JACC: CASE REPORTS VOL. 29, 2024
© 2024 THE AUTHORS. PUBLISHED BY ELSEVIER ON BEHALF OF THE AMERICAN COLLEGE OF CARDIOLOGY FOUNDATION. THIS IS AN OPEN ACCESS ARTICLE UNDER THE CC BY-NC-ND LICENSE (http://creativecommons.org/licenses/by-nc-nd/4.0/).

CRITICAL CARE AND RESUSCITATION

CASE REPORT: MULTIDISCIPLINARY TEAM DISCUSSIONS

Preemptive Use of a Left Microaxial Flow Pump in Peripartum Cardiomyopathy

Jerry Fan, MD, Patrick McGrade, MD, Yissela Escobedo, MD, Steven Costa, MD, John Schmittner, MD, Jaime Hernandez-Montfort, MD

ABSTRACT

Management of peripartum cardiomyopathy and cardiogenic shock often presents a significant clinical challenge. These patients are frequently best served at a specialized center with access to cardiac anesthesia, maternal-fetal medicine, and cardiac intensivists. Planning for delivery involves a plan for anesthesia and management of hemodynamic changes during the postoperative period. The use of temporary microaxial flow pumps for hemodynamic support allows for ventricular unloading and recovery without the use of catecholaminergic agents. We present a case of early left hemodynamic support with an Impella CP device (Abiomed) in the setting of cardiogenic shock during delivery. (JACC Case Rep. 2024;29:102751)
© 2024 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

A 26-year-old morbidly obese (body mass index, 44 kg/m^2) woman with a previous history of hypertension, type 2 diabetes mellitus, and morbid obesity presented at 23 weeks of gestation with severe preeclampsia and new onset systolic and diastolic heart failure with pulmonary edema.

The patient had a long history of uncontrolled hypertension treated with combination of losartan, 100 mg daily, and hydrochlorothiazide, 25 mg daily. Before admission, she was evaluated in the family medicine clinic for 4 missed menstrual cycles and had a positive qualitative and quantitative pregnancy test result. In the interim, she was treated for hypertension with escalating doses of labetalol. In her second trimester (23 weeks), she presented to an outside hospital with reports of palpitations, dyspnea, and peripheral edema. She was notably hypertensive, with systolic blood pressure >220 mm Hg and a heart rate >200 beats/min, reported by emergency medical services to be supraventricular tachycardia, which was treated with adenosine, with conversion to sinus tachycardia. A urine protein level of 74.3 mg/dL

TAKE-HOME MESSAGES

- Cardiomyopathy in the setting of severe preeclampsia presents a significant challenge for management of both the mother and infant.
- With a multidisciplinary team approach, hemodynamic challenges before, during, and after delivery are best managed by aggressive hemodynamic support.
- We opted for pre-emptive placement of an Impella CP device early in the development of cardiogenic shock to help temporize and maintain adequate perfusion during the vulnerable period of significant fluid shifts post-delivery.
- Previously reported uses of left ventricular assist devices in the setting of peripartum cardiomyopathy were all for rescue therapy when the patient was in extremis.
- This case demonstrates the utility of early mechanical support to maintain adequate hemodynamics, an approach that likely reduced morbidity, mortality, and length of stay.

From the Division of Cardiology, Baylor Scott and White Health-Temple, Temple, Texas, USA.
The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

Manuscript received July 10, 2024; revised manuscript received September 16, 2024, accepted October 2, 2024.

ISSN 2666-0849 https://doi.org/10.1016/j.jaccas.2024.102751

(reference range ≤12 mg/dL) and a urine protein-to-creatinine ratio of 1.89 (reference range ≤0.16) prompted transfer to a higher level of care for severe preeclampsia. On arrival, she was tachycardic, with a heart rate in the 110s beats/min, tachypneic to 30 breaths/min on 2 L of nasal cannula saturating 80%, and crackles on examination, with 3+ pitting edema in the lower extremities. Her B-type natriuretic peptide level was 213.

The chest radiograph demonstrated cardiomegaly with pulmonary vascular congestion and left-sided pleural effusion consistent with fluid overload (**Figure 1**). Before delivery, she was treated with intravenous furosemide, 60 mg.

QUESTION 1: WHAT IS THE DIFFERENTIAL DIAGNOSIS, AND WHICH TEST WOULD YOU SUGGEST TO PERFORM FIRST?

Answer: The patient has a long-standing history of hypertension before pregnancy. She presented to an outside hospital with reports of palpitations, dyspnea, and peripheral edema, with imaging and biomarkers consistent with pulmonary edema and heart failure. Given these findings, we wanted to investigate peripartum cardiomyopathy with a transthoracic echocardiogram. The transthoracic echocardiogram demonstrated normal left ventricular size, severe concentric hypertrophy, and severely reduced systolic function with an ejection fraction of 27% without significant valvular abnormalities (Video 1).

Other considerations include hypertensive heart disease, which is a constellation of long-term changes to the left ventricle secondary to long-standing poorly controlled hypertension that can lead to systolic, diastolic, or combination heart failure. On echocardiography, she had >1.6 cm thickness in both the interventricular septum and the posterior wall. Review of her clinic visits with family medicine and obstetrics and gynecology demonstrated systolic blood pressures between the 140s and 180s mm Hg and diastolic blood pressures in the 90s to 110s mm Hg despite treatment with labetalol, 200 mg 3 times per day.

Severe preeclampsia-induced pulmonary edema is a rare, life-threatening complication accounting for 0.08% of cases.[1] Multiple mechanisms have been proposed, including left ventricular dysfunction secondary to the increase in systemic vascular resistance, with a resultant change in the loading conditions of the left ventricle that can lead to heart failure and pulmonary capillary leakage.[1] Nonetheless, the initial treatment is often the same, with intravenous furosemide and close hemodynamic monitoring.[1]

Finally, genetic cardiomyopathy is always a consideration in a patient with newly depressed left ventricular systolic function. If no other causes of cardiomyopathy are identified, genetic testing could be a reasonable consideration.

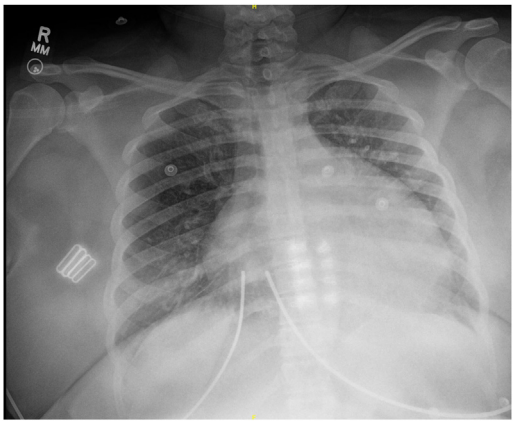
QUESTION 2: WHAT IS THE OPTIMAL PREOPERATIVE, INTRAOPERATIVE, AND POSTOPERATIVE MANAGEMENT OF ANESTHESIA?

Answer: The origin of the cardiomyopathy was presumed to be the result of a combination of uncontrolled hypertension and peripartum cardiomyopathy. With the significant left ventricular dysfunction, she is considered a modified World Health Organization class IV, the highest-risk delivery.[2] During the preoperative and intraoperative stages, the use of neuraxial analgesia can be helpful to reduce the catecholamine surge associated with labor that can be detrimental in the setting of peripartum cardiomyopathy and, in an ideal situation, to avoid the use of general anesthesia.[3,4] Unfortunately, on arrival to our facility, the patient's condition was quickly deteriorating, requiring escalating oxygen requirements and with worsening pulmonary edema. The decision to proceed with a cesarean delivery was made within 1 hour of her arrival to our facility. Multidisciplinary discussion among anesthesia, advanced heart failure, interventional cardiology, cardiac intensive care, maternal-fetal medicine, and neonatology opted for general anesthesia given her respiratory deterioration.[2-5] General anesthesia was induced with rocuronium, etomidate, and succinylcholine, and propofol and fentanyl were administered intraoperatively. The anesthesia department opted for a tidal volume of 5 to 7 mL/kg of ideal body weight (approximately 350-450 mL), a positive end-expiratory pressure of 8 cm H_2O, and a fraction of inspired oxygen of 90% to maintain adequate oxygenation and ventilation.

QUESTION 3: WHAT ARE THE HEMODYNAMIC CONSIDERATIONS FOR PERIPARTUM CARDIOMYOPATHY AND MANAGEMENT OF HEMODYNAMIC SHIFTS IN THE IMMEDIATE POSTOPERATIVE PERIOD?

Answer: Unfortunately, hemodynamic shifts during the postoperative period are often poorly tolerated in peripartum cardiomyopathy. Significant shifts in

FIGURE 1 Chest Radiograph



The image shows cardiomegaly with associated pulmonary vascular congestion and left pleural effusion consistent with congestive heart failure. R = right.

preload occur, with each uterine contraction returning approximately 300 to 500 mL of blood per contraction to the circulation and a substantial increase in preload from postdelivery autotransfusion.[6] Systemic vascular resistance and pulmonary vascular resistance also increase post partum and lead to increased preload and afterload that continue the detrimental cycle with peripartum cardiomyopathy.[6]

We opted for emergency delivery with sequential Impella CP device (Abiomed) placement for preemptive hemodynamic management of decompensated heart failure in the setting of dynamic fluid shifts in the postdelivery period.[4,7] The postdelivery course was complicated by the development of cardiogenic shock requiring high-dose epinephrine and norepinephrine to maintain mean arterial pressure >65 mm Hg on the way to the catheterization laboratory for placement of the Impella CP device. Initial hemodynamics demonstrated a central venous pressure of 6 mm Hg and a mean pulmonary artery pressure of 24 mm Hg (systolic, 32 mm Hg; diastolic, 19 mm Hg). The patient underwent aggressive diuresis (with intravenous furosemide, 5 mg/h), and vasopressor agents were rapidly weaned, with excellent hemodynamic support from the Impella CP device. Post-Impella CP placement, hemodynamics demonstrated a mean central venous pressure of 2 mm Hg and a mean pulmonary artery pressure of 18 mm Hg (systolic, 26 mm Hg; diastolic, 12 mm Hg). We decided to continue mechanical ventilation in the immediate postoperative period and opted against inotropic support because of the possibility of exacerbating peripartum cardiomyopathy. She had no evidence of end-organ dysfunction, with preservation of kidney function and normal lactic acid levels throughout her postoperative period.

The following morning, her mixed venous oxygen saturation was 64% with a calculated Fick cardiac output of 4.2 L/min (normal range, 4.0-8.0 L/min) and a cardiac index of 2.0 L/min/m^2 (normal range, 2.5-4.0 L/min/m^2) (**Table 1**). She had adequate urine output and was on minimal ventilator settings, and she was ultimately extubated on hospital day 2. On hospital day 4, a repeat echocardiogram demonstrated improved left ventricular systolic function to 45% to 50%; therefore, the Impella CP device was removed (Video 2). Hemodynamics on the day of Impella CP removal had a mixed venous oxygen saturation of 79%, with a calculated Fick cardiac output of 9.0 L/min (normal range, 4.0-8.0 L/min) and a cardiac index of 4.3 L/min/m^2 (normal range, 2.5-4.0 L/min/m^2) (**Table 1**).

Temporary mechanical circulatory support devices (eg, Impella CP) are approved for use in protected high-risk percutaneous coronary intervention and for management of cardiogenic shock after acute myocardial infarction.[8-10] There are no randomized

TABLE 1 Hemodynamics During Hospital Stay

	Normal	02/10/2024, PM	02/11/2024, AM	02/11/2024, PM
CVP, mm Hg	0-5	12	3	1
PAP (systolic/diastolic/mean), mm Hg	15-25/8-15/10-20	40/22/29	35/10/20	23/8/15
Cardiac output, L/min	4.0-8.0	4.2	6.2	9.0
Cardiac index, L/min/m^2	2.5-4.0	2.0	3.0	4.3
PVR, WU	<2.5	2.3	1.9	1.2
SVR, dynes/s/cm^5	800-1,200	1,527	1,157	660

CVP = central venous pressure; PAP = pulmonary artery pressure; PVR = pulmonary vascular resistance; SVR = systemic vascular resistance.

controlled trials for off-label use of temporary microaxial flow pumps in the management of peripartum cardiomyopathy. The engagement of a multidisciplinary team is critical to the timing and sequence of hemodynamic support for both mother and infant with regard to the development of cardiogenic shock during delivery.[2] Maternal hemodynamic changes during cesarean delivery include a 47% increase in cardiac index and a 39% decrease in systemic vascular resistance, which is poorly tolerated in cardiomyopathy.[11] Hemodynamic support and left ventricular unloading (through reduction of left ventricular end diastolic pressure, left ventricular wall tension, and myocardial oxygen demand) during the peripartum period are associated with very low 30-day (100% survival) and 6-month (80% survival) mortality, with low complication rates.[7] In peripartum cardiomyopathy, the administration of fluids, vasopressor agents, and inotropic agents is often contraindicated, and these fluids and medications are associated with multiorgan dysfunction and death.[7,12] Microaxial flow pumps offer an alternative to maintain adequate hemodynamics and perfusions without worsening cardiomyopathy with exogenous catecholamines.[4,7,12,13] The early use of the Impella CP device allowed us to avoid the use of vasopressor and inotropic agents after device implantation and to maintain adequate perfusion, as evidenced by normal end-organ function permitting rapid heart recovery.[4,7,12,13]

QUESTION 4: WHAT ARE THE ANTICOAGULATION CONSIDERATIONS FOR TEMPORARY MECHANICAL SUPPORT IN THE POSTPARTUM PERIOD?

Answer: Pregnancy is a prothrombotic state, and the highest risk for thrombosis is in the immediate postpartum period.[2,14] After stabilization of bleeding with oxytocin and tranexamic acid during delivery, we transferred the patient to the cardiac catheterization laboratory for placement of an Impella CP device with unfractionated heparin.[2,10,14] Although it is not optimal for postdelivery patients to receive anticoagulation, we opted out of neuraxial anesthesia to avoid any complications of epidural hematoma and believed that anticoagulation therapy was safe after hemostasis from delivery was achieved.[2,3,10] Bleeding complications from temporary mechanical support remain a source of morbidity and mortality.[10] We opted for low-dose heparin with an activated partial thromboplastin time goal between 40 and 60 seconds because it is short-acting and readily reversible if any severe complications were to arise.[10,14]

QUESTION 5: WHAT ARE THE OPTIONS FOR CONTRACEPTION OR STERILIZATION FOR PERIPARTUM CARDIOMYOPATHY?

Answer: Peripartum cardiomyopathy with severely reduced left ventricular systolic function is considered a contraindication to future pregnancies.[2] Contraception and sterilization options should be discussed with all patients to avoid future pregnancies. In a study of 177 patients with peripartum cardiomyopathy, 25% underwent permanent sterilization with tubal ligation, 22% opted for barrier methods such as condoms, and 16% opted for intrauterine devices; however, almost 30% reported no contraceptive method.[15] Our patient opted for a hormone-based intrauterine device, with 99% effectiveness lasting between 3 and 6 years.[15]

QUESTION 6: WHAT ARE THE CONSIDERATIONS FOR LACTATION IN THE POSTPARTUM PERIOD IN THE CONTEXT OF MANAGEMENT OF HEART FAILURE?

Answer: After pregnancy, pharmacologic considerations for heart failure management can be complicated. Loop diuretic agents, beta-blockers (most commonly metoprolol), a hydralazine-nitrate combination, digoxin, enalapril or captopril, and spironolactone are considered safe to take during lactation.[3,5] She was started on guideline-directed medical therapy, including the following: enalapril, 10 mg twice daily; furosemide, 40 mg daily; spironolactone, 25 mg daily; and metoprolol succinate, 50 mg daily. She had a repeat echocardiogram, which demonstrated a mildly dilated left ventricle with an ejection fraction of 40% to 45%. She had a Cardiomyopathy Comprehensive Panel (Invitae Inc) performed, and it revealed a desmoglein 2 (DSG2, variant: c.1478A>G, heterozygous) sequence variant, which is associated with arrhythmogenic right ventricular dysplasia, although this particular variant is considered a variant of unknown significance.

FUNDING SUPPORT AND AUTHOR DISCLOSURES

The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

ADDRESS FOR CORRESPONDENCE: Dr Jaime Hernandez-Montfort, Division of Cardiology, Baylor Scott and White Health-Temple, 2401 South 31st Street, Division of Cardiology, Temple, Texas 76504, USA. E-mail: jaime.hernandezmontfort@bswhealth.org. X handle: @JHMontfort10.

REFERENCES

1. Souabni SA, Belhaddad EH, Oubahha I, Nejmaddine KH, Aboulfalah A, Soummani AH. Preeclampsia complicated with pulmonary edema: a case report. *Pan Afr Med J Clin Med*. 2020;4:103.

2. Meng ML, Arendt KW, Banayan JM, et al. Anesthetic care of the pregnant patient with cardiovascular disease: a scientific statement from the American Heart Association. *Circulation*. 2023;147(11):e657–e673.

3. Chapman K, Njue F, Rucklidge M. Anaesthesia and peripartum cardiomyopathy. *BJA Educ*. 2023;23(12):464–472.

4. Padilla C, Hernandez Conte A, Ramzy D, et al. Impella™ left ventricular assist device for acute peripartum cardiomyopathy after cesarean delivery. *A A Case Rep*. 2016;7(1):24–26.

5. Shannon-Cain J, Hunt E, Cain BS. Multidisciplinary management of peripartum cardiomyopathy during repeat cesarean delivery: a case report. *AANA J*. 2008;76(6):443–447.

6. Sanghavi M, Rutherford JD. Cardiovascular physiology of pregnancy. *Circulation*. 2014;130(12):1003–1008.

7. Sieweke JT, Pfeffer TJ, Berliner D, et al. Cardiogenic shock complicating peripartum cardiomyopathy: Importance of early left ventricular unloading and bromocriptine therapy. *Eur Heart J Acute Cardiovasc Care*. 2020;9(2):173–182.

8. Møller JE, Engstrøm T, Jensen LO, et al. Microaxial flow pump or standard care in infarct-related cardiogenic shock. *N Engl J Med*. 2024;390(15):1382–1393.

9. O'Neill WW, Anderson M, Burkhoff D, et al. Improved outcomes in patients with severely depressed LVEF undergoing percutaneous coronary intervention with contemporary practices. *Am Heart J*. 2022;248:139–149.

10. Vandenbriele C, Arachchillage DJ, Frederiks P, et al. Anticoagulation for percutaneous ventricular assist device-supported cardiogenic shock. *J Am Coll Cardiol*. 2022;79(19):1949–1962.

11. Tihtonen K, Kööbi T, Yli-Hankala A, Uotila J. Maternal hemodynamics during cesarean delivery assessed by whole-body impedance cardiography. *Acta Obstet Gynecol Scand*. 2005;84(4):355–361.

12. Elkayam U, Schäfer A, Chieffo A, et al. Use of Impella heart pump for management of women with peripartum cardiogenic shock. *Clin Cardiol*. 2019;42(10):974–981.

13. Desai S, Sharma S, Paghdar S, Ruiz J, Goswami R. Percutaneous axillary left ventricular support as a lifesaving measure for peripartum cardiomyopathy shock: a case report. *Cureus*. 2023;15(8):e44224.

14. Alshawabkeh L, Economy K, Valente A. Anticoagulation during pregnancy: evolving strategies with a focus on mechanical valves. *J Am Coll Cardiol*. 2016;68(16):1804–1813.

15. Rosman L, Salmoirago-Blotcher E, Wuensch KL, Cahill J, Sears SF. Contraception and reproductive counseling in women with peripartum cardiomyopathy. *Contraception*. 2017;96(1):36–40.

KEY WORDS **hemodynamics, Impella CP, multidisciplinary team, peripartum cardiomyopathy, preeclampsia**

APPENDIX **For supplemental videos, please see the online version of this paper.**