Prophylactic Negative Pressure Wound Therapy for Cannula Sites of Extracorporeal Biventricular Assist Devices

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Abstract

We report wound management using a vacuum-assisted closure (VAC) system for the cannula sites of long-term extracorporeal biventricular assist devices (BiVADs). A 23-year old Chinese female patient with a diagnosis of giant cell myocarditis needed extracorporeal BiVADs for more than 9 months. When the cannula sites appeared necrotic 3 months after BiVADs placement, she underwent negative pressure wound therapy prophylactically for four cannula sites, using a VAC system for 3 months, followed by no infections. Such prophylactic VAC therapy may be useful to avoid cannula site infections, which is still a fatal adverse event causing sepsis, especially in patients with extracorporeal BiVADs.

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Key words: Extracorporeal biventricular assist devices, Cannula site, Negative pressure wound therapy, Vacuum-assisted closure system

INTRODUCTION

Short-term mechanical circulatory support, including extracorporeal ventricular assist device (VAD), is still a realistic option to reverse refractory cardiogenic shock, to ameliorate secondary organ failures, and to provide bridges to the next therapeutic stages [1], urgent heart transplantation or implantable VAD. Infection is a serious complication of extracorporeal VAD use with high mortality and difficulty to treat due to biofilm formation on the device surfaces, making bacteria less susceptible to antibiotics [2]. In this report, we describe prophylactic management of the cannula sites with a vacuum-assisted closure (VAC) system (KCI Inc, San Antonio, TX) in a patient supported by extracorporeal biventricular assist devices (BiVADs) for more than 9 months. This report was granted a waiver exemption by the Institutional Review Board due to the anonymous nature of the single-patient case report.

CASE PRESENTATION

A 23-year old Chinese female patient living in Japan was referred for our institute due to acute renal failure with fever and systemic erythema. With the diagnosis of drug-induced hypersensitivity syndrome, she began to receive prednisolone of up to 30 mg per day and underwent hemodialysis for about 2 months. With improved renal function, she was weaned from hemodialysis. Three months after hospital admission, she suddenly complained of chest pain with ST elevation on electrocardiography. With deteriorated cardiac function, sustained ventricular tachycardia developed with loss of consciousness. Following cardiopulmonary resuscitation, venoarterial extracorporeal membranous oxygenation were placed. Although Impella 2.5 was added for left ventricular decompression, it was difficult to expect cardiac function in short-term, because her myocardial biopsy revealed giant cell myocarditis (**Figure 1**). Therefore, BiVADs were placed in a paracorporeal fashion with two Rotaflow pumps (Getinge, Hirrlingen, Germany). Under CPB, a left VAD was established from the LV apex to the ascending aorta and a right VAD with a membrane oxygenator (Biocube^{TM}, Nipro, Tokyo, Japan) was established from the right atrium to the pulmonary artery. Following recovery of pulmonary function, the oxygenator was removed from the right-side circuit one month later. Under extracorporeal BiVADs, her cardiac function still did not show recovery. Since heart transplantation in Japan was difficult, we had to wait her transfer to her mother country in the condition of Coronavirus Disease 2019 (COVID-19) outbreak.

During extracorporeal BiVADs, we managed the stab wounds of four large-bore polyvinyl chloride cannulas/tubes with the size of 40Fr for right VAD inflow, 3/8 inch for left VAD outflow, 32Fr for left VAD inflow, and 3/8 inch for right VAD outflow, respectively (**Figure 2**). Following postoperative cefazolin, VCM and MEP were given for 2.5 months because the wound swab cultures showed *Enterobacter cloacae* . Thereafter, micafungin was added because the wound cultures showed *Candida parapsilosis* . From the 4th months after BiVADs placement on, only oral Levofloxacin had been given prophylactically.

When the cannula sites appeared necrotic 3 months after BiVADs placement, we applied negative pressure wound therapy for four cannula sites, using a VAC system (**Figure 3**). The CT scan showed neither fluid retention nor abscess-like formation along the four cannulas (**Figure 2**).

Under local anesthesia, the skin and subcutaneous tissue were debrided circumferentially around the cannula sites (**Figure 2**). An open-cell polyurethane ether foam material of the VAC system was fashioned and placed into the wound in direct contact with all debrided subcutaneous surfaces. An evacuation tube with side ports that communicate with the reticulated foam was embedded in the foam, permitting even distribution of the applied negative pressure to all spaces of the wound. The wound was then covered with an adhesive

film, creating an airtight closed system. However, it was difficult to create airtightness with an adhesive film because the four large-bore cannulas caused uneven contours with convexity and concavity. In order to fill or caulk uneven film contours to create a flatter surface and airtightness, we placed Adapt skin barrier paste (Hollister Inc., Libertyville, IL), which is usually used as a skin barrier to promote a good fit between the ostomy pouching system and the peristomal skin. Finally, controlled negative suction of 125 mmHg was achieved by connecting the evacuation tube to the vacuum pump with a chamber to collect fluid and debris.

This initial dressing was left in place for 48 hours, followed by sterile exchanges of the foam and adhesive film every 5 days until granulation tissue developed around the cannula sites. Over 3 months, granulation tissue surrounded and became adherent to all aspects of the cannulas (**Figure 2**). Once the wound became shallow, we had cared without VAC and with crystal violet solbase, according to Nihon University crystal violet method [3].

Fortunately, this patient supported with extracorporeal BiVADs was transferred to China by aircraft on the 282nd day after surgery, followed by successful heart transplantation on the 295th day in her mother country. Our wound management of the cannula sites had not produce any obstacles for the transfer and transplantation.

DISCUSSION

Extracorporeal VAD therapy is often the option for patients with severe heart failure, as a bridge to decision, recovery, and heart transplant. However, they are associated with severe complications, including stroke, bleeding, device malfunction, and infection. Cannula site infections are still fatal adverse events which can cause sepsis, especially in patients with extracorporeal BiVADs. In addition to antibiotics and surgical debridement, a VAC system has been used for treatment of VAD driveline and cannula site infections [2, 4 - 6] to promote granulation tissue formation.

The VAC system provides substantial wound stability with effective immobilization of the cannula sites and secure adherence of circumferential subcutaneous tissue to them. It also aids in fluid drainage, in removal of edema and bacterial debris, and in the approximation of wound edges. The hermetically sealed and well-drained conditions maintained by the VAC system is protective toward contamination and infection. Therefore, we prophylactically used the VAC system to avoid cannula site infections in our patient with BiVADs.

When we applied the VAC system for the cannula sites in extracorporeal VAD patients, the biggest issue was the uneven contours with convexity and concavity caused by the large-bore cannula, which disturbs airtightness with a covered adhesive film. To resolve this problem, we placed Adapt skin barrier paste, which is usually used for the ostomy pouching system. Our technique can provide an environment with negative pressure relatively easily, even with the surface of convexity and concavity.

Fig. 1.

Hematoxylin and eosin staining micrographs (magnification $\times 20$) of the myocardium at biopsy, showing giant cell myocarditis.

Fig. 2.

Axial (1) and three-dimensional (2) views of the cannula sites on computed tomography (CT) scans

Fig. 3.

Serial photographs of the cannula sites after placement of biventricular assist devices; (1) at 2 months after surgery, (2) at 3 months after surgery, (3) after debridement of the necrotic tissue at 3 months after surgery, (4) during VAC therapy after debridement, (5) at 4 months after surgery, showing the Adapt skin barrier paste to create a flatter surface and airtightness for VAC therapy, (6) during continued VAC therapy, (7) at 4.5 months after surgery, and (8) at 8 months after surgery without VAC therapy. VAC, vacuum-assisted closure.

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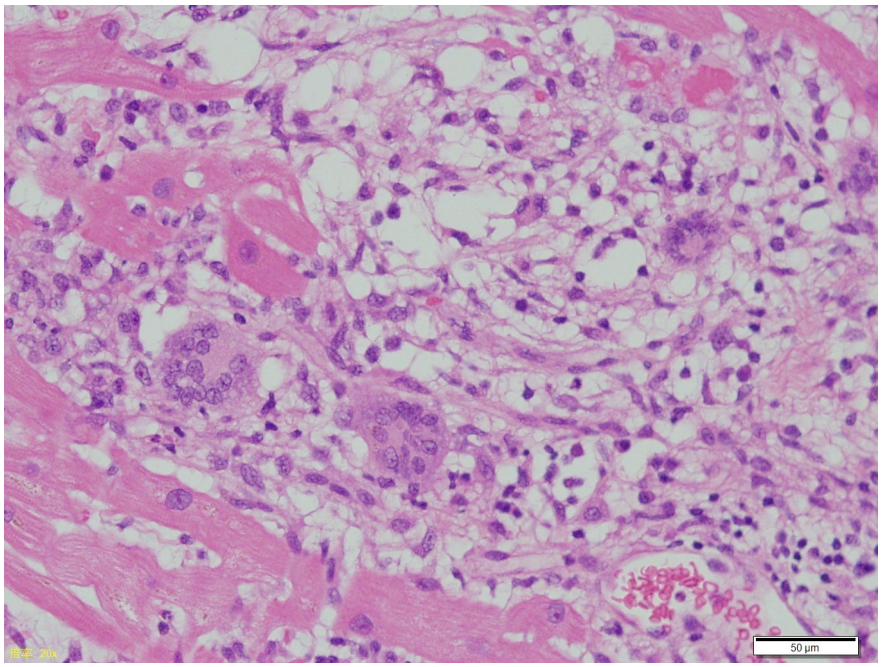

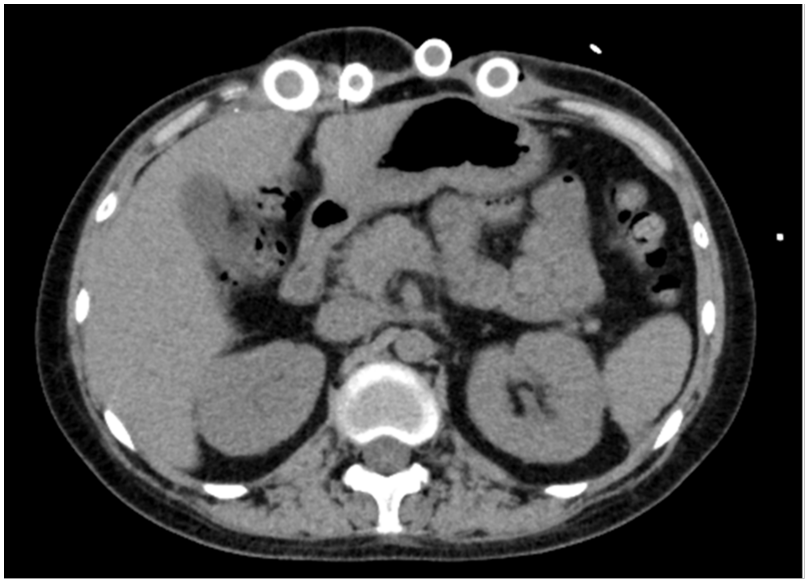

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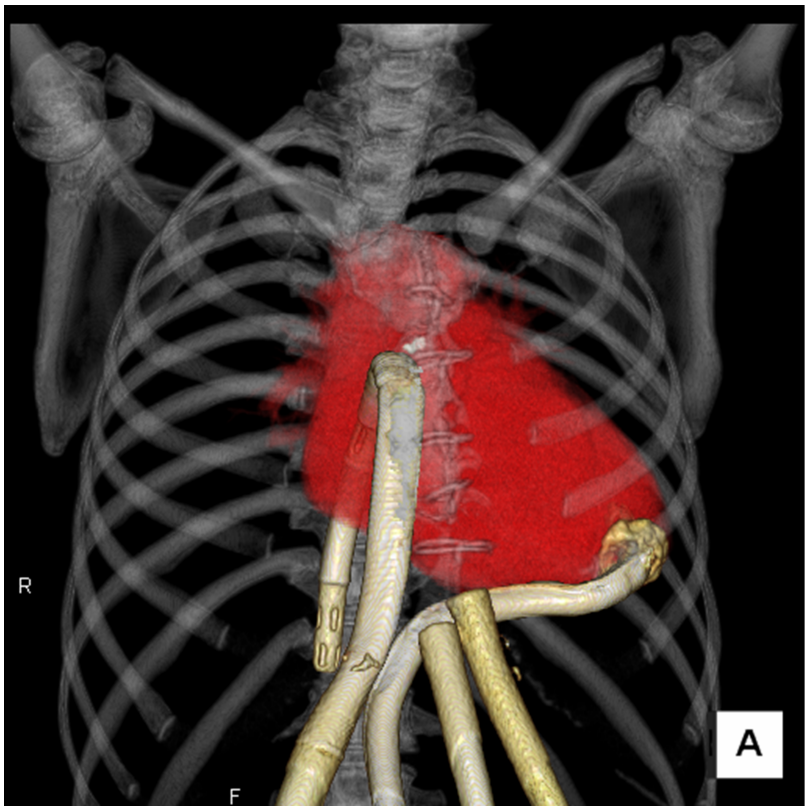

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