Optimal Timing of Left Ventricular Assist Device Implantation for Severe Heart Failure Patients
– Focus on End-Organ Function Not Hemodynamics –

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In this issue of the Journal, Yoshioka et al present their results of left ventricular assist device (LVAD) implantation and a retrospective analysis for determining the preoperative factors for 90-day mortality, comprising 3 independent analyses. Firstly, the authors divided all patients into 2 groups according to the Interagency Registry for Mechanically Assisted Circulatory Support (INTERMACS) profile: level 1 (n=41) and level 2/3 (n=43). Naturally, preoperative laboratory variables reflecting infection and multi-organ function were worse in the level 1 group than in level 2/3. The postoperative comorbidities were also more frequent in the level 1 group. Secondly, they focused on the preoperative predictor for 90-day mortality. Notably, they compared the early clinical results with Nipro LVAS (formerly known as Toyobo) between the 2 groups to eliminate a device selection bias. Regardless of Nipro LVAS support, 90-day mortality and comorbidity rate were higher in the level 1 group than in the level 2/3 group. The key finding of this subset analysis is that the mortality rate from 90 days after Nipro LVAS implantation was quite similar between the 2 groups. The multivariate analysis identified preoperative creatinine level (>1.96 mg/dl) as an independent predictor of 90-day mortality. Notably, they compared the early clinical results with Nipro LVAS (formerly known as Toyobo) between the 2 groups to eliminate a device selection bias. Regardless of Nipro LVAS support, 90-day mortality and comorbidity rate were higher in the level 1 group than in the level 2/3 group. The key finding of this subset analysis is that the mortality rate from 90 days after Nipro LVAS implantation was quite similar between the 2 groups. The multivariate analysis identified preoperative creatinine level (>1.96 mg/dl) as an independent predictor of 90-day mortality. According to third subset analysis of the effect of preoperative ECMO support on early mortality, identified as an independent risk factor for mortality in the intensive care unit, preoperative creatinine level <1.96 mg/dl also led to better prognosis in the level 1 group.

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The optimal timing of LVAD implantation for critically ill patients still remains an unsolved issue. There is no dispute that the INTERMACS classification system serves as a useful metric for risk-stratifying candidates for LVAD. The authors concluded that the more stable the patient’s preoperative condition when LVAD implantation was performed, the better the clinical outcome. Considering what this conclusion provides us, we must not discount the article by Saito et al. The simultaneous requirement of right ventricular assist device (RVAD) at LVAD implantation was identified as a strong risk factor for long-term mortality. RVAD was also an independent factor for device-related infection. On the other hand, serum total bilirubin and creatinine levels, and preoperative ECMO support were identified as independent factors for RVAD. What should we learn from this “two-part work” from Osaka, one of the leading institutes of integrated heart failure treatment in the country?

It is important to differentiate between the risk factors for early and late mortality because the cause of death differs according to the time period from LVAD implantation. Multi-organ failure (MOF) was a leading cause of 90-day mortality in Nipro LVAD patients (6/10) in Yoshioka et al’s study, whereas cerebral vascular accident (CVA), including both thromboembolism and hemorrhage, was a leading cause of long-term mortality (25/63), followed by sepsis and MOF in Saito’s study. Moreover, the rates of mortality were quite similar between the INTERMACS level 1 and 2/3 groups, regardless of Nipro LVAS support. Considering that MOF is mostly preexisting, early LVAD implantation before progressive deterioration of end-organ function is supposedly a key to improving outcome.

There are 2 possible reasons why MOF was a leading cause of early mortality after LVAD implantation. First, the optimal timing of the surgical intervention was missed and consequently MOF become irreversible despite all treatment, including sufficient perfusion for the damaged organs with LVAD. Therefore, much effort has been made to find the preoperative parameters as determinants of LVAD implantation. Considering that previous studies have demonstrated that preoperative laboratory variables reflecting end-organ function were independent predictors for mortality rather than hemodynamic variables, the optimal timing of LVAD implantation should be based on end-organ function.

Another conceivable reason was that the invasiveness of LVAD implantation itself could make severely damaged but reversible organs irreversible. To avoid this paradoxical situation, we should refine the strategy for patients in the “crash and burn” status. The most important issues in the salvaging and stabilizing of the moribund patient, mostly with questionable neurologic status and MOF, are both rapid sufficient organ perfusion and less invasive procedures. The ideal ventricular assist device and operative technique satisfying these concepts have been developed for years.

Several percutaneously inserted temporary LVADs have been introduced recently. TandemHeart (Cardiac Assist, Pittsburg, CA, USA), developed around a completely percutaneous concept, consists of a centrifugal pump with a hydrodynamic...
fluid bearing and a transseptal cannula, which is positioned in the left atrium by the Brockenbrough maneuver. This blood pump is capable of delivering up to 5L/min of blood flow. Brinkman et al have demonstrated the short-term use of TandemHeart for patients (n=22) with INTERMACS level 1 status with the indication as bridge to decision or transplantation. In particular, the average time required for insertion was 62±24 min, with fluoroscopic guidance and transesophageal echocardiography. The Impella LP 5.0 (Abiomed, Danvers, MA, USA) is an axial flow pump for isolated left ventricular failure. This endovascular system consists of an inflow tip positioned in the left ventricle and the outflow in the aorta, introduced via the femoral artery after a vascular cut down. Higgins et al have reported that the Impella LP 5.0 was successfully used for 29 patients in profound cardiogenic shock due to left heart failure with various etiologies. Unfortunately, these percutaneous VADs are not commercially available in Japan at present.

Likewise, devices and techniques for quick and less invasive establishment of biventricular support should be considered. Median sternotomy should not be avoided because drainage from the apex of the left ventricle is more suitable than from the left atrium to obtain sufficient perfusion and reduce the risk of the intracardiac thrombus. Most patients in INTERMACS level 1 suffer from severe pulmonary edema, congestive liver dysfunction and acute renal failure. Therefore, biventricular support with or without extracorporeal membrane oxygenation would be absolutely imperative to restore end-organ function as rapidly as possible.

The ideal circuit is considered to consist of a durable centrifugal pump capable of generating more than 5L/min of blood flow and an inflow cannula enabling easy and quick insertion. The Levitronix CentriMag (Levitronix LLC, Waltham, MA, USA) is ideal for this purpose because it generates as much as 10L/min flow and is capable of support for as long as 30 days with a low risk of thromboembolism. The Rotaflow Centrifugal Pump (MAQUET Cardiopulmonary AG, Hirrlingen, Germany) is a centrifugal pump that is available in Japan, and it also provides around 10L/min of blood flow. Although both of these centrifugal pumps have excellent hemodynamic characteristics, Yulong et al have demonstrated that the Rotaflow has a better performance than the CentriMag. With regard to the clinical setting, Kashiwa et al have reported more than 30 days’ use of temporary LVAD with the Rotaflow as a bridge to decision and recovery. A novel inflow cannula called the “Lantern cannula” fills the requirement. This cannula with a lantern-shaped tip enables easy and quick insertion via the apex of the left ventricle. Sumikura et al have demonstrated its superior hydrodynamic characteristics in terms of pressure loss.

A crucial factor for a better outcome after LVAD implantation is optimal patient selection. Two articles from Osaka substantiate that LVAD implantation in a patient in a stable condition with preserved end-organ function leads to better clinical outcome for patients with severe heart failure. In reality, the patient with advanced MOF resulting from prolonged low cardiac output is often delivered. How should we treat such a critically ill patient? There is increasing evidence that temporary VAD therapy as a bridge to decision or bridge would play an important role. Similarly, the devices suitable for temporary VAD have been developed and introduced into the clinical setting. A further concern would be how to decide the optimal timing of conversion to implantable VAD after temporary VAD support.

References