Use of Impella Ventricular Assist Device in Patients with Severe Coronary Artery Disease Presenting with Cardiac Arrest

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Abstract

Keywords

- ▶ ventricular assist devices
- ▶ coronary artery disease
- ▶ percutaneous coronary intervention
- ▶ ST segment elevation myocardial infarction
- ▶ cardiopulmonary resuscitation
- ▶ cardiac catheterization
- ▶ intra-aortic balloon pump

Impella (Abiomed, Danvers, MA) is a percutaneously inserted ventricular assist device (VAD). It has been increasingly used in patients with severe heart failure, cardiogenic shock, and high-risk percutaneous intervention (PCI). However, the use and efficacy of Impella in patients with severe coronary artery disease (CAD) presenting with cardiac arrest has rarely been reported. The objective of this study is to report our center experience in using Impella VAD in CAD patients presenting with cardiac arrest. From December 2010 to March 2011, three patients with severe CAD presented to our center with cardiac arrest underwent PCI with Impella support. We reported three cases of severe CAD presenting with cardiac arrest successfully treated with PCI and Impella support. Our experience demonstrated that Impella VAD may play an adjunctive role in obtaining hemodynamic stability in these high-risk patients undergoing PCI. One of the patients was supported to left VAD implantation, and the other two had excellent neurological and functional recovery. Our reports suggest an important role of Impella in cardiac arrest population. Earlier Impella implantation after cardiac arrest might provide cardiac support and tissue perfusion until recovery or high-risk PCI.

Impella is a miniaturized percutaneously inserted ventricular assist device (VAD) that can be placed via a retrograde approach across the aortic valve using a femoral arterial access. It has been used in patients with heart failure, cardiogenic shock (CS), and high-risk patients undergoing percutaneous intervention (PCI). The device proved easy to implant, performed well, and was associated with a low rate of adverse events. Earlier studies conducted in Europe drew similar conclusions,^{1,2} as did the recently published Europella registry study,³ Seyfarth et al,⁴ Alasnag et al,⁵ and USpella registry by Maini et al.⁶

The device pumps blood from the left ventricle into the ascending aorta and systemic circulation at the upper rate of 2.5 L/min. The Impella Recover LP 2.5 device potentially enables immediate and sustained unloading of the left ven-

tricle while increasing the overall systemic cardiac output and supports patients with CS. Left ventricular unloading with the Impella pump via the transthoracic or femoral approach is feasible and safe. The Impella provides a significant level of hemodynamic support and does not require a stable electrocardiography (ECG) or blood pressure signal to function properly.⁵ Impella supports led to a decrease in pulmonary capillary wedge pressure, increase in cardiac output, mean arterial blood pressure (MAP), and improved organ perfusion in patients with severe CS. Additionally, it was suggested that the device could be potentially useful in high-risk percutaneous coronary intervention.^{7,8}

Compared with other left VADs (LVADs), Impella LP 2.5, the catheter-based, miniaturized rotary blood pump affords easy

Table 1 Indications for PCI and impella support

Particulars	Case 1	Case 2	Case 3
Age (y)	70	75	70
Gender	Male	Female	Female
CAD	Yes	Yes	Yes
STEMI	No	No	Yes
LVEF (%)	15–20	20–25	30–35
CPR time (minute)	22	10	5
Anoxic brain injury	No	Yes	No
CPR to Impella time	17 h	13 d	10 h
Duration of Impella support	3 d	1 d	2 d
High-risk PCI	Yes	Yes	Yes
Outcome	Bridged until HeartMate II VAD implantation	Excellent recovery	Excellent recovery

Abbreviations: CAD, coronary artery disease; CPR, cardiopulmonary resuscitation; d, day; h, hour; LVEF, left ventricular ejection fraction; PCI, percutaneous coronary intervention; PCI, percutaneous intervention; STEMI, ST segment elevation myocardial infarction; VAD, ventricular assist device; y, year.

percutaneous access.⁹ The use of Impella LP 2.5 increased cardiac index, cardiac output, and MAP 30 minutes after implantation, whereas the intra-aortic balloon pump (IABP) significantly reduced diastolic arterial pressure. The improvement in hemodynamics with the Impella device may explain the more rapid reversal of serum lactate levels. The use of positive inotropic drugs or vasopressors was expected to be lower in patients with Impella.⁴ However, the use of Impella in patients with cardiac arrest, especially in the setting of severe coronary artery disease (CAD) has rarely been reported.¹⁰

Methods and Results

All data of patients were retrospectively retrieved from our computerized database in cardiac catheterization laboratory and hospitalization reports. From December 2009 to March 2011, three patients were presented to the University of Texas Medical Branch (UTMB) with severe CAD and cardiac arrest. All three patients underwent high-risk PCI while on Impella support. ► **Table 1** of Mukku et al¹¹ summarizes the indication for PCI, the cause of cardiac arrest, the duration of Impella support, as well as the clinical outcome of the patients.

Case Reports

The first case was a 70-year-old man with a significant past medical history of hypertension, diabetes mellitus type 2, coronary artery bypass graft (CABG), and recently diagnosed vein graft occlusion, who recently underwent redo CABG. He had pulseless electrical activity (PEA) cardiac arrest, 21 days postoperatively. The patient was intubated and resuscitated per advanced cardiac life support (ACLS) protocol, and three doses of intravenous atropine, calcium gluconate and five doses of intravenous epinephrine were given. Arterial blood gas sampled during a code revealed severe acidosis (7.033) and hyperkalemia ($K = 8.0$) and was treated with insulin, dex-

trose50, and bicarbonate. After 20 minutes of cardiopulmonary resuscitation (CPR), the patient regained rhythm with palpable pulses and was transferred to the surgical intensive care unit (SICU). In the SICU, the patient was connected to ventilator and atrioventricular paced via pacing wires. He was started on dopamine and Levophed (Norepinephrine bitartrate) for pressor support and treated for hyperkalemia and acidosis with several doses of bicarbonate, insulin, and dextrose50. A bedside echocardiogram revealed a very small pericardial effusion, noncollapsed right ventricle, and depressed left ventricle function. IABP was placed at bedside. An emergency catheterization found occlusion of the new grafts with severe stenosis of left internal mammary artery (LIMA) to left anterior descending artery (LAD). Impella, an external heart assist device was exchanged for the pre-existing IABP due to persistent CS. The patient underwent PCI to LIMA with Impella support and continued over the next few days with improvement in hemodynamics. However, due to concerns of adequate anticoagulation management with suspected heparin-induced thrombocytopenia, Impella was removed and was successfully supported with HeartMate II (Thoratec, Pleasanton, CA) LVAD implantation as a bridge to transplant. After 12 hours, the patient had a hypotensive episode as well as supraventricular tachycardia at a heart rate of 170 that converted to ventricular tachycardia (VT). After 1 hour of acute ACLS and repetitive shocks, the patient was pronounced dead.

The second patient was a 75-year-old woman with a past medical history of cardiomyopathy of unknown etiology, hypertension, and gout. She was found unconscious by her daughter, and was admitted, and resuscitated for VT cardiac arrest. She suffered anoxic brain injury. Therapeutic hypothermia, following resuscitation, was recommended as treatment for neurological injury. An emergency catheterization found severe stenosis of the LAD and left circumflex artery (LCx), and her awaited intervention depended on neurological recovery. The patient recovered from anoxic brain injury and was extubated after 5 days. The patient recovered her

short-term memory, and was working with speech pathology, physical therapy, and occupational therapy. The patient was transferred to the ward and a cardiothoracic surgeon evaluated her for possible CABG versus PCI. The family and patient decided to have the PCI. However, the patient had a second cardiac arrest pre-PCI with asystole with 1 minute of CPR. The patient was resuscitated, intubated, and placed on Impella 2.5 cardiac support. The patient had the PCI with bare metal stents to proximal LAD and mid-LCx. The patient also had a repeated echocardiogram postcatheterization, which showed an improved ejection fraction (EF) of 35 to 40% from 20 to 25%. Once the patient's condition improved, Impella was removed after 24 hours with manual pressure for 45 minutes with good hemostasis. Minimal bleeding was noted around Impella access site. With the improved EF, an implantable cardioverter defibrillator was not indicated. The patient was re-evaluated in the heart failure clinic after 2 months. Follow-up of the patient demonstrated excellent neurological and functional recovery.

The third patient was a 70-year-old woman with a past medical history of hypertension. She was away on a cruise ship and as the temperature dropped, she started having bilateral arm pain, cold hands, and back pain between the shoulders. The pain was not radiating, persisted several hours, and was associated with diaphoresis. She also began to feel chest pain in the anterior center chest, similar to the back pain. She went to the medical area and her blood work and ECG were normal. She left the clinic, but the pain continued to persist, becoming constant. She returned to the clinic later in the afternoon where her ECG showed ST segment elevation myocardial infarction. She was treated medically on the ship and then transferred to the UTMB. From ECG changes to catheterization, total time taken was 48 minutes. Door to balloon time was 60 minutes. An emergency catheterization found a totally occluded diagonal artery and a drug eluting stent was implanted. On day 1 postprocedure, patient had PEA cardiac arrest. An emergency catheterization found significant plaque shift to the proximal LAD, and the patient was treated with bifurcation stenting using Impella support. No complications were noted after the procedure and patient had good recovery and follow-up care.

Discussion

The introduction of easily manageable percutaneous LVADs constitutes a breakthrough in the practice of interventional cardiology. Patients who suffer CS after cardiac arrest have a very poor prognosis. Impella provides a new tool in the management of patients with severe left ventricular dysfunction and CS.^{12–14} A randomized clinical trial, by Seyfarth et al⁴ showed the feasibility and safety of a percutaneously delivered LVAD implanted in patients with CS caused by acute myocardial infarction. The LVAD Impella LP 2.5 offered an effective and superior hemodynamic support compared with standard treatment using IABP counterpulsation. A subsequent large multicenter Europella registry by Sjaun et al³ supported the safety, feasibility, and potential usefulness of hemodynamic support with Impella 2.5 in high-risk PCI.

Alasnag et al⁵ reported use of the Impella 2.5 during high-risk PCI in the “real world” (outside the controlled environment of a clinical trial) and was found to be safe and feasible. The device was easy to insert, operate, and remove. The major adverse cardiac events (MACE) rate on 30-day follow-up for 60 high-risk PCI patients treated with Impella support was low and they experienced no increase in peripheral vascular complications. Additionally, Impella hemodynamic support promoted more complete revascularization by reducing the time constraints posed by high-risk interventions. Age over 65 and plasma lactate level at admission greater than 3.8 mmol/L were demonstrated to be significant predictors of 30-day mortality.¹⁵

The new PROTECT II analysis concluded that more extensive revascularization with PCI is appropriate and leads to better outcomes at 90 days in patients with CAD and reduced left ventricular function. Furthermore, the patients that underwent more extensive revascularization had significantly better outcomes at 90 days with Impella support compared with those supported with the IABP.¹⁶

More recently, USpella registry by Maini et al⁶ confirmed that the use of the Impella 2.5 in a real-world multicenter setting was safe and provided sufficient hemodynamic support to facilitate high-risk single- or multivessel PCI. Moreover, the USpella registry data showed a very low 30-day MACE rate of 8.2% and only 0.9% revascularization rate ($n = 2$), showing Impella enables a more complete revascularization for the first time.¹⁷

In the present study, three cases of severe CAD patients presenting with cardiac arrest were successfully treated with Impella support. All three patients underwent high-risk PCI under Impella support. There was no technical failure during support and no increase in major bleeding, distal limb ischemia, arrhythmias, or infection. The increase in hemolysis in Impella patients was only transitory. These cases demonstrate successful use of Impella device in patients with profound CS following cardiac arrest. One of the patients was supported to LVAD implantation (bridge to bridge), and the other two had excellent neurological and functional recovery. The experience demonstrated that Impella may play adjunctive role in obtaining hemodynamic stability in these high-risk patients undergoing PCI.

A recent case report by Sibbald and Džavík¹⁸ reported severe hemolysis associated with use of Impella LP 2.5 device in a patient, which led to removal of Impella device 30 hours after implantation with subsequent improvement in bilirubin, lactate dehydrogenase, potassium, phosphate, and calcium. The severity of hemolysis may be linked to duration of device use. When used only for hours, little or no biochemical evidence of hemolysis was reported.^{19,20} However, routine measurement of biochemical markers of hemolysis and serial hemoglobin values during Impella device support allowed timely detection and treatment of this important complication.

Conclusion

Although Impella was used in all three patients during high-risk PCI, the device was not used to manage the

cardiopulmonary arrest state specifically except in the second case. The commonality among the cases was the presentation of arrest, but the device was specifically used to manage the arrest state in the second case. However, the percutaneous support continued after the emergent PCI for more than 24 hours except in the second case. Impella may be implanted earlier in patients' status postcardiac arrest to ensure a good hemodynamic support as a bridge to recovery or other procedures. Earlier Impella implantation after cardiac arrest may provide cardiac support and tissue perfusion until recovery or high-risk PCI. The study supports the feasibility and safety of Impella-assisted percutaneous coronary intervention in high-risk patients with cardiac arrest. Impella was efficacious in the cardiac arrest patients as a bridge for definitive therapy. However, Impella is not feasible to use in CPR situations routinely since some cardiac arrest is not cardiac especially ischemia related. Impella is more suitable to use in ischemia-related cardiac arrest, especially when cardiac intervention is needed. Vascular complications, such as major bleeding and limb ischemia, are major concerns. Further clinical trials are needed to more precisely identify the risks and benefits associated with this device.

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