Management of ECPELLA during mitral valve replacement in patients with cardiogenic shock due to post-infarct papillary muscle rupture.

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April 16, 2024

Abstract

Papillary muscle rupture is a fatal complication with a high operative mortality rate of 13–40%. Most patients experience cardiogenic shock and hypoxia due to pulmonary edema caused by severe mitral regurgitation. Although preoperative stabilization using a mechanical assist device potentially improves surgical outcomes, an appropriate strategy has not yet been established. ECPELLA is a useful mechanical circulatory support (MCS) strategy, combining venoarterial extracorporeal membrane oxygenation and Impella®, and potentially increases cardiac output and tissue perfusion and improves left ventricular distension and oxygenation in patients with refractory cardiogenic shock. Herein, we present our surgical technique involving the successful management of ECPELLA during surgery in patients with papillary muscle rupture.

Introduction

Post-infarct papillary muscle rupture (PMR) is a rare critical complication that occurs in 1–3% of patients after acute myocardial infarction (AMI). [1]PMR leads to cardiogenic shock (CGS) and pulmonary edema (PLE) due to severe mitral regurgitation (MR).[1-3] A high operative mortality rate of 13–40% associated with mitral valve surgery for PMR has been reported.[2-5]

Appropriate preoperative mechanical circulatory support (MCS), such as intra-aortic balloon pumping (IABP) or venoarterial extracorporeal membrane oxygenation (V/AECMO), may improve surgical outcomes in patients with PMR. [4, 5] Successful management using Impella® (Abiomed Inc., Danvers, MA) as a temporary percutaneous ventricular assist device for post-AMI MR, including PMR, has been also reported. [6, 7]

The combination of Impella and V/AECMO (ECPELLA) is a useful MCS strategy in cases of severe hypoxia with CGS. We aggressively initiated ECPELLA as a bridge to surgery for CGS due to PMR. Herein, we present our surgical and MCS management during mitral valve replacement (MVR) in which we applied ECPELLA for CGS due to PMR.

Case presentation

Case 1: A 61-year-old man presented to another hospital with hypotension and hypoxia. Electrocardiography (ECG) revealed an elevated ST segment in I and aVL, and ultrasonic echocardiography (UCG) showed moderate MR due to mitral valve prolapse (MVP). The patient was transferred to our hospital due to CGS. On arrival, arterial blood gas (ABG) analysis revealed a pH of 6.95, pO_2 of 59.8 mmHg, pCO_2 of 80.9 mmHg, HCO_3 level of 17.0 mEq/L, and lactate concentration of 12.4 mmol/L on the oxygen face mask at 10 L,

and the patient's blood pressure (BP) was 123 mmHg with a heart rate (HR) of 145 beats/min. The patient was immediately intubated. Chest radiography (CXR) revealed significant PLE (Figure 1A). V/AECMO was established between the right femoral vein (FV) and artery (FA) because systolic BP dropped below 40 mmHg. UCG revealed anterior MVP with anterolateral PMR (Figure 1C). Emergency coronary angiography (CAG) showed occlusion of the high-lateral branch (Figure 1B). We inserted the Impella CP device from the left FA for further hemodynamic support and LV unloading as a bridge to emergent surgery. Emergent MVR was performed. Cardiopulmonary bypass (CPB) with moderate hypothermia was established between the ascending aorta and bicaval venous cannulation. Aortic cannulation and aortic venting were positioned as far as possible to the distal ascending aorta to avoid clamping the motor of the Impella (Figure 1D). V/AECMO flow was decreased from 2.5 L/min to 0.6 L/min, and the Impella performance level (ImPL) was decreased from P6 to P2 after CPB initiation (Figure 2). After the ascending aorta carrying the Impella catheter was clamped using a soft joe aortic clamp, antegrade cold crystalloid cardioplegia (CCP) was administered, and the ImPL was reduced to surgical mode (P0). The heart immediately arrested. Although additional suction into the LV vent was required because of Impella-induced aortic regurgitation (AR) (Figure 1E), MVR could be performed safely. During de-airing of the LV, Impella was reestablished at ImPL P1. CPB was weaned with moderate doses of inotropic agents and sufficient oxygenation (Figure 2), and V/AECMO and Impella were removed. Prophylactic IABP was performed on the left FA. The patient was discharged uneventfully 3 weeks after surgery.

Case 2: An 81-year-old woman was transferred to another hospital with syncope and hypotension. ECG showed a depressed ST segment in II, III, aVF, and V2-6. Emergency CAG revealed severe stenosis of the left anterior descending branch and left circumflex (LCx). Percutaneous coronary intervention using a drug-eluting stent was performed on the LCx as the culprit lesion (Figure 3B, C). However, the patient developed severe respiratory failure and shock, which were managed using airway intubation, inotropic agents, and IABP. The patient was transferred to our hospital due to CGS. On arrival, ABG analysis revealed a pH of 7.150, pO_2 of 71.1 mmHg, pCO_2 of 29.2 mmHg, HCO_3 level of 10.2 mEq/L, and lactate concentration of 11.4 mmol/L on mechanical ventilation at FiO_2 100%, and the patient's BP was 62 mmHg with a HR of 95 beats/min with shock dose inotropic agents. UCG revealed posterior MVP with anterolateral PMR (Figure 3D). V/AECMO was immediately established through the right FA and FV. We escalated the MCS from IABP to Imeplla CP for LV unloading because CXR revealed significant PLE (Figure 3A). Emergent MVR was performed using the same management as in Case 1 (Figure 4). V/AECMO and Impella were removed during surgery, and prophylactic IABP was performed from the left FA. The patient was discharged uneventfully 2 weeks after surgery.

Discussion

Post-infarct PMR is a fatal complication that leads to CGS and PLE due to severe MR. [1] Previous studies have emphasized the importance of prompt diagnosis and an aggressive surgical approach without delay to improve the outcome of post-infarct PMR.[3-5] However, the SHOCK Trial Registry demonstrated that approximately half of patients with CGS due to severe post-AMI MR could not undergo surgery for unstable hemodynamics awaiting surgery.[2] Therefore, early preoperative stabilization using an appropriate MCS is warranted.

IABP is the most common MCS for CGS, and approximately 40–60% of patients with PMR undergo IABP preoperatively. However, the operative mortality of 13–40% was not satisfactory. [4, 5]Although Hryniewicz et al. demonstrated that V/AECMO potentially improves short- and long-term survival in patients with refractory CGS,[8] V/AECMO is not adequate to unload the LV and PLE because of increased afterload. Impella is a reasonable MCS for unloading the LV directly, reducing the severity of MR and increasing forward flow. The usefulness of Impella for CGS due to PMR or severe ischemic MR has been reported. [6, 7] However, Impella does not help hypoxia due to PLE. Several studies demonstrated that ECPELLA for CGS had a significantly lower mortality rate and higher rate of subsequent therapy or recovery compared with V/AECMO alone.[9-10] These reports highlighted ECPELLA's ability to facilitate forward-flow increase, improve systolic and diastolic pulmonary pressure, decrease vasoactive medication requirement, reduce the

area of myocardial ischemia, and improve PLE and oxygenation.[9-10] These effects are suitable for stabilizing the preoperative conditions in patients with PMR. Therefore, we recommend early ECPELLA as a bridge to surgery because early MCS for AMI-induced CGS potentially improves short-term outcomes. [5, 11]Although ECPELLA may have the potential risk of sucking the ruptured papillary muscle, we didn't confirm these findings in our cases.

Postoperative hemodynamic and respiratory management is important for achieving satisfactory surgical outcomes in patients with PMR. Previous studies have demonstrated that 70% of patients require postoperative IABP, 30% require postoperative ECMO, and 50% require prolonged respiratory assist. [3-5] Successful postoperative management using Impella 5.0 in a patient with PMR has been reported.[12] Despite a few knacks to master and pitfalls to overcome, as shown in Figure 5, we believe that ECPELLA should be maintained during surgery with the ImPL in surgical mode and a low ECMO flow (500–600 mL/min) for postoperative management. Ideally, ECPELLA should be removed during surgery if CPB can be weaned off without ECPELLA, because ECPELLA is associated with greater hemolysis, vascular complications, and a higher need for transfusion. [9-10]

In conclusion, ECPELLA is a useful and feasible MCS as a bridge to surgery in patients with CGS due to post-infarct PMR. MVs can be performed safely using ECPELLA.

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Figure Legends

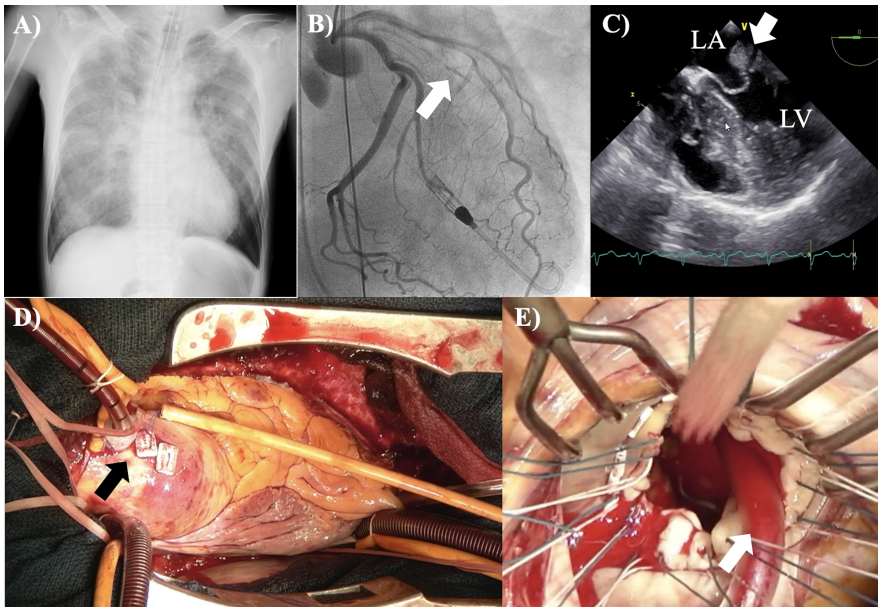
Figure 1. A: Chest X-ray (CXR) on admission revealing significant pulmonary edema (PLE). B: Coronary angiography (CAG) showing occlusion of the high-lateral branch (white arrow). C: Transesophageal echocardiography revealing mitral valve prolapse (MVP) with papillary muscle rupture (white arrow). D, E: Intraoperative findings. LA, left atrium; LV, left ventricle

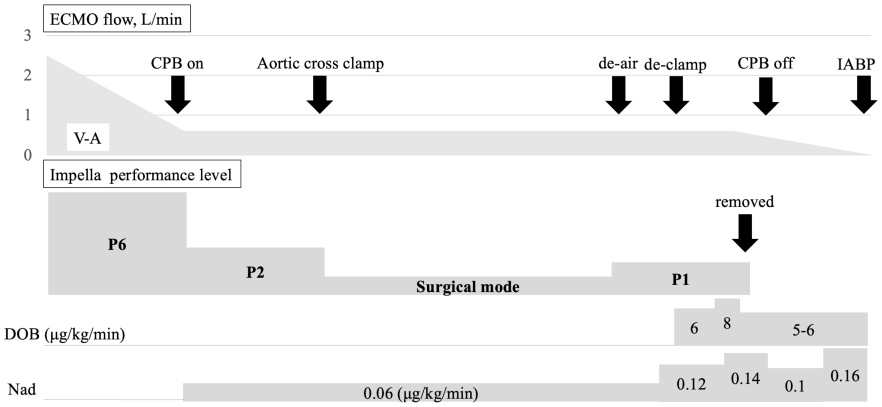
Figure 2. Extracorporeal membrane oxygenation (ECMO) flow, Impella performance level (ImPL), and inotropic-agent dose during surgery in Case 1. ECMO, extracorporeal membrane oxygenation; CPB, cardiopulmonary bypass; IABP, intra-aortic balloon pumping; V-A, venoarterial ECMO; DOB, dobutamine; Nad, noradrenaline; sBP, systolic blood pressure; dBP, diastolic blood pressure; pO_2, partial pressure of oxygen

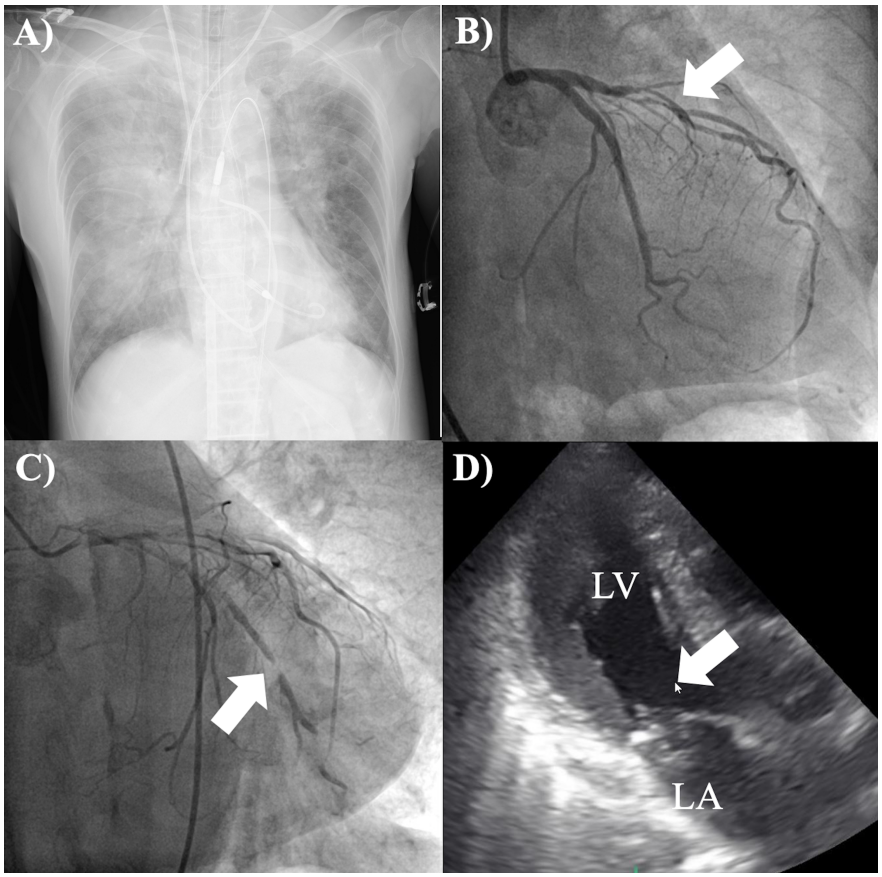
Figure 3. A: Preoperative CXR revealing significant PLE. B, C: CAG showing two vessel diseases (white arrow). D: Ultrasonic echocardiography (UCG) revealing MVP (white arrow).

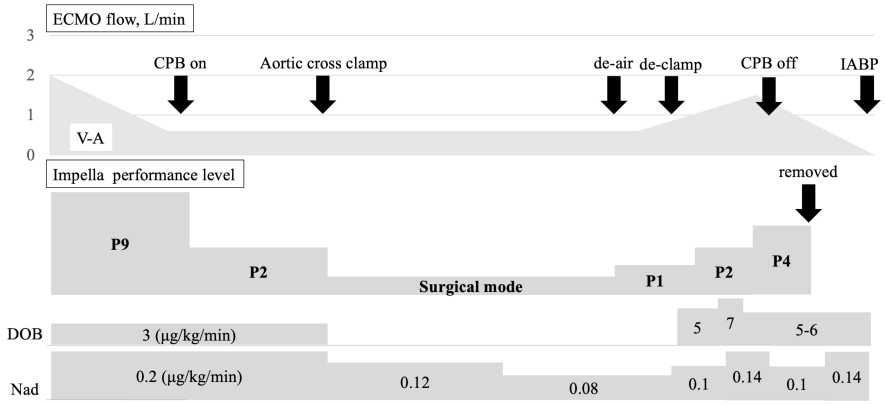
Figure 4. ECMO flow, ImPL, and inotropic-agent dose during surgery in Case 2.

Figure 5. Knacks and pitfalls during mitral valve surgery with Impella









Knacks to master and pitfalls
to overcome during mitral valve surgery with Impella

1. The aortic cannula and aortic clamp should be placed as far as possible on the distal side of the aorta to avoid injuring the pump of the Impella.

2. A soft jaw clamp should be used to avoid injuring the catheter of the Impella.

3. Retrograde cardioplegia may be required because of aortic regurgitation due to Impella.

4. Additional LV suction may be required because of aortic regurgitation due to Impella.

5. Impella should be reestablished on P1 during de-airing of the LV.