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Case Report

Non-Surgical Resolution of Inflow Cannula Obstruction of a Left Ventricular Assist Device: A Case Report

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A 55-year-old woman who had received an implantable left ventricular assist device 3 months earlier presented with dyspnea and a low-flow alarm of the device. Computed tomography and log-file analysis of the device system suggested inflow cannula obstruction. Since the patient had cardiogenic shock due to pump failure, venoarterial extracorporeal membrane oxygenation (ECMO) was initiated. With ECMO, surgical exchange of the pump was considered. However, the obstruction spontaneously resolved without surgical intervention. It turned out that an obstructive thrombus was washed out by rebooting the pump. Moreover, the thrombus was embolized in the patient's left subclavian artery. The patient underwent heart transplantation 4 months after the pump obstruction accident and continued to do well.

Keywords: Heart-assist devices, Ventricular assist devices, Embolism and thrombosis, Thrombosis, Case report

Case report

A 55-year-old woman with worsening dyspnea was referred to Samsung Medical Center. The patient had previously been diagnosed with refractory atrial fibrillation and ventricular arrhythmia with underlying hypertrophic cardiomyopathy (HCMP). She had several episodes of cardiac arrest due to ventricular fibrillation even after the insertion of an implantable cardioverter defibrillator. Transthoracic echocardiography (TTE) revealed severe left ventricular systolic dysfunction with a decreased left ventricular ejection fraction (30%). As a deteriorating clinical course was predicted considering her refractory arrhythmia with underlying HCMP, the patient received a HeartWare ventricular assist device (VAD) (HVAD; Medtronic International Inc., Framingham, MA, USA) as a bridge to heart transplantation. Before implantation of the HVAD, the diastolic left ventricular internal diameter was 53.4 mm. During the postoperative period after VAD implementation, the patient experienced gastrointestinal bleeding requiring reversal of anticoagulation, transfusion, and endoscopic hemostasis. The patient was discharged 45 days after VAD implantation with a lactate dehydrogenase (LD) level of 341 U/L and an international normalized ratio (INR) of 2.21 upon prothrombin time testing. She tolerated an HVAD speed of 2,400 rpm, a flow of 3.3 L/min, and a power of 2.8 W.

Three months after VAD implantation, the patient was admitted to the intensive care unit for sudden-onset dyspnea and continuous low-flow alarms of VAD. At her baseline VAD speed of 2,400 rpm and power reading of 2.2 W, the flow was limited to 0.8 L/min. Despite the manipulation of the VAD speed from 300 to 2,800 rpm, the flow was fixed at 0.8 L/min. The initial blood laboratory results showed an LD level of 662 U/L, and TTE showed no identifiable flow around the inflow cannula. The HVAD log-file analysis indicated pre-pump flow obstruction, which was characterized by the abrupt onset of low flow (Fig. 1). Computed tomography angiography (CTA) revealed possible inflow cannula obstruction with a thrombus (Fig. 2A, B), even though the interpretation of the CTA was limited due to metal artifacts. The rapid progression of cardiogenic

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shock led to the initiation of venoarterial extracorporeal membrane oxygenation (ECMO). The patient was heparinized to meet a target activated clotting time between 150 and 180 seconds and an activated partial thromboplastin time (aPTT) between 55 and 75 seconds. The patient was supported with ECMO for 2 days, and the flow of the pump was fixed at 0.8 L/min even with the parenteral heparinization. Since the pump thrombosis was not resolved by heparinization, surgical exploration and pump exchange were planned.

The patient was brought to the operating room. During surgical preparation, the power supply of the pump was disconnected for seconds to reconnect to the extension line. After this step, the pump was automatically turned off and restarted to reach a flow level of more than 3 L/min. Intraoperative transesophageal echocardiography identified normal blood flow around the inflow cannula. The planned surgical exchange of the pump was canceled. Immediately after the event, follow-up CTA was performed, and a 1-cm thrombus was found in the aortic arch at the level of the ostium of the left subclavian artery (Fig. 2C). Contrast-enhanced echocardiography confirmed that there was no thrombus in the pump cannula and left ventricular cavity. The patient was weaned from ECMO, and the VAD was stabilized with the following settings: speed of 2,400 rpm, flow of 3.2 L/min, and power of 3.0 W. Duplex scanning after 2 weeks revealed that the thrombus remained present at the left subclavian artery. Since no sign of exacerbation was observed, anticoagulation with warfarin was continued, and no other intervention was planned. The patient was discharged on day 24 after hospitalization.

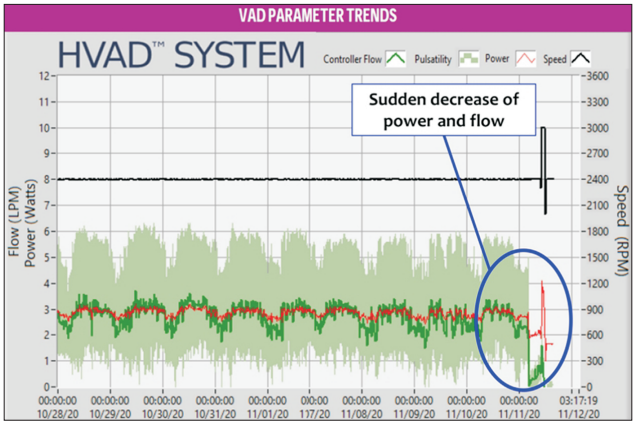

Fig. 1. Log-file analysis of the ventricular assist device revealed a sudden-onset decrease in flow.

Four months later, heart transplantation was performed, and the patient's heart was examined. Old thrombi had formed near the inflow cannula (Fig. 3). To determine the necessity of anticoagulation, duplex scanning was again performed. The duplex scan revealed that there was no remaining thrombus in the left subclavian artery. Four weeks after heart transplantation, the patient was discharged without complications, and at her last outpatient clinic visit, she continued to do well.

The study was approved by the Institutional Review Board of Samsung Medical Center (IRB approval no., 2021-06-069). The patient provided written informed consent for the publication of clinical details and images.

Discussion

Currently, VADs are increasingly used to treat end-stage heart failure as a bridge to transplantation or destination therapy. Although clinical outcomes have improved with

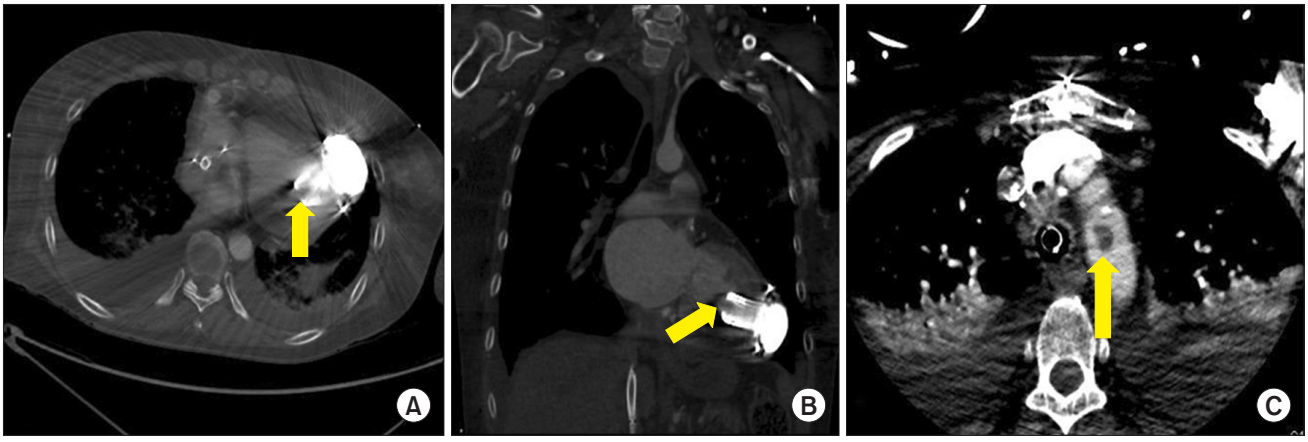

Fig. 2. Computed tomography showed obstruction of the ventricular assist device inflow cannula (A, B) (arrows), and a follow-up image revealed a 1-cm thrombus in the aortic arch at the level of the ostium of the left subclavian artery (C) (arrow).

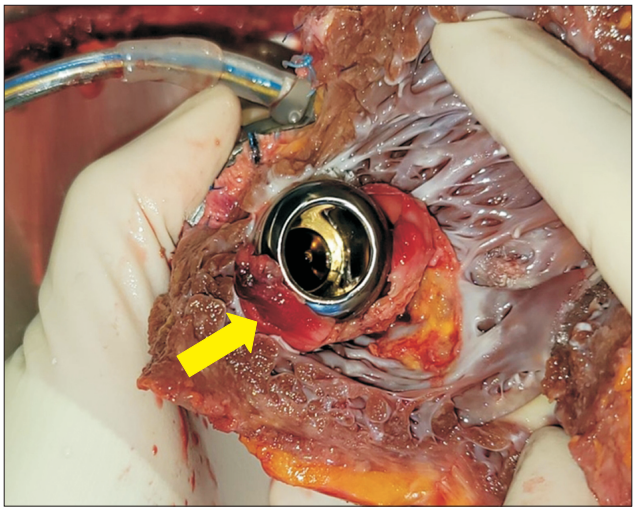

Fig. 3. An examination of the patient's heart revealed that old thrombi had formed near the inflow cannula (arrow).

the development of new devices [1], potential risks, such as bleeding, strokes, infections, and thromboembolic events, including pump thrombosis, remain [2]. Pump thrombosis is a devastating complication that can lead to urgent shock, as in the patient in this case report. Thus, optimal anticoagulation should be considered before thrombus formation and if pump thrombosis does occur, an appropriate assessment and clinical suspicion are important.

When using an HVAD system, the recommended INR is between 2.0 and 3.0. For patients with a smaller left ventricular cavity, as in our case, this anticoagulation is particularly important to prevent thrombus formation. However, this patient had experienced massive gastrointestinal bleeding, which required transfusion and reversal of anticoagulation, during the postoperative period following HVAD insertion. This led to an adjustment of the target range of anticoagulation to an INR of 1.5 to 2.0.

When pump thrombosis occurs, patients may present with clinical signs of hemolysis, device alarms, and cardiogenic shock if they have a totally VAD-dependent flow [3]. In this case report, the patient had all of those signs. Furthermore, her blood laboratory results revealed high levels of LD, which is one of the most specific indicators of device thrombosis [3]. Although CTA suggested the possibility of inflow cannula obstruction, preoperative TTE and CTA were inadequate for diagnosing pump thrombosis due to metal artifacts. Log-file analysis of HVAD systems provides hints regarding the type of blood flow obstruction. According to the algorithm for diagnosing and treating VAD-related blood flow obstructions introduced by Scandroglio et al. [4], after excluding other causes of low-flow status, an abrupt drop in flow suggests that a thrombus may have occluded the inflow cannula. This is different from other types of obstruction, such as the obstruction of the in-pump and outflow cannulas, which tend to show a gradual onset of low-flow status.

When thrombosis is suspected as the culprit of pump malfunction, a decision should be made to perform either medical thrombolysis or surgical exchange of the VAD. Several recent studies have suggested a conservative medical approach with heparinization as a treatment option considering the high risks of surgical pump exchange [5,6]. Alternatively, the "washout" maneuver, involving stopping and restarting the device using a filter-based cerebral protection system, has been introduced and is preferred as the first treatment option for VAD inflow obstruction [4]. In this case report, the patient suffered refractory cardiogenic shock, and we had to support the patient with ECMO while preparing for VAD exchange.

To maintain the ECMO flow, the patient was heparinized with a target aPTT between 55 and 75 seconds for 2 days. This did not lead to resolution of the thrombosis in the pump. In the operating room, we followed the washout procedure to some extent while connecting the extension line. Fortunately, the occlusion of the inflow cannula resolved without surgical intervention.

At our center, surgical exchange of the pump is the first option in cases of inflow cannula obstruction. This is because carotid protecting devices are not available in Korea. However, this case showed the effectivity of the washout maneuver and the necessity of a carotid protecting device. If there is a possible method to protect the central nervous system, active application of the washout maneuver would be recommended.

In summary, we encountered a thrombotic occlusion of the inflow cannula of the VAD, which is a rare complication. It was resolved using the washout maneuver without any surgical intervention. However, a cerebral protection strategy should be considered before rebooting the VAD in such a case. If surgical exchange is planned, connection of a driveline extension should be avoided to prevent automatic rebooting and embolization of the thrombus through the patient's aortic valve.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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