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The importance of coronary artery disease and special considerations for left ventricular assist device implantation

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Congestive heart failure (CHF) is one of the leading global healthcare problems, with an estimated worldwide prevalence of twenty-five million people (1). The shortage of healthy donor hearts gives rise to the need for alternative treatment options. Left ventricular assist devices (LVADs) have shown excellent outcomes in patients with CHF (2) and in those bridged for heart transplantations (3). LVAD is seen as a cornerstone of surgical treatment for patients with advanced heart failure, currently exceeding that of annual heart transplantations (4). Acute myocardial infarction (MI) and chronic ischemic cardiomyopathy are major indications for LVAD implantation. Persistent coronary artery disease (CAD) is typically not addressed during LVAD implantation, and yet it remains an important adverse risk to be considered after LVAD implantation.

In patients with preoperative ischemic cardiomyopathy and CAD-related risk factors, there is very low incidence of clinically relevant events and subsequent interventions. Adverse events during and after LVAD implantation are the “Achilles heel” of an otherwise highly successful procedure. Yet, the increase in combined surgery with subsequent increased risk of adverse events is duly noted. Combined surgery, including aortic, mitral and tricuspid valve surgery have become common, with incidence risen up to 35%, especially to prevent post-LVAD adverse events (5). Likewise, concomitant coronary artery bypass grafting (CABG) can also be performed to prevent post-LVAD events, yet the benefit of concomitant CABG has been questioned (6). LVAD with concomitant CABG was associated with a decreased survival, while

no reduction in early right ventricular (RV) failure was noted. In specific patients with preoperative severe RV dysfunction, concomitant CABG may yield benefit. Currently, a high incidence of early RV failure and early ventricular arrhythmias (up to 25%) are seen after LVAD implantation (7). Optimal coronary artery flow has been argued to reduce postoperative adverse events due to the positive impact on RV function.

Patients with severe ischemic cardiomyopathy (left ventricular function $\leq 30\%$) are also prone to developing severe ischemic mitral regurgitation. CABG with concomitant mitral repair has been the standard treatment in those patients with a 5-year survival of 51% (8). Nevertheless, a paradigm shift in the use of long-term mechanical support devices has led to the increase of LVAD use as destination therapy in patients with end-stage ischemic cardiomyopathy due to the unavailability of coronary targets or non-viability of the myocardium, with similar acceptable outcomes (9). LVAD is an effective treatment strategy if performed promptly and should always be considered early for patients with MI and severe left ventricular dysfunction. The coronary endothelial function does not worsen by long-term LVAD support and is in fact, improved.

Whether increased coronary blood flow due to CABG would reduce postoperative complications remains unanswered. While the risk factors and mechanisms of RV failure (RVF) are multifactorial, mostly attributed to changes in RV preload, RV afterload and RV contractility (10), concomitant CABG with LVAD increases cardiopulmonary

bypass time. Prolonged cardiopulmonary bypass duration has been independently associated with prolonged cardiac stunning and subsequently, increased post-operative morbidity and mortality in LVAD as well as cardiac surgery (10).

Special considerations

We believe there are special situations that merit discussion and thorough evaluation during the pre-operative phase. In patients with recent stent placement, it is critical to maintain a consensus on the management of peri-operative antiplatelet agents, a therapy-guided use of blood products, an avoidance of hypotension, and an increased awareness of risk of postsurgical coronary re-stenosis. Several of these factors alone or in combination can lead to early post-operative coronary complications. Postoperative RV failure or refractory arrhythmia can be related not only to LVAD placement, but also with coronary re-stenosis. The development of acute RV dysfunction and recurrent ventricular ectopy has been associated with early stent re-stenosis. Early coronary angiogram and percutaneous re-opening of the right coronary artery however, normalizes RV function and resolves ventricular arrhythmias.

In patients with previous coronary artery bypasses, it is critical to obtain a recent coronary angiogram to evaluate coronary anatomy prior to re-entry, but also to ascertain the topography of right-system coronary circulation. Patients with ischemic heart disease can be dependent on bypasses for right coronary circulation. The left internal mammary graft can potentially be the only source for collateralization to a large right-sided system. Injuries to the graft by sternal re-entry or amputation of distal left anterior descending artery (LAD) by apical placement of the LVAD can result in acute RV failure. A subsequent loss of RV perfusion from collateral flow amputation can result in peri-operative adverse outcomes. In these cases, ensuring the LVAD placement is kept safely away from the LAD becomes critical. A prophylactic graft to the right coronary artery or alternative placement using left thoracotomy anterolateral placement could help protect coronary perfusion.

CAD can present with acute MI complicated by left ventricular dysfunction (LVEF \leq 30%). Although, with early revascularization, LVAD implantation should be considered. The timing of LVAD implantation to prevent cardiogenic shock remains a topic of debate, yet early unloading of the infarcted myocardium has improved overall outcomes in patients who do not respond to medical therapy (11). Acute

MI can lead to the development of left ventricular aneurysm and conveys risk for adverse events (such as ventricular arrhythmias, thromboembolism, and even rupture). Left ventricular aneurysmectomy during LVAD implantation is indicated when there is (I) a thin scar wall of the aneurysm predicted to cause subsequent hemodynamic disturbances, and (II) clot formation in the aneurysmal sac. Therefore, LVAD implantation can be combined with concomitant modified endoventricular circulo-plasty (the Dor procedure). The left ventricular aneurysmal sac is opened, thrombotic material is removed, and the transition zone between the scar and viable myocardial muscle is identified. Two purse-string 2-0 Prolene sutures are placed circumferentially at the transition zone and tied after the LVAD pump is secured to the ring to compensate for eventual size discrepancy between the pump and left ventricular opening. The apical ring of the LVAD is then sutured with multiple circumferential pledgeted sutures (12).

LVAD remains an effective treatment strategy and should be considered in patients with CAD and left ventricular dysfunction. Vigilance for unexpected complications in patients with previous CAD and with previous revascularization should be maintained.

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Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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