and haemodynamics by systematic preoperative management [19]. At an advanced stage of HF, evaluation of the risk of postoperative right decompensation is complex and several scores have been described and appear pertinent for determining the assistance strategy and the need for biventricular assistance. These scores take into account a number of clinical, haemodynamic, echocardiographic and biological factors: alteration of RV stroke work index ($< 300\,mmHg/mL/m^2$); central venous pressure > 16—18 mmHg; mean pulmonary pressure < 25 mmHg and low diastolic pressure < 15 mmHg under perfusion of positive inotropes; increase in pulmonary vascular resistance; echocardiographic signs of altered RV systolic function; decreased systolic arterial pressure ≤ 96 mmHg; bilirubin ≥ 2.0 mg/dL; creatinine > 1.9—2.3 mg/dL; aspartate aminotransferase ≥ 80 IU/L; ascites; multiorgan failure (oliguria, increase in international normalized ratio); or need for vasopressors [20—24]. Invasive measurement of pulmonary pressure and its reversibility is systematic and must be carried out by the HF centre doing the implantation; it is also important that this evaluation is carried out before the initiation of ECMO. The pharmacological test uses a combination of positive inotropes, intravenous and inhaled (nitric oxide) pulmonary vasodilators and diuretics in order to optimize central venous pressure, capillary pressure, transpulmonary gradient and systemic and pulmonary vascular resistance. This optimization enables the accurate evaluation of RV systolic function. Kormos et al. [19] showed that 84% of patients who did not have RV

dysfunction at the time of implantation of an LVAD had systolic pulmonary pressure > 52 mmHg, while only 5% of patients with RV dysfunction had raised pulmonary pressure. Several studies have also highlighted the value of measuring the contractile reserve at the time of pharmacological testing; at the advanced stage of HF and despite the presence of both pulmonary arterial hypertension and RV systolic dysfunction, perfusion of dobutamine may reveal the existence of a contractile reserve in the form of an increase in pulmonary pressure and tricuspid annular plane systolic excursion [25].

Operative risk evaluation

Scores for operative risk specific to LVAD implantation have been validated. These take into account general state, nutritional status, renal and hepatic dysfunction, haemorrhagic risk, right cardiac dysfunction and use (or not) of vasodilators. Their role is to help medicosurgical teams to decide the indication, stratify patients with different degrees of risk and evaluate the change in risk after therapeutic optimization [15,26].

Confirmation of the indication

The general evaluation of the patient should attempt to eliminate a permanent or relative contraindication. In particular, neurological investigations (brain scan or magnetic resonance imaging) should evaluate the presence of a preoperative stroke. Intestinal investigations (oesophagastroduodenal fibroscopy, colon scan) should look for potential causes of digestive bleeding, as an increased risk in patients with continuous flow circulatory assistance has been described. Urological and gynecological investigations are also carried out systematically. All concurrent ailments and infections should be treated before the intervention.

Psychiatric and psychological consultations should be carried out because mood disorders are often difficult to diagnose at this stage and their treatment is essential in the context of the long-term follow-up of LVAD patients. Psychological follow-up should take place systematically. It is crucial to meet with the patient's family because, despite recent progress, LVAD patients depend on their relatives, who should be capable of taking over from them in managing the electrical supply. Assessment of the patient's relatives is therefore important before assistance and their education is required. A meeting with an assisted patient should be proposed systematically.

Strategy and follow-up of advanced heart failure patients

Several clinical situations may present (Fig. 3). Most often, the haemodynamic state is unstable, the patient is dependent on inotropes, the period of national priority on the waiting list has not resulted in a graft and the indication for an implant has been confirmed; this will be organized within several days, with (or without) the need for a period of optimization before surgery (treatment of congestion, denutrition, pulmonary infection, etc.). The implant is considered as a bridge until transplantation or a destination therapy.

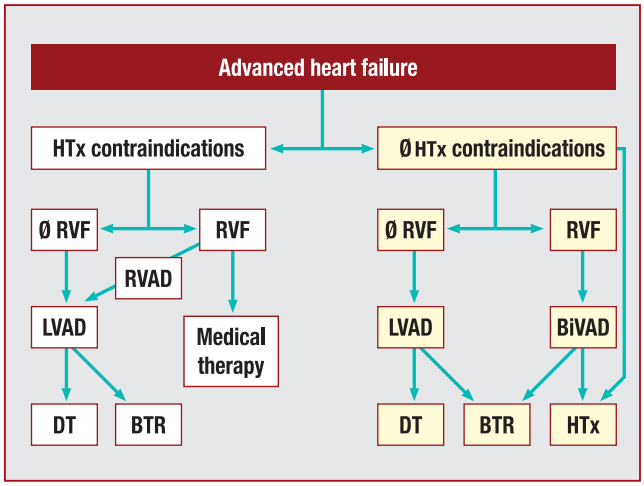

Figure 3. Left ventricular assist device (LVAD) or biventricular assist device (BiVAD) strategies according to clinical profiles. BTR: bridge to recovery; DT: destination therapy; HTx: heart transplantation; RVAD: right ventricular assist device; RVF: right ventricular function.

The second most common situation is that of a patient with class IV non-congestive HF, or class III with recurrent episodes of congestion. In these highly unstable patients, clinicians should consider a decision within a few weeks, allowing a period of reflection for the patient. This is a critical period during which deterioration of right heart function may occur rapidly and close clinical surveillance is mandatory. The follow-up of patients with severe HF for whom an LVAD is being considered but has not yet been decided upon includes monthly visits to the general practitioner and/or cardiologist as well as clinical and biological reassessment at least every 3 months within the reference centre. Echocardiographic monitoring should be carried out every 3 months to detect possible recovery and signs of inverse remodeling; it should systematically evaluate pulmonary pressure and the development of RV dysfunction.

In a number of cases, the indication for an LVAD is not confirmed due to a permanent contraindication or if it appears to be too early or if there is the possibility of optimization of medical treatment. In this situation, alternating follow-up by the cardiologist and an HF centre should be organized on a three-monthly cycle.

The observation of biventricular failure will direct the patient towards heart transplantation or, in the case of instability, towards biventricular bridge assistance or artificial heart until transplantation.

Surgery for left ventricular assist device implantation

A short period of hospitalization prior to surgery is favoured. Surgery for implantation of an LVAD device is currently no more serious than that required for a transplant, and if implantation is carried out correctly, good functioning of the pump is certain, which is not always the case with a heart transplant. The route of approach may be a

vertical median sternotomy or a thoracotomy, depending on the type of assistance. Implantation of an LVAD is carried out with a beating heart, with or without extracorporeal circulation/ECMO assistance. In all cases, the drainage cannula is positioned at the apex of the left ventricle and the ejection tube on the aorta (ascending or descending depending on the approach). Miniaturization of the pumps allows them to be implanted directly in the pericardial cavity and the possibility of not using extracorporeal circulation or only an ECMO system greatly reduces the risk of haemorrhagic complications. Tunellization of the drive line connecting the pump to its external controller should be carried out carefully in order to avoid bleeding, which is a source of secondary infection. Before closure of the thorax, it is important to take precautions to avoid the formation of intrapericardic adherences in order to facilitate reoperation; for this, membranes (resorbable or not) are arranged around the heart and the pump. Peroperative transoesophageal echocardiography is necessary to assess the absence of air in the cardiac cavity, the opening of the right-left shunt, good positioning of the apical cannula, the magnitude of left ventricular flow and RV function. Several factors favour the protection of RV function: implantation with a beating heart, limited left assistance flow in the first few days and decreases in pulmonary arterial pressure. The pre-emptive temporary use of right assistance should be proposed when necessary or without delay or by default if RV failure develops. If implantation is carried out under peripheral ECMO, this should be left in place during closure of the thorax and even longer if necessary, so that the right ventricle is not charged too quickly. Postoperatively, particular attention should be paid to haemostasis, to the quality of left ventricular flow and to RV function. Regular measurement of flow by echocardiography or SvO_2 Swan-Ganz catheter may be necessary as flow estimated by the pumps is not reliable in all situations. Special care should also be paid to immobilization of the percutaneous driveline and to the wound dressing to prevent infection. Experienced nurses and the skills of the intensive care unit are the keys to success.

Organization of ambulatory follow-up of left ventricular assist device

The postoperative period of hospitalization is used to educate the patient and his/her entourage concerning the technical aspects of assistance, wound care of the exit site of the percutaneous drive line, the basic hygiene precautions required and the measures to prevent infection. Before leaving the hospital, the patient should have mastered recharging and replacing of the the batteries, knowledge of the autonomy of the batteries, use of the controller and test procedures, recognition of warning signs/main alarms and management of unusual situations. At least one person in the patient's entourage should be trained to change the battery before authorization is given for the patient to leave the HF unit. The hygiene precautions regarding the wound are crucial and the reference centre should also train the nurse who is responsible for caring for the patient at home. However, some centres train patients to change the wound dressing themselves. Education regarding medical treatment is also given in parallel—particularly the management of anticoagulants. The level of anticoagulation differs slightly depending on the system but the target international normalized ratio is generally around 2; antiplatelet agents are given frequently but not systematically. It is necessary to organize a stay in rehabilitation before the patient returns home, during which they undertake a programme of physiotherapy in order to consolidate muscular reconditioning and train them to perform regularly physical activities. This period enables the reinforcement of education. Before home discharge, a meeting that includes the general practitioner, local nurse, coordinating nurse from the HF centre and the LVAD coordinator and technician can be organized. The HF centre is primarily responsible for the follow-up and the delivery of information to the health care providers and local ambulance service about the specific management of the LVAD patient. The quality of the organization of the ambulatory management is crucial and the reference centre should be organized to respond to care providers and patients' calls or need for assistance on a 24-hour basis, 365 days per year.

Ambulatory follow-up will include an initial monthly follow-up at the HF centre, followed by a visit every 2—3 months. The ventricular assist device coordinator, referent cardiologists and surgeons are involved in the clinical and echocardiographic monitoring, wound control, technical check-up and CRT/ICD monitoring. Transient opening and remodeling of the aortic valve should be monitored, as well as RV function and tricuspid insufficiency. Medical treatment (ACE inhibitors, AA2 antagonists, beta-blockers, mineral receptor antagonists, diuretics) is maintained but arterial pressure should not be decreased too markedly and mean systemic arterial pressure should stay above 80 mmHg to insure sufficient pump flow. Irrespective of the aetiology, 2—4% of patients may recover and this should therefore be monitored during follow-up. Inverse remodeling may be progressive. Recovery of functional capacities can be studied using the exercise test VO_2 (at months 3, 6 and 12 of follow-up). Ventricular arrhythmias should be detected systematically and treated. Psychological follow-up is very important and interviews should be proposed systematically to the patient.

Regular meetings should also be held with the patient's entourage. Travel is allowed as well as driving a car. Air travel is possible but the airline company should be warned in advance of the constraints of batteries and the possible need to use an electrical supply during the flight. A reference centre close to the travel destination should be contacted in advance and the location conveyed to the patients and their family.

Conclusion

Dramatic improvements in survival and quality of life have been observed during the past 5 years in LVAD patients in relation to technical progress. LVADs are now part of the treatment of HF patients as bridges to transplantation or as destination therapy. Clinical cardiologists have to be aware of this important evolution in the context of increasing numbers of advanced HF patients. The cardiological community should master recognition of the severity of advanced HF

patients as patient selection and timing of implantation are the keys to success.

Disclosure of interest

JNT: advisory activity for Thoratec.
PL: advisory activity for Thoratec, Terumo, Syncardia, Berlinheart.
OB: acting as main investigator for Berlinheart.
CL: no conflict of interest related to the article.
CG: expert/survey report for Thoratec.
JPG: no conflict of interest related to the article.
FB: no conflict of interest related to the article.
MCI: no conflict of interest related to the article.
DL: no conflict of interest related to the article.
RI: no conflict of interest related to the article.

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