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CASE SERIES PERIOPERATIVE MEDICINE

Pitfalls due to improper positioning of Impella®CP device for left ventricular support: a case series

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ABSTRACT

Background: The Impella® device is a type of antegrade left ventricular assist device that includes a pump catheter designed to reside in the mid-left ventricular cavity. It has received approval for temporary use in providing left ventricular support, with the aim of augmenting cardiac output and reducing myocardial oxygen demand. We document four cases in which we encountered challenges in circulatory management during Impella device insertion. These challenges arose from issues such as incorrect positioning leading to restricted maximum flow rate or the development of new-onset aortic insufficiency (AI) associated with the placement of the device.

Cases presentation: Two of our four patients showed improper positioning; either the inlet part was too much in the ventricle or too close to the heart wall. Due to the placement of the Impella, all four patients experienced the development of new-onset aortic insufficiency with a relatively low total assisted flow rate. In one of the cases, sufficient total flow was achieved when the Impella device was utilized alongside veno-arterial extracorporeal membrane oxygenation (ECMO).

Conclusion: Circulatory management with Impella device insertion can be challenging due to certain pitfalls, such as the incorrect positioning of Impella and the development of AI following Impella placement with a restricted flow rate. During the acute phase when patients experience deteriorating cardiogenic shock, the use of ECMO for management is considered to be an effective approach.

Abbreviations: ECMO: Extra-corporeal membranous oxygenation; PCPS: Percutaneous cardiopulmonary support; LVAD: Left ventricular assist device; LVEF: Left ventricular ejection fraction; CCO: Continuous cardiac output; AI: Aortic insufficiency.

Keywords: Aortic Insufficiency; ECMO; Cardiogenic Shock; Impella; Ventricular Assist Device

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1. INTRODUCTION

The Impella (Abiomed, USA) is an antegrade left ventricular assist device (LVAD) equipped with an intravascular microaxial blood pump. Its purpose is to alleviate the workload on the left ventricle by unloading blood from the left ventricle and delivering it directly to the ascending aorta. It can be rapidlyinserted percutaneously through the femoral or axillary artery. It can be used solely as LVAD for left ventricular decompression or in conjunction with veno-arterial extracorporeal membrane oxygenation (VA ECMO).[1-3] The clinical application of Impella began in 2004 in Europe and in 2008 in the USA. Since then, it has found application in over 50,000 patients globally.

The Impella catheter is positioned within the mid-left ventricular cavity, with its inlet area located roughly 4.5 cm below the aortic annulus, while its outlet area is positioned in the ascending aorta. On the Impella console you can see two waveforms, the placement signal (red) and motor current (green); through them, you can verify that the Impella is properly positioned or not. The placement signal indicates the pressure (measured in mmHg) generated across the cardiac cycle originating from an open pressure region. The motor current, typically measured in milliamps, indicates the amount of energy consumed by the motor. This pulsation is a result of the pressure difference among the aortic outlet and the ventricular inlet regions.

Table 1: Presents the demographic and clinical data.

Patient	Age (years)	Gender	BSA (m^2)	Primary disease	Preop EF (%)
1	66	Male	1.7	3VD	30
2	56	Male	1.8	ICM	20
3	42	Female	1.5	DHCM	25
4	70	Male	1.7	Cardiogenic shock	10-15

3VD: 3 vessel disease, ICM: ischemic cardiomyopathy, DHCM: dilated phase of hypertrophic cardiomyopathy, BSA: Body surface area

Close monitoring is crucial for hemodynamic conditions, as improper positioning and aortic insufficiency (AI) are potential adverse events associated with Impella placement.[4] In our four cases, hemodynamic disturbances were experienced following the insertion of Impella® CP devices, as well as a restricted flow rate of it.

2. CASE PRESENTATION

Table 1 displays the demographic and clinical data of the four cases in which the primary diseases were ischemic heart disease, ischemic cardiomyopathy, complicated acute heart failure, and hypertrophic cardiomyopathy (dilated phase).

Table 2 shows the circulatory parameters of the four cases where pitfalls were discovered with Impella insertion during anesthetic management.

Impella was recommended due to the risky nature of the procedure and insufficient unloading of the failing left ventricle, resulting in subsequent pulmonary congestion. All of these patients had undergone intubation and were receiving ventilation. Anesthesia was induced with fentanyl 1–2 µg/kg, ketamine 1-2 mg/kg and rocuronium 0.4–0.5 mg/kg. Monitoring involved pulse oximetry (SpO_2), transesophageal echocardiography (TEE), and electrocardiography (ECG). Data from a central venous catheter and an intra-arterial line were extracted. While closely observing hemodynamic conditions, the insertion of Impella® CP via the femoral or axillary artery was performed.

Table 2: Displays four individuals' circulatory parameters.

Patient	ABP CVP (mmHg)	Approach vessel	Inotropic agent and vasoconstrictor dose*1 (µg/kg/ min)	CCO (L/min)	Inotropic agent and vasoconstrictor dose*2 (µg/kg/min)	Mixed venous oxygen saturation (%)	ABP CVP Post-operative (mmHg)	ECMO Use
1	89/54 (62) 7	LFA	DOA 5 NAD 0.1	3.7	DOA 5 NAD 0.15	65%	90/50 (65) 8	No
2	95/57 (66) 8	LFA	DOA 6 NAD 0.05	3.1	DOA 3 NAD 0.08	86%	100/48 (77) 11	No
3	96/52 (62) 12	LFA	DOA 5 NAD 0.08	3.5	DOA 2 NAD 0.1	72%	100/52 (62) 10	No
4	70/52 (63) 16	RSCA	DOB 5 NAD 0.1 AD 0.2	3.2	DOB 2 NAD 0.03	85%	82/78 (79) 12	YES

*3VD: 3 vessel disease, ICM: ischemic cardiomyopathy, ABP: arterial blood pressure, ECMO: extracorporeal membrane oxygenation, BSA: body mass index, DHCM: dilated phase of hypertrophic cardiomyopathy, CVP: central venous pressure, LFA: left femoral artery, CCO: continuous cardiac output, AD: adrenaline, NA: noradrenaline, DOB: dobutamine, DOA: dopamine, RSCA: right subclavian artery, *1: Initial dosage prior to Impella insertion *2: Dosage following departure from the operating room*

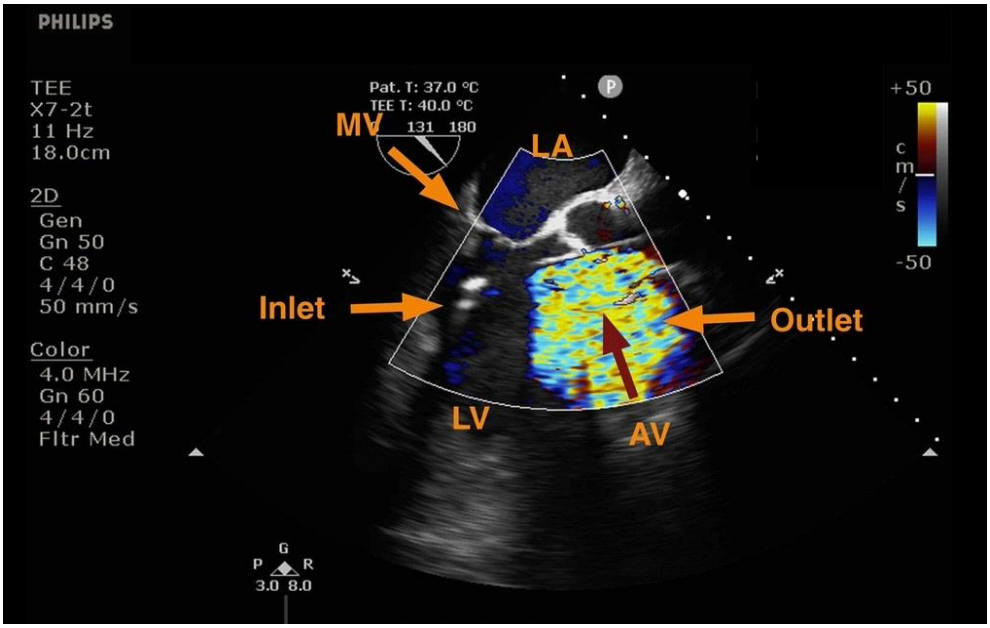

Figure 1: Improper positioning of the Impella catheter, as it was inserted more than 4.5 cm below the aortic valve. Additionally, a transesophageal echocardiogram (TEE) revealed turbulent flow with a dense mosaic pattern beneath the aortic valve when the catheter outlet area crossed the valve.

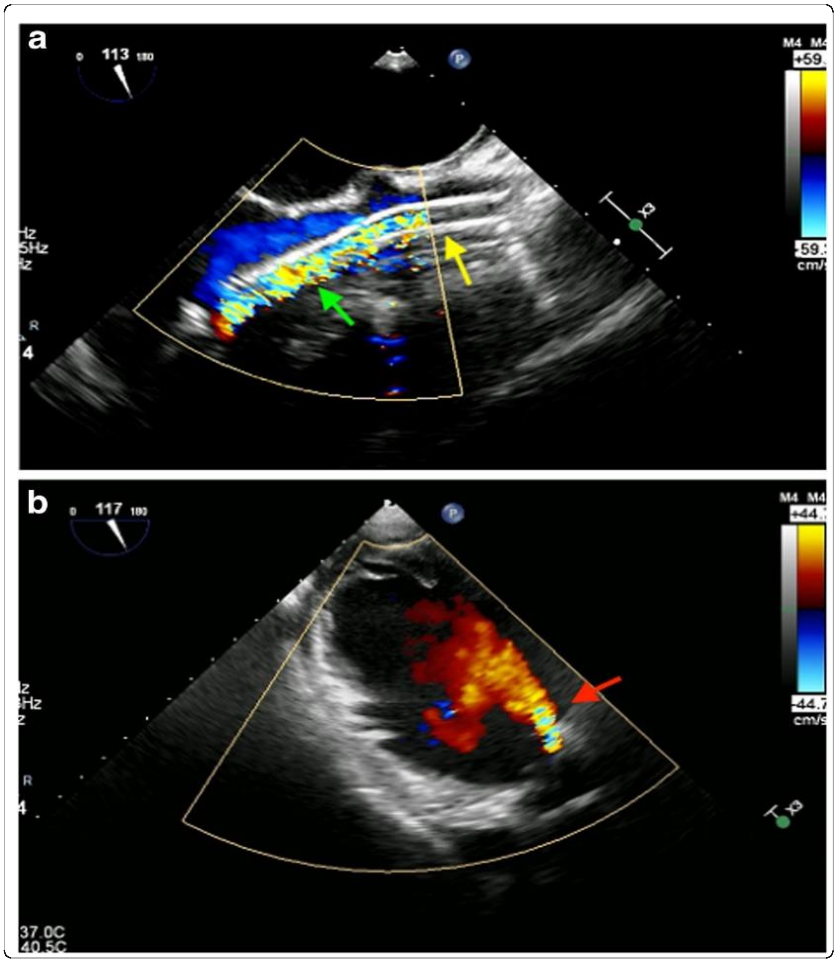

Figure 2 (a):

Transesophageal echocardiography (mid-esophageal long-axis view). The Impella cannula is denoted by the yellow arrow, while the artifacts are indicated by the green arrow. The presence of axial blood flow-related reverberation artifacts within the Impella device made it difficult to accurately diagnose aortic insufficiency using transesophageal echocardiography.

(b): Deep trans gastric view. The regurgitation jet, which resulted from aortic insufficiency, is indicated by the red arrow. This view presented a clear identification without any artifacts.

Improper positioning

In patient 1 and 3, there was troubleshooting position alarm and low flow rate than expected, which confirmed by TEE as incorrect Impella catheter placement. In patient 1, the catheter inlet area was located more than 4.5 cm below the aortic valve (Figure 1). In patient 3, the catheter was too close to the heart wall.

2.2. New-onset aortic insufficiency

After the placement of Impella, all patients experienced a decrease in flow rate and new-onset aortic insufficiency. In Patient 1, the Impella consol indicated 5.0 L/min is the anticipated flow rate when the Impella device was operating at its highest level of assistance. Nevertheless, the cardiac output measured through a pulmonary artery catheter was observed to be 3.5 L/min. TEE revealed the presence of recently formed AI subsequent to the insertion of Impella (Figure 2a, 2b). This finding suggested that the reduction in cardiac output by 1.5 L/min could be attributed to the volume of AI. Likewise, patients 2, 3, and 4 exhibited CCO that was more than 1 L/min below the anticipated flow indicated on the Impella console, indicating the presence of newly formed aortic insufficiency.

3. DISCUSSION

Impella is a ventricular assist device renowned for its ability to be easy implanted with minimal invasiveness. Based on our experiences, we have observed instances of incorrect positioning in certain cases and the emergence of newly developed aortic insufficiency linked to the insertion of Impella. Circulatory management may encounter pitfalls due to these factors.

3.1. Improper positioning

Improper positioning may result in a limited flow rate or even loss of mechanical support. Therefore, it is mandatory to verify the proper positioning of the catheter by using TEE and waveform characteristics on the control unit screen. In a previous case report, it was depicted that the catheter's inlet area was improperly positioned in the aorta.[5] Similarly, in one of our cases, we found that the inlet area was too far from the aortic valve.

3.2. New-onset aortic insufficiency

After the insertion of Impella, newly developed aortic insufficiency emerged in all four patients. A previous case report documented a situation where aortic insufficiency remained present even following the Impella device's removal, which was attributed to aortic valve injury.[6] In our cases, the presence of aortic insufficiency vanished following the extraction of Impella, most properly indicates to an incomplete leaflet coaptation, which resulted from mechanical compression by the Impella cannula.

The conventional quantitative assessment of aortic insufficiency while using a ventricular assist device may result in underestimated measurements, as the volume of aortic insufficiency can fluctuate depending on the length of time the aortic valve remains closed., Sometimes, aortic insufficiency may occasionally occur throughout the entire cardiac cycle.[7]

Due to reverberation artifacts caused by axial blood flow within the Impella device, accurate identification of aortic insufficiency was challenging by TEE for patient 1 (Figure 2a). Precise diagnosis of aortic insufficiency required careful observation with different views. It was clearly observed on the deep transgastric view as it was distinctly identified (Figure 2b)

3.3. Limited flow rate of the Impella device

Restricted flow rate of Impella may lead to an insufficiency of organ perfusion, as was reported by a previous study.[8] LVADs with higher flow rates have the potential to compensate for decreased organ perfusion caused by AI.[9]

In patient number four, the flow rate assisted by the Impella device decreased due to new-onset aortic insufficiency. Nevertheless, ECMELLA (combination of Impella with VA ECMO) increased the overall rate of flow and helped to sustain organ perfusion and arterial blood pressure. Thus, a minimal number of vasoconstrictors was sufficient to uphold the overall blood pressure within the body. In an earlier case study, a patient experiencing the progressive organ failure and the acute phase of fulminant myocarditis showed improved organ function when the Impella device was utilized as ECMELLA.[10]

When Impella alone fails to enhance circulatory function adequately because of its restricted flow rate, the utilization of ECMELLA has been recognized as an effective alternative.

4. CONCLUSIONS

- Circulatory management can be compromised by incorrect positioning and the development of aortic insufficiency following Impella placement, which can lead to a restricted flow rate. The anaesthesiologists should be oriented with these pitfalls during management of those cases.
- During the acute phase of cardiogenic shock, ECMELLA has shown effectiveness in improving

- cardiac function until patients recover.

5. Conflict of interest

The study utilized the hospital resources only, and no external or industry funding was involved.

6. Authors' contribution

AA: assembled the data for the study

YH: assistance in preparing the manuscript and interpreting the data

AI: preparing the manuscript and assistance in interpreting the data

7. REFERENCES

1. Impella ventricular support systems for use during cardiogenic shock and high-risk PCI: instructions for use and clinical reference manual. Danvers, MA: Abiomed; 2016.
2. Kapur NK, Jumean MF: Defining the role for percutaneous mechanical circulatory support devices for medically refractory heart failure. Curr Heart Fail Rep. 2013;2:177–84. [PubMed] DOI: 10.1007/s11897-013-0132-1
3. Seyfarth M, Sibbing D, Bauer I, Frohlich G, Bott-Flugel L, Byrne R, et al. A randomized clinical trial to evaluate the safety and efficacy of a percutaneous left ventricular assist device versus intraaortic balloon pumping for treatment of cardiogenic shock caused by myocardial infarction. J Am Coll Cardiol. 2008;52:1584–8. [PubMed] DOI: 10.1016/j.jacc.2008.05.065
4. Dimas VV, Morray BH, Kim DW, Almond CS, Shahanavaz S, Tume SC, et al. A multicenter study of the impella device for mechanical support of the systemic circulation in pediatric and adolescent patients. Catheter CardiovascInterv. 2017;90(1):124–9. [PubMed] DOI: 10.1002/ccd.26973
5. R Chandola, R Cusimano, M Osten EH. Severe aortic insufficiency secondary to 5 L Impella device placement. J Card Surg. 2012;27:400–402. [PubMed] DOI: 10.1111/j.1540-8191.2012.01454.x
6. Hong E, Naseem T. Color Doppler Artifact masking iatrogenic aortic valve injury related to an Impella device. J Cardiothorac Vasc Anesth. 2019 Jun 1;33(6):1584–7. [PubMed] DOI: 10.1053/j.jvca.2018.09.035
7. Stainback RF, Estep JD, Agler DA, Birks EJ, Bremer M, Hung J, et al. Echocardiography in the management of patients with left ventricular assist devices: recommendations from the American Society of Echocardiography. J Am Soc Echocardiogr. 2015;28(8):853–909. [PubMed] DOI: 10.1016/j.echo.2015.05.008
8. Pieri M, Contri R, Winterton D, Montorfano M, Colombo A, Zangrillo A, et al. The contemporary role of Impella in a comprehensive mechanical circulatory support program: a single institutional experience. BMC Cardiovasc Disord. 2015;15(1). [PubMed] DOI: 10.1186/s12872-015-0119-9
9. Lim HS, Howell N, Ranasinghe A. The physiology of continuous-flow left ventricular assist devices. J Card Fail. 2017;23(2):169–180. [PubMed] DOI: 10.1016/j.cardfail.2016.10.015
10. Narain S, Paparcuri G, Fuhrman TM, Silverman RB, Peruzzi WT. Novel combination of Impella and extra corporeal membrane oxygenation as a bridge to full recovery in fulminant myocarditis. Case Reports Crit Care. 2012;2012:1–3. [PubMed] DOI: 10.1155/2012/459296

