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Review Article | SOJ Surgery | Open Access

Lvads: A Two-Sided Dilemma when Buying Time for Heart Transplantation

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Received: 11 January, 2017; Accepted: 23 February, 2017; Published: 04 March, 2017

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Abstract

Our ageing population is experiencing an unprecedented level of heart disease. Medical therapy is often inadequate in those with end-stage heart failure. Mechanical cardiac support devices are becoming increasingly utilized as a means of both bridging these patients to heart transplant and as destination therapy. However, they are far from risk-free. This review encompasses the complications associated with left ventricular assist devices (LVADs), including their often-unpredictable effects on the right ventricle.

Review

Lifetime risk of heart failure is approximately 20% and the one-year mortality rate of end-stage heart failure is in excess of 50% [1,2]. Heart transplantation is the gold standard therapy for end-stage heart failure. Despite improvements, heart donation rates in Australia remain inadequate [3] and prior to the advent of mechanical circulatory support up to 20% of patients on the waiting list died [2-5].

By alleviating left ventricular (LV) strain in a failing heart, left ventricular assist devices (LVADs) are used to buy time for patients on the heart transplant waiting list and are now the destination therapy for patients denied transplant [2, 5]. Patients are chosen for LVAD based on criteria that indicate cardiac and organ status, for example pulmonary capillary wedge pressure and cardiac index [6]. The updated scale for classifying heart failure and the need for mechanical circulatory support, the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) determines suitability for LVAD [6]. Continuous-flow LVADs, which involve a single moving part, the propeller, are being used in increasing numbers, largely supplanting pulsatile devices. These draw and propel blood continuously, delivering it from the apex of the LV, or other inflow sites such as the left atrial appendage, via an inflow cannula to the aortic root through an outflow graft. By stabilizing haemodynamics and ameliorating end organ dysfunction, LVADs bridge patients to transplant with up to 90% survival [4, 7, 8]. Whilst patients treated solely by medical interventions are left greatly debilitated, most LVAD patients return to daily activities - and even exercise - with reduced readmission to hospital [5, 9].

Right ventricular failure (RVF) is a leading cause of LVAD failure. Estimates of incidence of RVF following LVAD implantation vary from 5% [10] to 35% [11]. Perioperative and overall mortalities are increased by approximately 19-44% and 20-23% respectively in LVAD patients with RVF [4,11,12]. LVAD patients are considered to have refractory RVF when requiring more than 14 days of intravenous inotropic support, over 48 hours of inhaled nitric oxide support or right ventricular (RV) mechanical assistance after LVAD insertion [4, 10]. Mechanical assistance is required when a patient is unable to be weaned from cardiopulmonary bypass [4, 12, 13]. The right ventricular assist device (RVAD) is the most common device used for mechanical assistance of the RV. Patients fare better with expedited RVAD insertion and hence multiple attempts have been made to predict RV deterioration in patients receiving a LVAD [4,8,12,14,15].

Complicating the matter of RVF is the unpredictable return of RV function days and weeks after a LVAD relieves RV afterload [8,14,16-18]. Because a LVAD relieves pulmonary capillary wedge pressure, a structurally normal RV may regain function following temporary mechanical support [8,17,18]. Hence temporary RVAD placement has recently gained popularity [19-21]. Once the RVAD is removed patient survival to transplant returns to levels experienced with isolated LVAD implantation [22,23]. Alternatively, short-term use of veno-pulmonary arterial extra-corporeal membrane oxygenation (VPA-ECMO) can be implemented [17]. VPA-ECMO has the advantage of extracorporeal membrane oxygenation. This ensures complete oxygenation of the patient's blood, which potentially benefits the ailing myocardium, particularly in hypoxic patients[24]. For this reason, in a study by Bhama et al., 2009, six of 35 patients requiring RVAD required intraoperative exchange of RVAD for veno-arterial ECMO [19].

Multiple other factors must be considered before and after LVAD insertion. The balance between bleeding and thrombosis in LVAD recipients is of utmost importance. The operative inflammatory milieu, coupled with the presence of aforeign body and altered haemodynamics makes atrial, ventricular and pump thrombosis a high risk with potentially catastrophic consequences [25,26]. Thromboembolism affects under 5%

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of LVAD patients with modern pumps [25,27]. Previous acute myocardial infarction, cannulation of the left atrial appendage and postoperative bleeding all increase the likelihood of thrombosis with LVAD therapy [25]. Continuous-flow LVADs appear to be of similar risk to pulsatile LVADs, even with variable adherence to INR targets [27]. A combination of prophylactic aspirin therapy (with or without an additional antiplatelet) and warfarinisation to an INR of 2-3 (or even 1.5-2.5) is reasonably employed in continuous-flow devices, but is dependent on the LVAD manufacturer [2,26,28,29]. Thromboembolic prophylaxis increases the risk of bleeding [28]. Approximately 10% of patients with continuous-flow LVADs develop gastrointestinal (GI) bleeding requiring blood transfusions [30]. Others have reported much higher rates of GI bleeding - up to 40% - much higher than pulsatile devices [28,31]. A past history of GI bleeding, particularly if recent, must be carefully considered before LVAD implantation [30]. Bleeding is not only troubling in the short term but the potential need to withhold blood thinners increases the subsequent likelihood of thrombo embolism [28].

LVAD recipients are susceptible both to infections unrelated to the device (urinary tract infection, pneumonia etc) and those complicating the various foreign bodies used in the therapy. In a review of 247 LVAD recipients at their institution, Nienaber et al found infection of the percutaneous driveline to be the most common LVAD-related infection and the most common cause of septicaemia in these patients [32]. Owing to the high prevalence of bacterial colonization, diagnosis of driveline infections can be difficult andimaging with ultrasound or CT is often vital for identifying and defining any associated abscess. Infections should be treated aggressively so as to prevent blood stream infection [32-34]. If a diagnosis of blood stream infection is made, it may involve the LVAD and this must be determined early. Intraoperative device cultures are the gold standard for this purpose but TOE is more commonly employed as a first-line measure [33]. Clinical suspicion is raised if a blood stream infection fails to respond to appropriate antibiotics. Whilst replacement of infected LVADs is optimal, it is performed at great risk and only if lifelong antimicrobial suppression has failed [29,32,33].

LVADs are an exciting addition to the armamentarium forcombating heart failure. However, once used, it is far from an easy patient journey. Consequently, LVAD technology and the understanding and prediction of LVAD complications, such as RVF, must continue to improve.

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