Right Ventricular Failure
– A Continuing Problem in the New Era of Left Ventricular Assist Device Therapy –
Goro Matsumiya, MD, PhD

The discrepancy between the limited availability of heart donors and the ever-increasing number of patients suffering from end-stage congestive heart failure (CHF) has led to a growing interest in alternatives to heart transplantation. Among these, the use of left ventricular assist devices (LVAD) has shown significant growth during the last several years. The LVAD has been utilized mainly as a bridge to transplantation since the 1980s. However, recent technological advancements, especially the introduction of continuous flow pumps, have enabled longer and safer mechanical support. As a result, destination therapy (ie, life-long support for advanced CHF patients) has become the most common indication of LVAD treatment in the United States, where more than 1,600 patients received a LVAD in 2011.1 More importantly, with the rapid development of LVAD technology, there is a gradual but steady shift of candidate selection toward less sick patients.1

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Nevertheless, there still exist inherent risks of LVAD therapy. Besides the major limitations of infection, thromboembolism and mechanical failure, right ventricular (RV) failure is the major early complication leading to increased morbidity and mortality. RV failure results in venous congestion and poor filling and output of the LVAD, which further develops vital organ hypoperfusion. An additional RV assist device (RVAD) is required to overcome the advanced RV failure, but survival of patients requiring biventricular assist device is severely limited.2-4 The pathophysiology of postoperative RV failure is complex. Previous studies have suggested multiple factors, including RV myocardial dysfunction, elevated pulmonary vascular resistance and right and left ventricular interaction, play a role in the setting. RV myocardial dysfunction might be unmasked by the increased preload afforded by a LVAD. The presence of RV failure is associated with longer cardiopulmonary bypass time during surgical intervention and subsequent need for more transfusion, which further increases pulmonary vascular resistance. Unloading of the LV creates a sepsis shift toward the LV, which alters the RV geometry and impairs contractility.7 Several past studies tried to establish a scoring system to predict RV failure after LVAD implantation by combining clinical, hemodynamic and laboratory parameters. However, the past literature does not yet support a consensus on which preoperative parameters can be used to predict the need for biventricular support.5-6

In this issue of the Journal, Shiga et al8 describe their original RV failure risk score derived from 79 patients who underwent LVAD implantation. Among them, 9 patients (11.4%) required a biventricular assist device and they had significantly worse survival than patients requiring LVAD only. The authors RV failure score consists of a central venous pressure (CVP)/pulmonary capillary wedge pressure (PCWP) ratio >0.5, body surface area (BSA) <1.4 m², requirement for continuous hemodiafiltration (CHDF), brain natriuretic peptide level >1,200 pg/ml, and LV diastolic dimension (LVDD) <62 mm. More advanced CHF and severe multi-organ failure manifesting as elevated creatinine and bilirubin levels, or requirement of ventilator and CHDF have been identified as RV failure risk factors in many previous studies.1-6 Smaller BSA has been also identified as a risk factor.6,8 One study attributed this to a higher prevalence of myocarditis as the etiology of heart failure in younger and smaller patients.6 Shiga et al suggested diastolic cardiomyopathy in younger populations genetically affects the RV more severely,8 but no other previous report has demonstrated a smaller LVDD as a RV failure risk factor. Although the authors suspect that decreased preload for the LV resulting from RV dysfunction may be an explanation, this might rather reflect the different etiology of CHF in patients requiring biventricular support. In either case, there may be some difficulty in applying these findings to the general adult CHF population.

RV myocardial dysfunction could be the most significant factor for the requirement of biventricular support. Direct evaluation of RV function is still limited, although recent data suggested several echocardiographic indices, such as RV longitudinal strain, as significant predictors of RV failure.9 Investigators have attempted to define a reliable parameter to quantify RV dysfunction that is independent of LV function. Several past reports have shown that elevated CVP and lower pulmonary artery pressure are associated with a requirement of biventricular assist device. The CVP/PCWP ratio is a combination of those factors and seems to be a simple but reliable predictor of intrinsic RV myocardial dysfunction that can differentiate RV failure resulting mainly from increased left-sided filling pressure. There are several limitations in their study,
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particularly the small sample size and single-center experience, which limit the usefulness and relevance of their study. Many etiologies of heart failure are included in the study population and those with acute heart failure, especially, may have a different pathophysiology from chronic CHF. Predominant use of paracorporeal pulsatile pumps in their study requires cautious implication in current practice where second- or third-generation continuous-flow pumps are mainly utilized. Despite these limitations, the efforts by Shiga et al highlight the importance of careful analysis of preoperative hemodynamic parameters and RV dysfunction to determine optimal timing of LVAD implantation.

Preoperative identification of LVAD candidates at high risk for RV failure has important clinical implications for management strategies. First, optimization of RV function before LVAD implantation can be tried if a patient has a high likelihood of developing RV failure. LVAD implantation can be delayed until the patient’s hemodynamic condition is optimized by aggressive diuretic therapy, CHDF, or temporary intra-aortic balloon pumping. Optimization of the coagulation profile to avoid intra- and postoperative bleeding and subsequent transfusion is also critically important in these patients. Secondly, recent studies demonstrated that in high-risk patients, preemptive RVAD implantation at the time of initial surgery results in improved outcomes compared with delayed conversion to biventricular support. The intraoperative decision to use a RVAD in addition to a LVAD is often a complicated and difficult process. RV failure score may aid surgeons in the selection of patients who may benefit from planned biventricular support. Thirdly, although anecdotal experience has demonstrated possible dual use of implantable continuous flow pumps for biventricular support, the majority of RVAD currently used for long-term support are extracorporeal pulsatile pumps, which require a large control system and have limited portability, thereby offering reduced quality of life. Long-term support with biventricular assist devices exceeding several years has not become a reality, so such patients should be considered poor candidates for destination therapy and instead should be given a high priority for heart transplantation. Lastly, patients with severe RV failure requiring biventricular support are more severely ill with end-organ dysfunction. Earlier indication of LVAD implantation before developing end-organ dysfunction may help avoid the need for biventricular support and improve overall outcomes. RV failure scoring system can help to determine the appropriate timing of LVAD implantation in patients with CHF.

In Japan, because of the stringent restriction of organ procurement, the waiting period for heart donors has exceeded 800 days and more than 90% of the recipients have required LVAD as a bridge to transplantation. Although reliable long-term support is an urgent necessity, the Nipro LVAD, which was designed almost 30 years ago as a pneumatically driven para-corporeal device, had been the only selection for most of these patients. However, in 2010, 2 implantable, continuous-flow LVAD became commercially available as a bridge to transplantation and a new era of LVAD therapy has finally begun. At the same time, the Japanese registry of Mechanical Circulatory Support (JMACS) was established to prospectively accumulate the data from all LVAD recipients in Japan. That scheme will enable a detailed analysis of multicenter data to establish a RV failure risk score and further refine the surgical timing and patient selection for LVAD implantation in the Japanese CHF population.

References

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