I. Introduction

Acute myocardial infarction (AMI) with cardiogenic shock (CS) is associated with poor prognosis among patients requiring circulatory support with intra-aortic balloon pumping (IABP) or veno-arterial extra corporeal membrane oxygenation (VA-ECMO)\(^1\)\(^-\)\(^3\). Impella (Abiomed, Danvers, Massachusetts, USA) is a micro-axial flow pump. It provides mechanical left ventricular (LV) unloading and end-organ perfusion. It is increasingly used in patients with AMI complicated with CS undergoing percutaneous coronary intervention (PCI) and managed to survive. Transthoracic echocardiogram in the subacute phase revealed a preserved left ventricular systolic function though the culprit lesion was in LMT and the area at risk for myocardial infarction was extremely large. Left ventricular unloading using Impella CP could contribute to preservation of cardiac function and diminishing of myocardial damage.

KEY WORDS: Impella, intra-aortic balloon pumping, myocardial infarction, percutaneous coronary intervention, percutaneous ventricular assist device

II. Case report

An 85-year-old Japanese woman with no significant medical history was admitted to our emergency department with a sudden chest pain. In the emergency room, her blood pressure dropped to 53/38 mm Hg, pulse was 54/min, and respiratory rate was 24/min with an O2 saturation of 89% on room air. On arrival, electrocardiography showed no ST-segment elevation but ST segment depressions in leads II, III, aVF. However, electrocardiography changed 15 minutes after admission and revealed a right bundle branch block-type intraventricular conduction disturbance and an ST-segment elevation in leads aVR and aVL (Fig. 1). She went into respiratory arrest and was intubated. She was transferred to the catheterization laboratory. At first, an IABP and a temporary pacemaker were inserted to stabilize her circulation. Angiography showed subtotal occlusion of the LMT by a large thrombus (Fig. 2A). Immediately after angiography, she developed ventricular fibrillation (VF) resistant to defibrillation. VA-ECMO was immediately inserted to get away from collapsed circulation. Then Impella CP was inserted before PCI for LV unloading and reducing myocardial damage. PCI was performed under mechanical supports using VA-ECMO and Impella CP via the left radial artery. Thrombus aspiration and the simultaneous kissing balloon dilatation were performed in the LMT with a 3.0-mm balloon (Sapphire NC, OrbusNeich Medical, Inc., Fort Lauderdale, FL, USA) from the LMT to LAD and a 2.5-mm balloon (Ryurei, Terumo Medical Corporation, Tokyo, Japan) from...
the LMT to LCX (Fig. 2B). After the procedure, angiogram revealed thrombolysis in myocardial infarction (TIMI) grade 3 flow with residual thrombus (Fig. 2C). We did not place a stent in the LMT because stenting could provoke no reflow phenomenon or side branch occlusion. The time course of the clinical scenarios is shown in Fig. 3.

The following day, she showed an improvement from cardiogenic shock with a peak CPK level of 2960 IU/L at 18 h and peak CK-MB level of 249 ng/ml at 8 h after the onset of AMI. Although her cardiac function was severely impaired with the left ventricular ejection fraction (LVEF) of approximately 20% (Fig. 4A and Online movie 1), VA-ECMO could be weaned off.
and removed on the same day under Impella support of 3.5 L/min at the P-8 level. On day 3, the LV wall motion gradually improved and Impella CP was weaned off and removed.

After cardiac rehabilitation, Transthoracic echocardiogram (TTE) showed that cardiac function was recovered and the left ventricular ejection fraction was 48% with little anterior wall asynergy (Fig. 4B and Online movie 2). ECG showed an almost normal study without Q waves.

On day 20 after admission, follow-up coronary angiography (CAG) and optical coherence tomography (OCT) revealed thrombus regression and sufficient lumen area. Therefore, she was administered optimal medical therapy without additional PCI. Finally, she was discharged from hospital on day 30.

III. Discussion

Herein, we report a case of an 85-year-old woman who survived STEMI complicated with cardiopulmonary arrest. Moreover, her cardiac function recovered in the sub-acute phase though the culprit lesion was in LMT and the area at risk for myocardial infarction was extremely large.

We suggest that four factors might have contributed to the favorable outcome in our patient. These factors might include: left ventricular unloading by Impella CP prior to PCI, successful recanalization by the following PCI, and the LMT was not totally occluded even though it was severely obstructed by a large thrombus. In addition, ST-segment elevation and right bundle branch block-type intraventricular conduction disturbance occurred 15 minutes after admission and the times between ST-segment elevation and VA-ECMO, Impella and balloon were relatively short.

Mechanical cardiac support by axial flow pump, Impella can prevent myocardial damage. Several preclinical investigations have documented the impact of LV mechanical unloading on infarct size using Impella. Left ventricular unloading by Impella reduces myocardial oxygen consumption and increases myocardial oxygen supply due to decreased microvascular resistance and increased myocardial perfusion. Moreover, left ventricular

---

Fig. 3  The time courses of the clinical scenario.

Fig. 4  Transthoracic echocardiography in the left parasternal long axis view.
A: Transthoracic echocardiography in the left parasternal long axis view immediately after the procedure. Cardiac function was severely impaired with the left ventricular ejection fraction (LVEF) of approximately 20%.
B: Transthoracic echocardiography on the left parasternal long axis view 10 days after admission. Cardiac function was recovered with the left ventricular ejection fraction of 48% with little anterior wall asynergy.
unloading inactivates pro-apoptotic pathways and preserves mitochondrial function, which protects the myocardium from reperfusion injury\(^8\)\(^-\)\(^9\). These mechanisms are considered for the reduction in infarct size by Impella. In fact, several animal experiments showed that Impella could reduce infarction size\(^8\)\(^-\)\(^9\).

At first, we used IABP for cardiogenic shock in the present case. However, IABP was insufficient and the patient’s condition deteriorated to cardiac arrest, which required cardiopulmonary resuscitation and VA-ECMO. If we had inserted Impella CP first, the patient would not have developed circulatory collapse. A registry study showed that patients who underwent IABP prior to Impella had higher AMI mortality than patients who underwent Impella first without IABP\(^9\). In fact, we experienced another case who suffered from ventricular fibrillation and was circulatory stable with Impella support. In this present case, we applied Impella CP support prior to performing PCI after stabilizing circulatory dynamics by VA-ECMO, which seems to lead to favorable results. VA-ECMO has a strong capacity of cardiopulmonary support. However it increases cardiac afterload and cannot reduce infarction size\(^8\). It has been reported that patients undergoing Impella in addition to VA-ECMO had a higher rate of weaning from mechanical circulatory support and a better prognosis than those patients undergoing VA-ECMO alone\(^8\)\(^-\)\(^9\). The present case could also be weaned from VA-ECMO on day 2 and weaned from Impella on day 3. It is controversial whether Impella should be performed prior to PCI or after PCI. However, several studies showed possibility for using Impella prior to PCI. The Door-To-Unload in STEMI Pilot Trial suggested that 30 minutes of LV unloading by Impella before PCI reduces infarct size among patients with a total ST-segment elevation of >6 mm\(^8\). Another study showed that patients undergoing Impella prior to PCI had better prognosis than patients undergoing Impella after PCI\(^8\). Early LV unloading by Impella CP prior to PCI could lead to diminished myocardial damage in our case. The increased coronary blood flow obtained by Impella CP also might have contributed to the prevention of LMT re-occlusion by a large residual thrombus after PCI. Impella CP can be implanted via the femoral artery; the diameter of the access vessels is needed to be ≥ 5mm. In this case, the patient was a very small Japanese old woman. However, we implanted Impella CP very easily. Finally, this is a case report on diminished myocardial damage using Impella CP prior to PCI in a Japanese patient with STEMI complicated with cardiopulmonary arrest. Our experience suggests that Impella CP could be used as a reliable and safe support tool to diminish myocardial damage in patients with STEMI with CS.

Acknowledgments

We gratefully acknowledge the work of past and present members of our laboratory.

Conflicts of interest

The authors declare that they have no conflict of interest.

References

1) Thiele H, Zeymer U, Neumann FJ, et al: Intraaortic balloon support for myocardial infarction with cardiogenic shock. N Engl J Med 2012; 367: 1287–1296
2) Menees DS, Peterson ED, Wang Y, et al: Door-to-balloon time and mortality among patients undergoing primary PCI. N Engl J Med 2013; 369: 901–909
3) Morisawa D, Higuchi Y, Iwakura K, et al: Predictive factors for successful weaning from percutaneous cardiopulmonary support in patients with cardiogenic shock complicating acute myocardial infarction. J Cardiol 2012; 60: 350–354
4) Amin AP, Spertus JA, Curtis JP, et al: The evolving landscape of Impella use in the United States among patients undergoing percutaneous coronary intervention with mechanical circulatory support. Circulation 2020; 141: 273–284
5) Saku K, Kakino T, Arimura T, et al: Left ventricular mechanical unloading by total support of Impella in myocardial infarction reduces infarct size, preserves left ventricular function, and prevents subsequent heart failure in dogs. Circ Heart Fail 2018; 11: e004397
6) Meyns B, Stolinski J, Leunens V, et al: Left ventricular support by catheter-mounted axial flow pump reduces infarct size. J Am Coll Cardiol 2003; 41: 1087–1095
7) Esposito ML, Zhang Y, Qiao X, et al: Left ventricular unloading before reperfusion promotes functional recovery after acute myocardial infarction. J Am Coll Cardiol 2018; 72: 501–514
8) Briceno N, Annamalai SK, Reyelt L, et al: Left ventricular unloading increases the coronary collateral flow index before reperfusion and reduces infarct size in a swine model of acute myocardial infarction. J Am Heart Assoc 2019; 8: e013586
9) O’Neill WW, Schreiber T, Wohls DHW, et al: The current use of Impella 2.5 in acute myocardial infarction complicated by cardiogenic shock: Results from the USpella Registry. J Interv Cardiol 2014; 27: 1–11
10) Pappalardo F, Schulte C, Pieri M, et al: Concomitant implantation of Impella® on top of veno-arterial extracorporeal membrane oxygenation may improve survival of patients with cardiogenic shock. Eur J Heart Fail 2017; 19: 404–412
11) Patel SM, Lipinski J, Al-Kindi SG, et al: Simultaneous venoarterial extracorporeal membrane oxygenation and percutaneous left ventricular decompression therapy with Impella is associated with improved outcomes in refractory cardiogenic shock. ASAIO J 2019; 65: 21–28
12) Kapur NK, Alkhouri MA, DeMartini TJ, et al: Unloading the left ventricle before reperfusion in patients with anterior T-segment-elevation myocardial infarction. Circulation 2019; 139: 337–346
13) Basir MB, Schreiber TL, Grines CL, et al: Effect of early initiation of mechanical circulatory support on survival in cardiogenic shock. Am J Cardiol 2017; 119: 845–851