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Percutaneous Mechanical Assist for Acute ST Elevation Myocardial Infarction

a report by
José PS Henriques

Director, Catheterisation Laboratory, Academic Medical Centre, University of Amsterdam

Despite considerable improvements in the treatment of acute ST elevation myocardial infarction (STEMI), outcomes have predominantly improved in STEMI patients without cardiogenic shock (CS). Nevertheless, cardiogenic shock occurs in approximately 7–10% of STEMI patients and is the leading cause of death for hospitalised patients. In-hospital mortality rates of STEMI complicated by CS are around 50%, despite reperfusion by primary percutaneous coronary intervention (PCI), the current standard of treatment.1 Currently, two therapeutic approaches can be adopted for STEMI patients presenting with CS or cardiogenic pre-shock to support the endangered circulation and the failing myocardium:

• Pharmacological inotropic support: there is a variety of inotropic and vasopressor agents enabling quick improvement of haemodynamic parameters in CS. However, these agents failed to demonstrate improved survival in randomised studies. Currently, pharmacological circulatory support is listed as a class IIA recommendation.2

• Mechanical left ventricular (LV) support: this modality was made possible in humans first and foremost by the introduction of intra-aortic balloon counterpulsation about four decades ago. Currently, mechanical LV support with an intra-aortic balloon pump (IABP) is listed as a class IB recommendation.2

Intra-aortic Balloon Pump

The IABP was first introduced in the setting of CS in 1968.3 Ever since, and especially after the development of a percutaneous insertion technique, IABP therapy has been increasingly used for several clinical conditions requiring mechanical LV support. In current practice, it is still the most frequently used method of mechanical cardiac assistance in the catheterisation laboratory.

Currently, the main indication for IABP therapy in STEMI – as adjunctive therapy to revascularisation – is CS not quickly reversed by pharmacological therapy. This indication is listed in the American College of Cardiology (ACC)/American Heart Association (AHA) guidelines as a class IB recommendation, although no randomised controlled trials have been performed in CS. In our recently conducted, simultaneously performed meta-analysis of observational studies in STEMI patients with CS, data were significantly affected by confounders.4

Notwithstanding the lack of evidence to support the use of IABP therapy either in STEMI patients or in STEMI patients presenting with CS, it is still a popular treatment strategy. Moreover, it is the only method for mechanical cardiac assistance that is widely available and easily applicable in current practice.

Percutaneous Left Ventricular Assist Devices

Surgically implantable LV assist devices (LVADs) have been shown to provide more effective circulatory support. However, in the setting of STEMI complicated by CS, the applicability of this therapy is limited. Therefore, the development of percutaneous LVADs has been of great interest. More recently, the TandemHeart and the Impella 2.5LP and the Impella 5.0LP have been introduced.5

TandemHeart

The TandemHeart percutaneous ventricular assist device (pVAD) is an extracorporeal, dual-chambered, centrifugal, continuous-flow pump. It is a left atrial to femoral artery bypass system, designed for short-term mechanical LV support (see Figure 1). At a maximum rotational speed of 7,500rpm, the TandemHeart pVAD can deliver a maximum output of 4.0l/min. The device can be inserted in the catheterisation laboratory, under fluoroscopy. The 21Fr trans-septal inflow cannula is first inserted through the femoral vein and positioned in the left atrium, guided by fluoroscopy. The outflow cannula (15–17Fr) is inserted through the femoral artery and positioned at the level of the aortic bifurcation. The implantation procedure takes around 30–45 minutes, but there is a substantial learning curve.

Two randomised trials comparing IABP with TandemHeart have been conducted in STEMI patients with CS. In both of these trials, haemodynamic parameters improved significantly in patients who were supported by the TandemHeart VAD. However, both small studies revealed a high complication rate in the TandemHeart-supported patients. Complications observed included tamponade, major bleeding, critical limb ischaemia, sepsis and arrhythmias. The most important factors contributing to these complications are likely to be the highly invasive and complex insertion procedure and the extracorporeal support method, combined with full high anticoagulation. In a recent review article we performed a meta-
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analysis, including only 74 patients, revealing a slight trend towards an odds ratio (OR) in favour of IABP therapy (OR 1.17, 95% confidence interval [CI] 0.47–2.96; p=0.73).

In conclusion, although the TandemHeart device is capable of delivering effective mechanical LV and circulatory support, the complexity of the device and its high complication rate may impede its widespread use. Nevertheless, it may be useful in specific circumstances. Specifically, the device may be useful if a left atrial approach is required, for instance in the case of aortic valve disease or as a means of percutaneous mechanical circulatory support during aortic valve interventions. Also, it may be a useful treatment option when complexity is less of an issue, for instance in the post-cardiotomy setting.

**Impella**

The Impella LP2.5 and the Impella LP5.0 are catheter-mounted micro-axial blood pumps designed for short-term mechanical LV and circulatory support. Both of these pumps are inserted through the femoral artery and subsequently positioned across the aortic valve into the LV using fluoroscopy (see Figure 2). The Impella LP2.5 can be introduced percutaneously, whereas the larger Impella LP5.0 still requires a surgical cut-down of the femoral artery. At maximum rotational speeds of 33,000 and 50,000rpm, respectively, they produce a maximum output of 2.5 and 5.0l/min, respectively, by expelling aspirated blood from the LV into the ascending aorta.

In the setting of mechanical LV support during elective high-risk PCI, we have previously reported on the safety and feasibility of Impella LP2.5 support. In the setting of acute MI, the safety, feasibility and efficacy of Impella LP2.5 support was studied in patients with large anterior STEMI in the MACH 2 trial. In this non-randomised study, prolonged Impella 2.5LP support was evaluated as adjunctive therapy to primary PCI (n=10) compared with routine care (n=10). Besides demonstrating the safety and feasibility of Impella LP2.5 support, the study revealed an improvement in mean LV ejection fraction (LVEF) from 28% at baseline to 41% after four months in the Impella-supported patients. In the control group, mean LVEF improved from 40 to 45%. These data suggest a beneficial effect of LV unloading on post-infarct LV remodelling and, therefore, a beneficial effect on LV function.

There have also been several studies in the setting of CS. In the ISAR-SHOCK trial, in which 26 STEMI patients with CS were randomised to concomitant Impella LP2.5 support or IABP therapy, Impella LP2.5 support resulted in reduced blood lactate levels. However, no difference in mortality rate was observed. Preliminary data from our database of CS patients treated with either Impella LP2.5 or Impella LP5.0 show that in most cases 2.5l/min of support is insufficient. The Impella LP5.0 was more effective in LV unloading and reversal of CS. A percutaneous method for the insertion of the Impella LP5.0 without the need for surgical cut-down would simplify the use of this device and should therefore be developed.

In conclusion, Impella technology offers the opportunity for mechanical LV support in many clinical settings. Both the Impella LP2.5 and the percutaneously implantable Impella LP5.0 may be the first step towards addressing the need for a minimally invasive and easily deployable mechanical assist device that provides superior haemodynamic support compared with IABP.
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Future Perspectives

In STEMI patients without CS, outcomes have improved considerably. Nevertheless, long-term outcome is strongly affected by LV remodelling, especially in the case of a large MI. Unloading of the LV may beneficially affect the remodelling process. The efficacy of pharmacological LV unloading has been demonstrated. The recently conducted MACH 2 trial suggested the efficacy of mechanical unloading in a clinical setting. To further elaborate on the efficacy of LV unloading and the beneficial effect on LV remodelling, we have recently initiated the IMPRESS in STEMI trial (see Figure 3), comparing mechanical support by IABP versus Impella LP2.5 in STEMI patients with signs of pre-shock. The primary end-point will be LVEF after four months, as assessed by magnetic resonance imaging (MRI). In STEMI complicated by CS we will initiate the IMPRESS in severe shock trial. This trial will compare the effects of mechanical support by IABP versus Impella LP5.0 in STEMI patients presenting with deep CS. The primary end-point will be mortality after 30 days.

Conclusion

Many LV support devices have been developed, but only a few have reached more widespread usage in the catheterisation laboratory. A suitable percutaneous LV support device should be easy to use and powerful in its circulatory support. Mechanical LV support could be beneficial in a variety of clinical settings, but especially in the setting of STEMI. In STEMI patients without CS, the primary purpose of mechanical LV support is myocardial recovery. In STEMI with CS, mechanical LV support is directed at both myocardial and organ recovery. The IABP is currently the most widely available and most easily applicable method of mechanical LV support; however, IABP therapy has failed to improve clinical outcome in randomised trials. Surgical LVADs provide superior haemodynamic support, but many issues withhold their widespread application in the setting of CS.

Shifting the Paradigm

Therefore, after four decades of IABP support, the development and increasing clinical experience with percutaneous LVADs herald the dawn of a new era of superior haemodynamic support as an additional treatment besides primary PCI, which will eventually improve outcome in STEMI patients with and without CS. In the future this may lead to shifting the paradigm from time to balloon to time to circulatory support. At this moment the Impella technology seems to be best equipped for this purpose.