Perioperative Management of the Right and Left Ventricles

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KEYWORDS

• Left ventricular assist device (LVAD) • Heart failure • Preoperative care • Intraoperative care
• Right ventricular failure • Extracorporeal membrane oxygenation (ECMO)

KEY POINTS

- The greatest risk of death after left ventricular assist device is within the early postoperative period, with in-hospital deaths accounting for two-thirds of all deaths in the first year.
- Preoperative strategies to reduce mortality emphasize medical and mechanical support of the left and right ventricles to improve volume status and organ perfusion; improving nutrition, hematologic abnormalities, and renal function; and reducing infection risks.
- Intraoperative approaches highlight anesthesia related issues, management of concomitant valve disease, right ventricular failure, and weaning from cardiopulmonary bypass.
- Early postoperative efforts concentrate on augmenting right ventricular function, addressing pulmonary hypertension, supporting other end-organ recovery, and quickly identify potential complications.

INTRODUCTION

A majority of patients with heart failure with reduced ejection fraction respond to guideline-directed medical therapy and device therapy. Despite optimal treatment, however, approximately 10% of patients progress to advanced heart failure characterized by progressive symptoms, poor quality of life, poor prognosis, and high risk of recurrent hospitalizations.[1] For appropriately selected patients with advanced heart failure, left ventricular assist devices (LVADs) can provide significant improvements in survival and quality of life.[2,3] As a consequence, rates of LVAD implantation have grown tremendously over the past decade.[4]

Even with improvements in device technology, risk stratification, and patient management, LVAD support remains associated with high morbidity and mortality.[4] There has been a modest improvement in intermediate and long-term survival in recent years, but short-term mortality after LVAD implant remains high and is essentially unchanged over eras (**Fig. 1**).[4] The greatest risk of death after LVAD remains during the implant hospitalization with in-hospital deaths accounting for two-thirds of all deaths in the first year.[5]

Numerous preoperative risk factors correlate with adverse outcomes after LVAD implantation. These include older age, presence of cardiogenic shock Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) Profiles 1 to 2 (**Table 1**), need for concurrent right ventricular (RV) support, preimplant dialysis, and increased surgical complexity.[4] Other laboratory findings predictive of in-hospital death after

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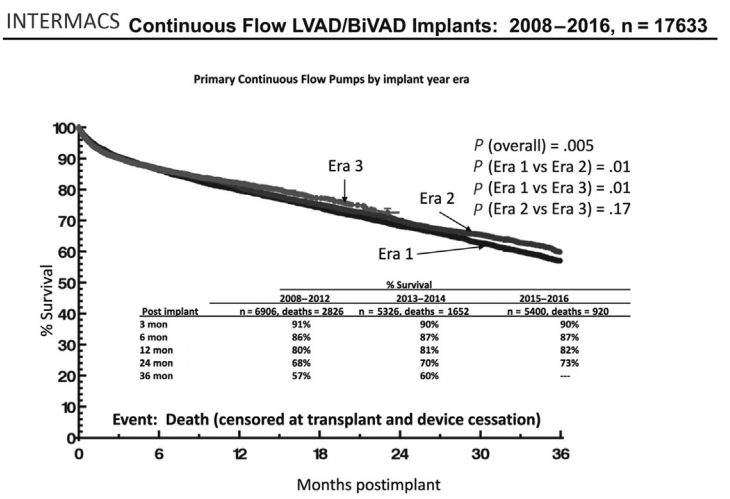

Fig. 1. Kaplan-Meier survival after continuous flow ventricular assist device implant, stratified by era at the time of implant. BiVAD, biventricular assist device. (*From* Kirklin JK, Pagani FD, Kormos RL, et al. Eighth annual INTERMACS report: special focus on framing the impact of adverse events. J Heart Lung Transplant 2017;36(10):1081; with permission.)

LVAD implant include decreased platelets, elevated international normalized ratio (INR), elevated creatinine, leukocytosis, hypoalbuminemia, and elevated transaminases.[5] These variables are often used to assist in LVAD patient selection and have been combined into numerous risk scores to predict which patients will be successful with LVAD support.[5,6] Numerous perioperative strategies to modify these known risk factors have evolved in an effort to improve LVAD outcomes.

OPTIMIZATION OF THE LEFT VENTRICLE

Previously reserved for short-term support of patients in cardiogenic shock, LVADs have improved sufficiently to allow for intermediate and long-term support in patients waiting for cardiac transplant or as destination therapy in the transplant ineligible. Yet, patients in progressive cardiogenic shock have worse survival (**Fig. 2**) and longer lengths of stay than "less sick" inotrope dependent patients.[4,7] Accordingly, the percentage of LVAD implants in stable, inotrope dependent patients (INTERMACS Profile 3) has steadily increased since 2008.[4] Despite this, delays in the recognition of advanced heart failure or delayed referral to a tertiary center have kept the proportion of patients implanted in cardiogenic shock (INTERMACS Profile 1) stable at 14% to 16%.[4] With limited medical options to optimize left ventricular (LV) function in cardiogenic shock, there is a definitive role for temporary mechanical circulatory support in these situations. Temporary

Table 1
Interagency Registry for Mechanically Assisted Circulatory Support Profiles

Profile	Description	Details
1	Critical cardiogenic shock: crashing and burning	Life-threatening hypotension despite rapidly escalating inotropic support, with critical organ hypoperfusion
2	Progressive decline: sliding on inotropes	Declining function despite intravenous inotrope support
3	Stable but inotrope dependent: dependent stability	Stable on continuous intravenous inotrope support
4	Resting symptoms: frequent flyer	Patient experiences daily symptoms of congestion at rest or with activities of daily living
5	Exertion intolerant: housebound	Patient comfortable at rest and with activities of daily living but unable to engage in any other activity
6	Exertion limited: walking wounded	Patient has fatigue after the first few minutes of any meaningful activity
7	Advanced NYHA class III: NYHA IIIb	Patients living comfortably with meaningful activity limited to mild physical exertion