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Case Report

Acute hypoxemia caused by Impella in a patient with fulminant myocarditis and patent foramen ovale

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ABSTRACT

Impella ™ (Abiomed, Danvers, MA, USA) is effective in the acute management of fulminant myocarditis and myocardial infarction with cardiogenic shock. Here, we report a case of a 70-year-old man with fulminant myocarditis in cardiogenic shock who developed right-left shunt via patent foramen ovale during acute management with Impella 5.0, resulting in sudden hypoxemia. With combined support of veno-arterial extracorporeal membrane oxygenation and Impella (ECPELLA), his circulation and oxygenation became stable. The same phenomenon is well known in left ventricular assist device. In such situations, ECPELLA is effective to improve the hypoxic condition. It should be kept in mind that hypoxemia can occur in patients with intracardiac shunt disease when using Impella.

Learning objective: Impella is effective to maintain circulation in patients with cardiogenic shock; however, several complications have been reported. Intra-cardiac shunt can suddenly cause severe hypoxemia by Impella. We should mention the presence of intra-cardiac shunt, if the patients have sudden hypoxemia when using left ventricular assist.

Introduction

Extracorporeal membrane oxygenation (ECMO) and intra-aortic balloon pumping (IABP) were the only mechanical support for cardiogenic shock with poor prognosis, until Impella (Abiomed, Danvers, MA, USA) appeared in clinical practice, which has been reported to improve the prognosis [1,2]. Although mechanical support devices are useful in cardiogenic shock, there are various risks of complications, such as valve injury, bleeding, and thrombosis [1,3].

Fulminant myocarditis is an acute myocarditis with a fatal course due to rapid hemodynamic collapse, cardiogenic shock, and life-threatening arrhythmia, in which the mortality rate is very high at 43 %, especially in the acute phase of this disease [4]. However, the mortality rate reduces if the patients are able to survive the acute phase [5], suggesting that the management in the acute phase is important. In the acute management, it is usually required to maintain circulatory dynamics using mechanical support such as ECMO; however, increased afterload is a major concern, which is caused by veno-arterial extracorporeal membrane oxygenation (V-A ECMO) and has a negative impact on hemodynamics. In this situation, Impella is expected to increase cardiac output and decrease afterload, which can improve the prognosis.

In the presence of cardiac shunt diseases, it has been reported that left ventricular assist device (LVAD) is ineffective due to manifestation of right to left (R-L) shunt [6]; however, little is known in Impella. Here, we report a case of R-L shunt due to patent foramen ovale (PFO) manifested by the use of Impella.

Case report

A 70-year-old Japanese man, who had fatigue, dyspnea, and chest discomfort during exertion for 3 days, was admitted to our hospital. On admission, his blood pressure was 90/48 mmHg, heart rate was 118 beats per minute and regular, and arterial oxygen saturation was 98 % (room air). He had jugular venous distention and cold extremities. Electrocardiography showed sinus tachycardia with a heart rate of 100 beats per minute, with first-degree atrioventricular block (PR 0.21 s) and wide QRS (QRS 0.147 s), indicating conduction disturbance (Fig. 1A). Chest X-ray showed marked pulmonary congestion and

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cardiac enlargement (Fig. 1B). Echocardiography showed reduced left ventricular ejection fraction (LVEF; 37.5 %) with diffuse hypokinetic left ventricular wall motion, and left-right shunt via PFO (Fig. 1C-E). Blood tests showed elevated troponin I (27,273.3 pg/mL), creatine kinase (CK; 799 IU/L), and creatine kinase-MB (CK-MB; 95 IU/L).

After admission, we started continuous intravenous administration of catecholamine (Fig. 2); however, the response was poor and lactate was also elevated. Then, we decided to use mechanical support on day 2. The initial right heart catheterization showed PAPI [pulmonary artery pulsatility index] of 0.9, and we considered that right ventricular function was preserved. In 2018, we had 2 options; Impella 2.5 and 5.0. Because long-term mechanical support and large left ventricular support might be required, we inserted Impella 5.0 through the right subclavian artery via an artificial vessel to maintain circulatory dynamics. If hemodynamics were not stabilized, we planned to add V-A ECMO. Coronary angiography showed no significant stenosis (Fig. 1F-H), and we performed myocardial biopsy (right ventricle). The CPO [cardiac power output] was 0.8 after starting circulatory support by Impella. On the same day, we started steroid pulse therapy for 3 days, followed by steroid maintenance therapy. On day 4, we additionally administered high-dose intravenous immunoglobulin therapy.

Impella 5.0 support stabilized his circulatory status and lowered lactate. However, on day 4, hypoxia suddenly appeared. Chest X-ray showed no congestive findings or pneumonia. We considered pulmonary

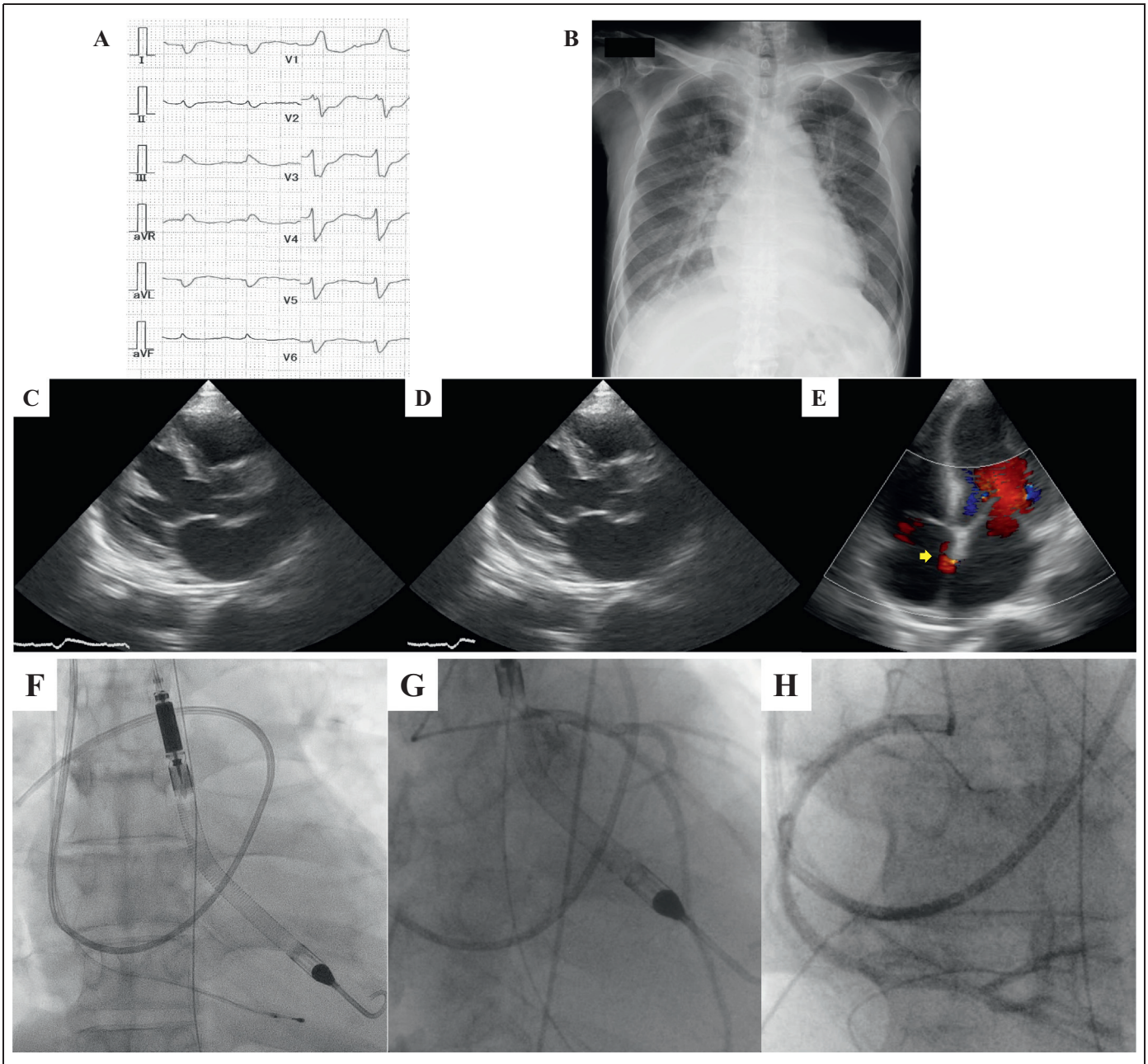

Fig. 1. Findings. (A) Electrocardiography. (B) Chest X-ray. (C-E) Echocardiography of systole (C), diastole (D), and color Doppler echo (E). Arrow indicates a trivial left-right shunt flow via the patent foramen ovale. (F-H) Coronary angiography. No significant coronary stenoses were observed. (I) Four-chamber image during Impella insertion with P7 and ECMO flow of 3.0 L/min clearly shows right-to-left shunt flow through the patent foramen ovale (PFO, arrows). (J) Hematoxylin and eosin staining of the myocardial sample (original magnification ×400). Mixed inflammatory infiltrates comprising histiocyte giant cells and lymphocytes were observed. (K) Four-chamber image after weaning from Impella showing left-to-right shunt flow through the PFO. (L) Autopsy finding of PFO.

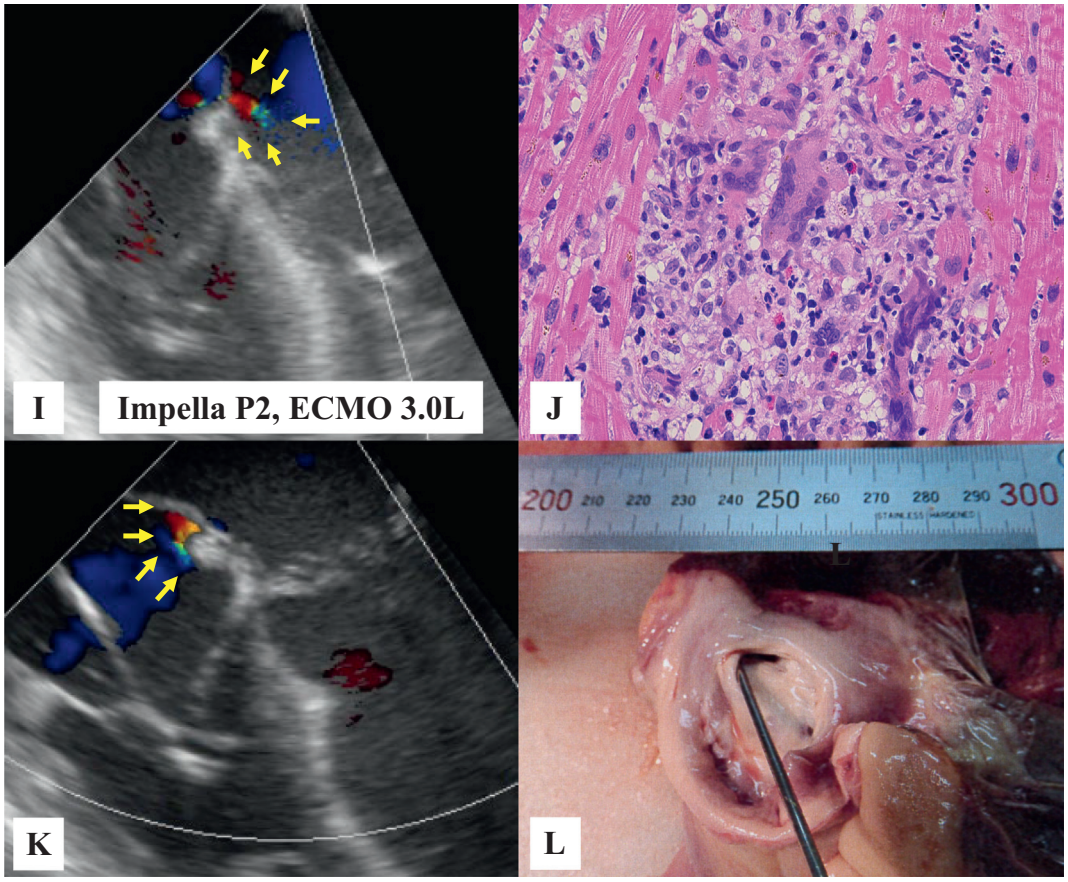

Fig. 1 (*continued*).

thromboembolism, but there were no elevation of pulmonary artery pressure or D-dimer in blood test, as well as no findings of left ventricular pressure exhaustion in echocardiography. The cause of hypoxia remained unknown, we increased oxygen of the ventilator up to 100 % FiO_2; however, PaO_2 was still 34.5 mmHg. As desaturation was remarkable, we added V-A ECMO to maintain oxygenation, and then oxygenation was improved (Fig. 2). Although transthoracic echocardiography was not clear due to Impella flow, transesophageal echocardiography clearly showed R-L shunt flow through PFO, which was considered to cause hypoxemia (Fig. 1I). Under the support of V-A ECMO and Impella (ECPELLA), his circulation and oxygenation became stable. On day 5, myocardial biopsy revealed giant cell myocarditis (Fig. 1J). We were able to start weaning from mechanical support on day 6. As we considered that Impella could re-exacerbate hypoxemia caused by R-L shunt, we first withdraw Implella. We switched from Impella to IABP, and discontinued Impella on day 8, ECMO on day 11, and IABP on day 18. Transesophageal echocardiography after Impella also showed a R-L shunt through the PFO, as observed on admission (Fig. 1K). On day 60, LVEF improved only to 42 % using dobutamine (3 μg/kg/min). His heart failure management was relatively good, but it was difficult to control infection. He died on day 76, and an autopsy confirmed PFO, with a diameter of 10 mm (Fig. 1L).

Discussion

Here, we reported a case of R-L shunt due to PFO manifested by the use of Impella. After the additional V-A ECMO, his circulation and oxygenation became stable, and we were able to continue the fulminant myocarditis management in the acute phase. It is well known that R-L shunt appears via PFO after LVAD implantation, leading to hypoxemia, and if the opening of the foramen ovale can be confirmed preoperatively, it must be closed before insertion [6].

The prevalence of PFO is reported to be around 20 % [7], and additional closure of PFO was reported in about 5 % of patients at the time of LVAD insertion [8]. Further, surgical closure, transcatheter closure, LVAD flow adjustment, and positive end-expiratory pressure adjustment after LVAD insertion was reported [9,10]. In this case, we considered that the PFO should be closed, but surgical closure was too invasive. We were not able to perform transcatheter treatment at that time. If closure option was available, we should have chosen transcatheter PFO closure at the time of V-A ECMO weaning.

In congestive heart failure, the patient's left atrial pressure (LAP) is usually much higher than the right atrial pressure (RAP). After LVAD implantation, LAP is markedly decreased, and RAP is also decreased due to the decrease in pulmonary vascular resistance and right ventricular afterload. However, if RAP is still higher than LAP (in case of right ventricular dysfunction due to myocarditis), the presence of PFO is suggested in LVAD patients, in which the shunt flow might be detected by echocardiography. Also, this situation can cause hypoxemia during LVAD support.

Although the left ventricular assist power by Impella is smaller than LVAD, the use of Impella 5.0 and the rapid progression of right ventricular dysfunction due to fulminant myocarditis, as shown in this case, can contribute to R-L shunt. In the present case, the combined use of V-A ECMO and Impella stabilized blood oxygenation, reduced RAP, and allowed Impella flow to be regulated while maintaining total cardiac output, which were able to reduce R-L shunt, improved oxygenation, and manage safely.

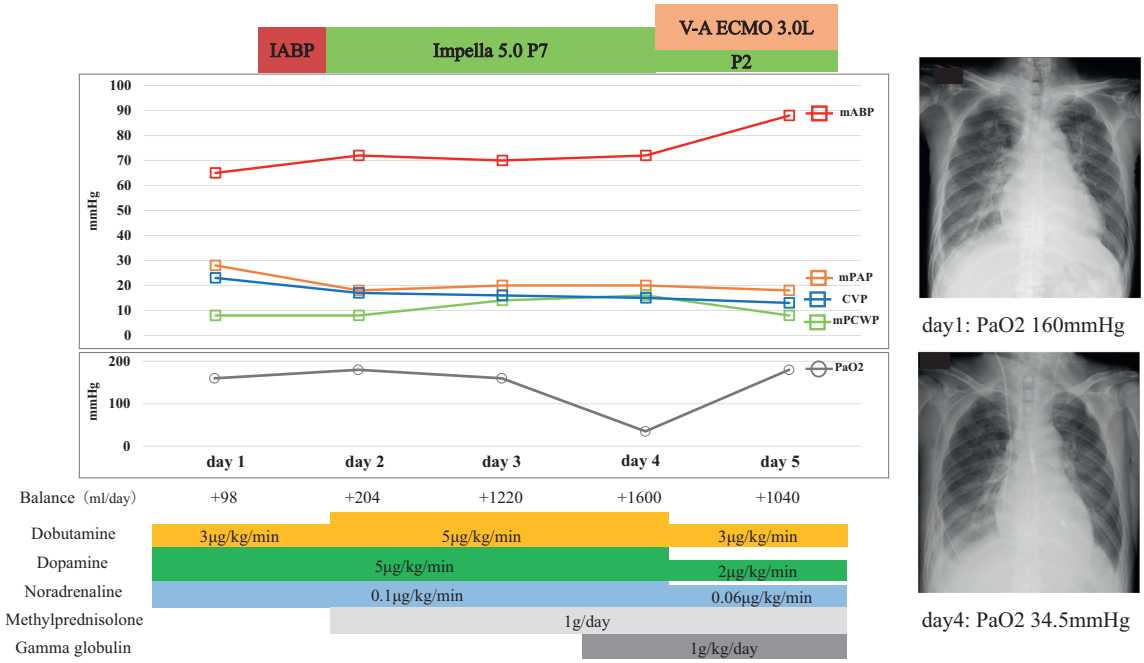

Fig. 2. Clinical time course.
Impella 5.0 support had stabilized hemodynamic state from days 2 to 3, but hypoxia progressed acutely without pulmonary congestion or infiltration on day 4. Although the fraction of inspiratory oxygen was elevated to 100 %, the partial pressure of arterial oxygen remained at 34.5 mmHg. We added V-A ECMO and weakened the Impella output level to P2, which led to recovery from hypoxemia.[V-A ECMO; veno-arterial extracorporeal membrane oxygenation].

In the weakening of mechanical support, we were forced to wean Impella first, because we considered that hypoxemia occurred due to the exacerbation of R-L shunt. However, support with V-A ECMO alone was undesirable, which increases the left ventricular afterload. V-AV ECMO or V—V ECMO may have been able to make better use of Impella and reduce cardiac workload (Fig. 3).

It is usually difficult to detect intracardiac shunt disease such as PFO, because Impella is mostly used in cases of cardiogenic shock, which require urgent care. Further in such situations, transthoracic echocardiography is not sensitive and tends to underestimate the severity of the shunt, and color Doppler is difficult to assess because of Impella flow. Transesophageal echocardiography is effective to diagnose PFO. Therefore, when hypoxemia is observed that cannot be explained by the findings on chest X-ray after Impella, we should perform transesophageal echocardiography to detect intracardiac shunt.

Conclusion

PFO suddenly caused hypoxemia when we started Impella support in a patient with fulminant myocarditis. In such a situation, the combined use of ECMO was effective to improve the hypoxic condition.

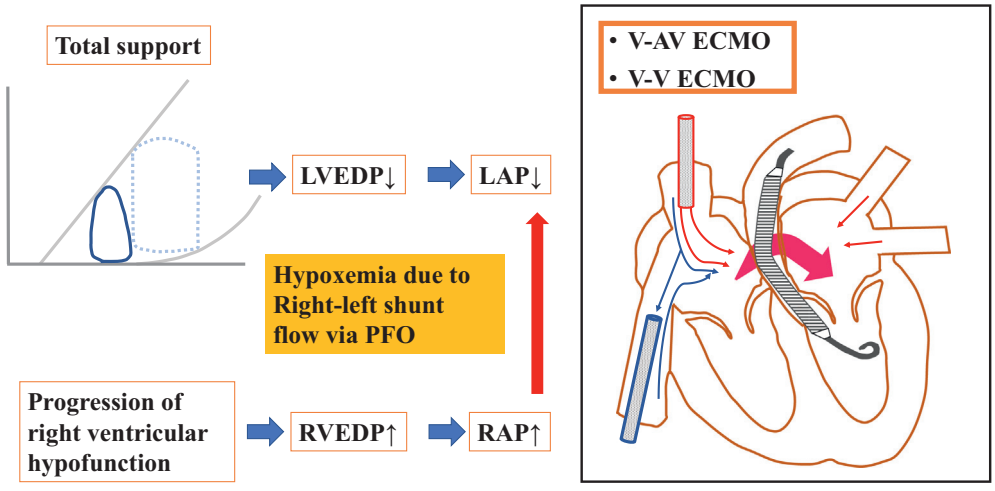

Fig. 3. Mechanism of sudden hypoxemia. Left panel: In the present case of rapid progression of right ventricular dysfunction due to fulminant myocarditis, right arterial and right ventricular end-diastolic pressures were elevated and surpassed left arterial pressure, which was reduced by Impella support, as well as left ventricular end-diastolic pressure. An increased right-to-left (R-L) shunt flow via the patent foramen ovale resulted in serious hypoxemia. Right panel: Prevention of hypoxemia. The combined use of veno-arterial-venous or veno-venous extracorporeal membrane oxygenation provides sufficient oxygenated flow into the right atrium and left atrium via the R-L shunt, which is systematically supplied. [R-L; right to left, ECMO; extracorporeal membrane oxygenation].

Declaration of competing interest

The authors declare no conflict of interest.

Acknowledgment

None.

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