The Texas Heart Institute® Journal

Case Reports

Restoration of Epicardial Blood Flow After Left Ventricular Unloading With the Impella CP Heart Pump in a Patient With STEMI Treated With Surgical Revascularization

Jason Liu, MD[1]; Syed B. Peer, MD[2]; Samar S. Sheth, MD[3]; Gabriel Loor, MD[2]

[1]Department of Cardiology, The Texas Heart Institute, Houston, Texas
[2]Division of Cardiothoracic Transplantation and Circulatory Support, Michael E. DeBakey Department of Surgery, Baylor College of Medicine, Houston, Texas
[3]Department of Cardiology, Baylor St Luke's Medical Center, Houston, Texas

Abstract

Left main occlusion presenting as ST-segment elevation myocardial infarction is an exceedingly morbid condition. This article reports a case of cardiac arrest in a patient after a treadmill stress test. Coronary angiography revealed 100% occlusion of the left main coronary artery. Left ventricular unloading with the Impella CP heart pump (ABIOMED/Johnson & Johnson MedTech) was used, after which epicardial blood flow was restored without angioplasty. The patient underwent surgical revascularization. Despite a prolonged revascularization time, there was no evidence of severe myocardial injury postoperatively.

Keywords: Coronary occlusion; myocardial reperfusion injury; myocardial infarction

Case Report

Presentation and Physical Examination

A 55-year-old Black woman presented to the emergency department (ED) with cardiac arrest after a treadmill exercise stress test at an outpatient clinic. Throughout exercise, she did not develop any symptoms or electrocardiographic changes. During recovery, the patient developed ST-segment elevations in leads V_1 and aVR, with reciprocal depressions in the inferior leads followed by polymorphic ventricular tachycardia (Fig. 1). Cardiopulmonary resuscitation was initiated. The patient was defibrillated twice, intubated by emergency medical personnel, and transported to the ED. On arrival, the patient had no murmur on auscultation and no lower extremity edema or jugular venous distention. A baseline electrocardiogram obtained in the ED showed continued ST-segment elevations in leads V_1 and aVR, with diffuse ST-segment depressions (Fig. 2).

Medical History

The patient had a medical history of hypertension, dyslipidemia, and a 30-pack-year history of tobacco use. She had had no prior surgeries. During her initial clinic visit, she reported increasing dyspnea on exertion over the prior 6 months. An outpatient echocardiogram reported normal left ventricular (LV) ejection fraction.

Citation: Liu J, Peer SB, Sheth SS, Loor G. Restoration of epicardial blood flow after left ventricular unloading with the Impella CP heart pump in a patient with STEMI treated with surgical revascularization. *Tex Heart Inst J*. 2024;51(1):e238322. doi:10.14503/THIJ-23-8322
Corresponding author: Jason Liu, MD, The Texas Heart Institute, 6770 Bertner Ave, Houston, TX 77030 (jason.liu@bcm.edu)

Differential Diagnosis

The main differential diagnosis was obstructive coronary artery disease (CAD). Various forms of cardiomyopathy and structural abnormalities were considered less likely.

Technique

Laboratory test results were obtained, including an initial high-sensitivity troponin I level of 7 pg/mL (7 ng/L) (reference range, <17 pg/mL) and a brain-type natriuretic peptide level of 23 pg/mL (23 ng/L) (reference range, 0-100 pg/mL) (Table I). A computed tomogram of the patient's head did not show any evidence of intracranial bleeding. The patient was taken emergently to the catheterization laboratory on norepinephrine and vasopressin support, with coronary angiography revealing 100% occlusion of the distal left main coronary artery (Fig. 3) and an 80% ostial right coronary artery stenosis. The patient had ongoing hemodynamic deterioration, with multiple additional episodes of ventricular tachycardia. The LV end-diastolic pressure was measured at 40 mm Hg. Owing to persistent hemodynamic instability and cardiogenic shock physiology, an Impella CP heart pump (ABIOMED/Johnson & Johnson MedTech) was inserted. Intravenous cangrelor was started. The patient was also treated with 10 mg of intracoronary alteplase.

Key Points

- Emergent presentation of a left main coronary artery occlusion resulting in cardiogenic shock is associated with high rates of mortality and poor outcomes, with limited evidence to guide treatment in this patient population.
- Evaluation of patients for CABG or PCI in left main CAD should be individualized, accounting for coronary anatomy and hemodynamic status.
- Ongoing studies evaluating the safety and feasibility of LV unloading before coronary reperfusion have shown promise in limiting myocardial injury.

Abbreviations and Acronyms

CABG	coronary artery bypass graft
CAD	coronary artery disease
ED	emergency department
LV	left ventricular
PCI	percutaneous coronary intervention
STEMI	ST-segment elevation myocardial infarction

The patient's hemodynamic status subsequently improved. Repeat coronary angiography revealed partial restoration of epicardial coronary blood flow (Fig. 4). Subtotal distal left main coronary artery disease and high-grade disease of the left anterior descending coronary artery and left circumflex coronary artery were noted.

Fig. 1 Electrocardiogram at the time of cardiac arrest shows polymorphic ventricular tachycardia.

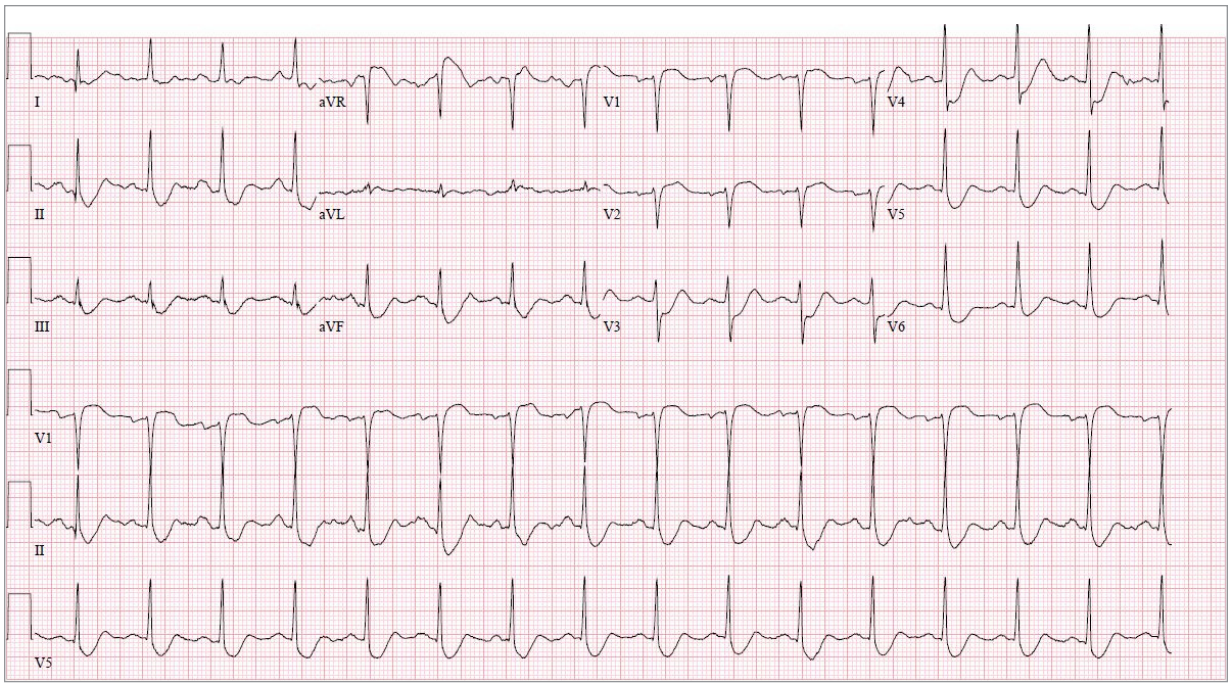

Fig. 2 Electrocardiogram at the time of presentation to the emergency department shows ST-segment elevations in leads aVR and V_1, with diffuse ST-segment depressions.

After discussion of the case with cardiac surgery colleagues, a decision was made to proceed with emergent coronary artery bypass graft (CABG) surgery. Certainly, CABG would increase revascularization time compared with percutaneous coronary intervention (PCI) and, in the setting of an acute ST-segment elevation myocardial infarction (STEMI), would increase the risk of severe reperfusion injury, but the team felt that this risk was attenuated by the restoration of partial epicardial flow achieved pharmacologically and the ventricular unloading the Impella CP pump provided. Additionally, the patient had a high SYNTAX score of 46, suggesting a survival benefit from CABG over PCI.

The patient was transported directly from the catheterization laboratory to the operating room. The procedure was performed on cardiopulmonary bypass with arrest using Buckberg cardioplegia. The aorta was clamped with an Applied Medical aortic cross-clamp with a size 5 soft insert (Applied Medical Corp), allowing the Impella CP pump to remain in place. Three-vessel bypass was performed, with the left internal mammary artery to the left anterior descending coronary artery, saphenous vein graft to the right coronary artery, and saphenous vein graft to the ramus. The total cross-clamp time was 84 minutes, total bypass time was 106 minutes, and the total time between the patient's entrance in the ED and release of the cross-clamp (ie, door to revascularization interval) was 9 hours, 28 minutes.

The Impella CP pump was removed in the operating room because there was concern that the flow from the pump was pressurizing the hood of the vein grafts, increasing the risk of bleeding. Furthermore, the patient's hemodynamics and cardiac function by intraoperative transesophageal echocardiography were excellent. Nevertheless, an intra-aortic balloon pump was placed in the opposite groin as a precaution to protect against possible reperfusion injury.

Outcome and Follow-Up

The patient was extubated the day after the procedure. An echocardiogram obtained on postoperative day 2 revealed a normal LV ejection fraction (55%-60%), with a mildly hypokinetic apex. The intra-aortic balloon pump was removed on postoperative day 3. An electrocardiogram obtained close to the time of hospital discharge showed sinus rhythm, with an incomplete right bundle-branch block (Fig. 5). The patient was discharged on postoperative day 13 on maximally tolerated doses of optimal medical therapy. She has since made several outpatient follow-up appointments and has had resolution of her dyspnea on exertion.

TABLE I. Laboratory Values on Days 1 and 4 of Hospitalization

Value	Day 1	Day 4
Sodium, mEq/L	141	139
Potassium, mEq/L	4.4	3.8
Chloride, mEq/L	114	110
CO_2, mEq/L	18	22
Serum urea nitrogen, mg/dL	13	13
Creatinine, mg/dL	0.94	0.72
Hemoglobin, g/dL	10.6	9.5
White blood cell count, K/μL	14.7	20.2
High-sensitivity troponin I, pg/mL	7	17,438
Brain-type natriuretic peptide, pg/mL	23	562
Cholesterol, mg/dL	128	NA
Triglycerides, mg/dL	69	NA
High-density lipoprotein, mg/dL	36	NA
Low-density lipoprotein, mg/dL	78	NA
Hemoglobin A_{1c}, %	5.3	NA

NA, not available.

SI conversion factors: For sodium, potassium, chloride and CO_2, to convert mEq/L to mmol/L, multiply by 1. For urea nitrogen, to convert mg/dL to mmol/L, multiply by 0.357. For creatinine, to convert mg/dL to μmol/L, multiply by 88.4. For hemoglobin, to convert g/dL to g/L, multiply by 10. For white blood cell count, to convert K/μL to $\times 10^9$/L, multiply by 0.001. For troponin I, to convert ng/mL to μg/L, multiply by 1. For brain-type natriuretic peptide, to convert pg/mL to ng/L, multiply by 1.0. For cholesterol, high-density lipoprotein, and low-density lipoprotein, to convert mg/dL to mmol/L, multiply by 0.0259. For triglycerides, to convert mg/dL to mmol/L, multiply by 0.0113. For hemoglobin A_{1c}, to covert from the percentage of total hemoglobin to the proportion of total hemoglobin, multiply by 0.01.

Discussion

Left main coronary artery occlusion with cardiogenic shock presenting acutely is a catastrophic event with high rates of associated mortality.[1] This article presents a case of STEMI after a routine stress test resulting from an acutely occluded distal left main coronary artery that resulted in cardiogenic shock and refractory arrhythmia. Use of mechanical circulatory support, uncertainty of distal coronary anatomy, and the decision to pursue surgical rather than percutaneous intervention all resulted in a substantial delay in revascularization time.

As reflected in current guidelines, primary PCI is the preferred treatment for STEMI when time to treatment is short, with a high priority placed on achieving a door-to-balloon time of 90 minutes or less.[2] Given the delay in revascularization associated with surgical procedures, CABG is reserved for patients with coronary anatomy not amenable to PCI, and its role has been limited to those with failed PCI, mechanical defect, or high-risk features, including cardiogenic shock.[2] Although studies have shown the benefit of CABG in patients with stable left main CAD, less is known about outcomes of surgical revascularization for left main CAD in the setting of STEMI and cardiogenic shock. One registry study examining PCI outcomes reported an in-hospital mortality rate of 42% in patients with unprotected left main coronary artery stem occlusion who underwent primary PCI,[3] while another study examining unprotected left main coronary artery PCI in cardiogenic shock reported an in-hospital mortality rate of 64.4%.[4]

In the present case, the patient did not show evidence of severe myocardial reperfusion injury and had no issues coming off bypass, despite a prolonged delay in revascularization. The LV unloading that the Impella CP pump provided in this case may have contributed to a safe extension of the door-to-revascularization time. The Impella CP pump is a percutaneous ventricular

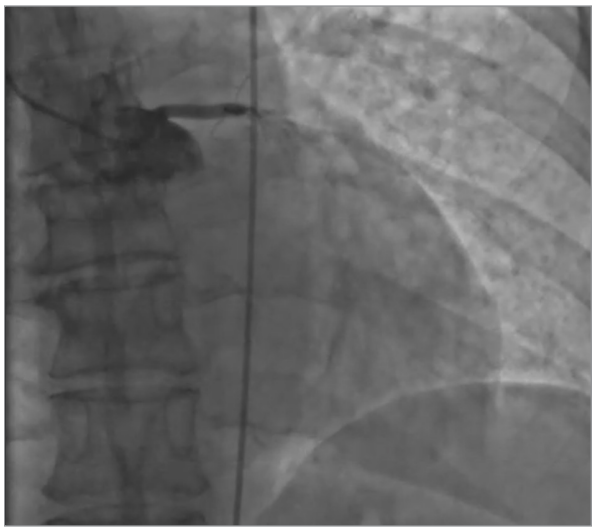

Fig. 3 Initial coronary angiogram reveals acute thrombotic occlusion of the distal left main coronary artery.

Supplemental motion image available for Figure 3.

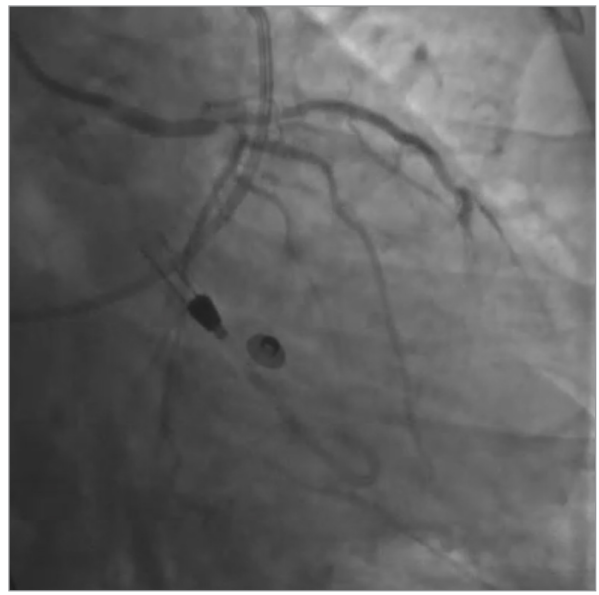

Fig. 4 Repeat coronary angiogram after left ventricular unloading and pharmacologic treatment shows partial restoration of coronary flow, with high-grade lesions in the left main, left anterior descending, and left circumflex coronary arteries.

Supplemental motion image available for Figure 4.

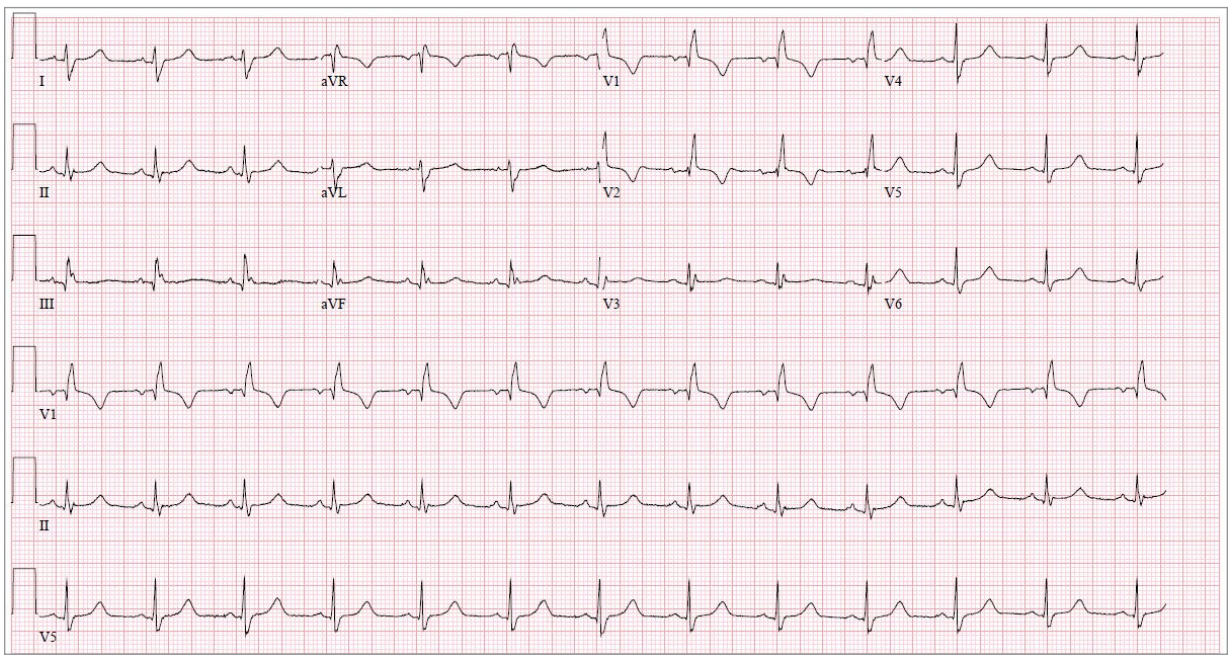

Fig. 5 Electrocardiogram obtained closest to the time of hospital discharge shows sinus rhythm and incomplete right bundle-branch block.

assist device that is currently indicated for patients at high risk of PCI and cardiogenic shock.[5] A pilot trial has suggested a clinical benefit in mechanical unloading of the left ventricle by reducing myocardial oxygen consumption before coronary reperfusion in patients with anterior STEMI.[6] By unloading the left ventricle before reperfusion, myocardial damage and infarct size may be reduced through multiple mechanisms, including alterations in myocardial supply-demand mismatch, limitation of ischemia reperfusion injury, and enhancements in microcirculatory coronary flow.[6,7] A recent meta-analysis of studies evaluating mortality in patients who developed cardiogenic shock after acute MI showed that Impella pump placement before PCI was associated with improved survival.[8]

Furthermore, acute LV unloading with the use of an Impella pump allowed a window during which adjunctive pharmacologic therapy could be administered. Interestingly, after repeat angiography, epicardial coronary blood flow was restored without angioplasty after LV unloading. Although data on coronary flow after LV unloading by Impella pump are limited, Alqarqaz et al[9] examined coronary hemodynamics using a coronary pressure wire during high-risk PCI and reported that use of an Impella pump can improve coronary perfusion pressures in patients with critical coronary artery stenosis. Beyond the acute setting, Watanabe et al[10] reported that coronary flow can be improved by mechanical LV unloading in a porcine model of ischemic heart failure. In the case reported here, the combination of pharmacologic therapy and the favorable effect on coronary hemodynamics with LV unloading may have contributed to restoration of epicardial coronary blood flow.

Conclusion

This article reports a case of STEMI resulting from left main coronary artery occlusion, with restoration of epicardial blood flow after acute LV unloading that was ultimately treated with surgical revascularization. The patient did not have evidence of severe myocardial injury postoperatively, despite a delayed door-to-revascularization time. In patients with acute MI with associated cardiogenic shock, LV unloading with the Impella CP heart pump may limit myocardial injury before revascularization.

Article Information

Published: 28 May 2024

Author Contributions: All authors contributed to drafting and preparing the manuscript.

Conflict of Interest Disclosures: The authors have nothing to disclose.

Funding/Support: There was no funding involved in this work.

References

1. Vis MM, Beijk MA, Grundeken MJ, et al. A systematic review and meta-analysis on primary percutaneous coronary intervention of an unprotected left main coronary artery culprit lesion in the setting of acute myocardial infarction. *JACC Cardiovasc Interv.* 2013;6(4):317-324. doi:10.1016/j.jcin.2012.10.020
2. O'Gara PT, Kushner FG, Ascheim DD, et al. 2013 ACCF/AHA guideline for the management of ST-elevation myocardial infarction: a report of the American College of Cardiology Foundation/American Heart Association Task Force on Practice Guidelines. *Circulation.* 2013;127(4):e362-e425. doi:10.1161/CIR.0b013e3182742cf6
3. Patel N, De Maria GL, Kassimis G, et al. Outcomes after emergency percutaneous coronary intervention in patients with unprotected left main stem occlusion: the BCIS national audit of percutaneous coronary intervention 6-year experience. *JACC Cardiovasc Interv.* 2014;7(9):969-980. doi:10.1016/j.jcin.2014.04.011
4. Yeoh J, Andrianopoulos N, Reid CM, et al. Long-term outcomes following percutaneous coronary intervention to an unprotected left main coronary artery in cardiogenic shock. *Int J Cardiol.* 2020;308:20-25. doi:10.1016/j.ijcard.2020.03.005
5. O'Neill WW, Kleiman NS, Moses J, et al. A prospective, randomized clinical trial of hemodynamic support with Impella 2.5 versus intra-aortic balloon pump in patients undergoing high-risk percutaneous coronary intervention: the PROTECT II study. *Circulation.* 2012;126(14):1717-1727. doi:10.1161/CIRCULATIONAHA.112.098194
6. Kapur NK, Alkhouli MA, DeMartini TJ, et al. Unloading the left ventricle before reperfusion in patients with anterior ST-segment-elevation myocardial infarction. *Circulation.* 2019;139(3):337-346. doi:10.1161/CIRCULATIONAHA.118.038269
7. Swain L, Reyelt L, Bhave S, et al. Transvalvular ventricular unloading before reperfusion in acute myocardial infarction. *J Am Coll Cardiol.* 2020;76(6):684-699. doi:10.1016/j.jacc.2020.06.031

8. Miyashita S, Banlengchit R, Marbach JA, et al. Left ventricular unloading before percutaneous coronary intervention is associated with improved survival in patients with acute myocardial infarction complicated by cardiogenic shock: a systematic review and meta-analysis. *Cardiovasc Revasc Med.* 2022;39:28-35. doi:10.1016/j.carrev.2021.10.012
9. Alqarqaz M, Basir M, Alaswad K, O'Neill W. Effects of Impella on coronary perfusion in patients with critical coronary artery stenosis. *Circ Cardiovasc Interv.* 2018;11(4):e005870. doi:10.1161/CIRCINTERVENTIONS.117.005870
10. Watanabe S, Fish K, Kovacic JC, et al. Left ventricular unloading using an Impella CP improves coronary flow and infarct zone perfusion in ischemic heart failure. *J Am Heart Assoc.* 2018;7(6):e006462. doi:10.1161/JAHA.117.006462