A Case of a Patient Who Successfully Achieved Early Wound Closure by Local Negative Pressure Wound Therapy (NPWT) against Compromised Wound Healing after Arterio-Venous Graft Infection

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Abstract: The primary treatment strategy for arterio-venous graft (AVG) infection includes appropriate antibiotic use and removal of the infected graft. It is well known that patients with hemodialysis are likely to experience compromised wound healing, which often leads to various postoperative complications. Negative pressure wound therapy (NPWT) is a non-invasive procedure that promotes wound healing by sealing the wound under negative pressure. Although NPWT is practically accepted in general surgery, there are only a few reports of this strategy to the vascular access operation for patients with hemodialysis due to the possibility of severe bleeding. In the present report, we report a case of a patient who successfully achieved safe and early wound closure by NPWT against compromised wound healing after AVG infection.

Keywords: AVG; NPWT; graft infection

1. Background

Arterio-venous graft (AVG) infection is one of the severe complications that require immediate treatment. The mainstay of the treatment of AVG infection includes the use of antibiotics and surgery. In surgery, total removal of the artificial vessel is recommended in sepsis and partial removal in case of local infection [1]. Patients treated with hemodialysis are generally known to experience suture failure due to compromised immunology, malnutrition, and chronic edema, leading to delayed wound healing after surgery. Negative pressure wound therapy (NPWT) is a non-invasive procedure that promotes wound healing by sealing the wound under negative pressure. In the present report, we report a case of a patient who successfully achieved safe and early wound closure by NPWT for the treatment of compromised wound healing after AVG infection.

2. Case Report

Seventy-four-year-old female, 135 cm in height, 26 kg in weight. She had a history of Parkinson’s disease, heparin-induced thrombocytopenia, and hypothyroidism, but neither diabetes mellitus nor peripheral vascular disease. Five years ago, an AVF (radial artery-radial cutaneous vein) was created in the left forearm due to the progression of chronic kidney disease by glomerulonephritis, followed by the induction of hemodialysis. In late February of X year, the AVF was occluded due to stenosis of the peripheral branch near the elbow. Multiple PTAs and recurrence of the re-occlusion led to the indication for surgery.
The arterio-venous veins in the right upper arm were both thin and difficult to create an AVF from, so a loop-type AVG (brachial artery–brachial vein) (Figure 1) was created in the left upper arm. The patient was discharged in mid-March but was rehospitalized in early April due to AVG infection with wound dehiscence at the venous anastomosis.

The patient was admitted to the hospital and started antibiotic therapy. The size of the wound dehiscence was approximately 1.5 cm, with edematous edges and no redness, abscess, or bleeding. The artificial vessel graft near the anastomosis on the venous side could be observed from the wound (Figure 2a). There was no elevation of white blood cells or CRP in the blood examination (Table 1). Although MRSE was detected in the culture of the tissue from the wound, blood culture was negative. Thus, we first checked the extent of the local infection to the AVG at the beginning of the operation. Since the infection appeared to be localized at the venous side of the anastomosis, we decided to preserve the arterial side of the original AVG. The new AVG was implanted at a sufficient distance from the infected area, then the venous side of the original AVG exposed to the wound was removed with sufficient debridement. The wound was kept open, and we attempted to close it spontaneously by daily washing of the wound. However, infected granulation tissue from the edematous tissue seemed to disturb the growth of the normal granulation. With a BMI of 14.3, she was at risk for delayed wound healing. Hence, confirming that the wound culture was negative, NPWT was started. The equipment used was RENASYS TOUCH (Figure 3), and the suction pressure was set at −80 mmHg. RENASYS foam filler (polyurethane ether) was selected as the wound dressing, and the dressing was changed twice a week. NPWT was started on the 6th postoperative day. NPTW resulted in the enhanced development of normal granulation (Figure 2b). On the 28th postoperative day, NPWT was terminated, followed by simple sutures of the wound. The patient was discharged in early June.

Table 1. The result of blood examination at re-admission.

| Blood Counts          | Value  | Unit     |
|-----------------------|--------|----------|
| White blood cell      | 7500   | /µL      |
| Neutrophil            | 73.2%  |          |
| Eosinophil            | 3.6%   |          |
| Basophil              | 0.5%   |          |
| Monocyte              | 5.9%   |          |
| Lymphocyte            | 16.8%  |          |
| Red blood cell        | 290    | ×10^{4}/µL|
| Hemoglobin            | 8.9    | g/dL     |
| Platelet              | 19.7   | ×10^{4}/µL|
| Blood chemistry       |        |          |
| Sodium                | 136    | mEq/L    |
| Potassium             | 5.4    | mEq/L    |
| Chloride              | 99     | mEq/L    |
| Calcium               | 7.8    | mg/dL    |
| Phosphorus            | 5.5    | mg/dL    |
| Urea nitrogen         | 56.6   | mg/dL    |
| Creatinine            | 5.19   | mg/dL    |
| Total protein         | 6.6    | mg/dL    |
| Albumin               | 4.2    | mg/dL    |
| AST                   | 28     | U/L      |
| ALT                   | 8      | U/L      |
| ALP                   | 253    | U/L      |
| γGTP                  | 44     | U/L      |
| CK                    | 354    | U/L      |
| Total bilirubin       | 0.2    | mg/dL    |
| Glucose               |        | mg/dL    |
| C-reactive protein    | 0.02   | mg/dL    |
| Procalcitonin         | <0.5   | ng/mL    |
Figure 1. The design of the original arterio-venous graft (AVG) before the infection.

Figure 2. (a) The wound before re-operation. The artificial vessel graft near the venous-side anastomosis was visible from the wound. (b) The wound after the NPWT treatment successfully achieving granulation without recurrence of infection or bleeding.

Figure 3. RENASYS TOUCH used for the NPWT.
3. Discussion

AVG infection is one of the severe complications that require immediate treatment. The mainstay of the treatment of AVG infection includes the use of antibiotics and surgery. In surgery, total removal of the artificial vessel is recommended in sepsis and partial removal in case of local infection [1]. Patients treated with hemodialysis are generally known to experience suture failure due to compromised immunology, malnutrition, and chronic edema, leading to delayed wound healing after surgery.

Since NPWT has been shown to improve wound healing by an animal study in 1997, this method has been utilized in various clinical settings [2]. The premise of the method involves an enhancement of wound healing by sealing the wound with a drape to keep a negative pressure, which offers various benefits such as bacterial reduction, dead space reduction, fluid reduction, etc. [3]. These pros also reduce the number of dressing changes, shorten hospital stay, and eventually reduce medical costs compared to conventional therapies [4,5].

The specific method of NPWT is as follows. First, if there is necrotic tissue, debridement should be performed with complete hemostasis. The wound surface is covered with a dressing and a drape is applied (Figure 4) that is several centimeters higher than the wound to seal the entire wound. A soft port (Figure 5) is attached and connected to a continuous suction device. Two main types of dressings are used: polyurethane ether (Figure 6a) for deep wounds or wounds with much exudate and polyvinyl alcohol (Figure 6b) for cases with extensive pockets or unevenness. It was reported that a suction pressure of $-125 \text{ mmHg}$ or less enhances the proliferation of granulation tissue, and therefore the suction pressure of $-125 \text{ mmHg}$ is considered the optimal pressure. More suction pressure is required for cases with massive drainage, and lower pressure of $-50 \text{ mmHg}$ can be considered for wounds with chronic ulcers [2,6]. The recommended frequency of change of wound dressing is every 2–4 days since the suction pressure gradually decreases over 48 h. In the case of more exudate, more frequent changes should be considered [7].

It is contraindicated for use on wounds with malignancy, untreated osteomyelitis, or wounds with exposed arterioles, nerves, or organs. It is also a relative contraindication for patients at risk of excessive bleeding due to the physical stimulation and increased blood flow caused by negative pressure (patients with hematologic disorders, patients on anticoagulants/antiplatelets, infected wounds, and patients with active bleeding from the wound).

In the present case, the patient was a hemodialysis patient with emaciation, which is associated with a high risk of wound healing failure. Therefore, we considered the post-operational management with the usage of NPWT, while bleeding and worsening of the infection were at risk because of the re-operation of the replacement of AVG and removal of the infected artificial vessel around the venous anastomosis. To reduce the risk of bleeding, the suction pressure was set at $-80 \text{ mmHg}$, which is lower than the recommendation. In addition, to minimize the risk of reinfection, blood and wound cultures were collected and confirmed to be negative after removing the artificial vessel. As a result, we successfully achieved granulation without recurrence of infection or bleeding.

In general, a central venous catheter is used during the treatment of AVG infection. The previous report shows that the median duration of catheterization of central venin was 3.8 months in the case of AVG infection [8]. In the present case, the hospital stay was about two months, including follow-up and home adjustment. The wound was closed about one month after the operation by NPWT treatment, which we believe was earlier than the expected hospital stays without this method to the wound.

Recently, in the field of vascular surgery, there have been several case reports of artificial vessel infection, in which the use of NPWT was curative with preservation of the artificial vessel without removal [6,9]. Although there are some restrictions for these cases, including no sepsis, etc., these findings suggest that the NPWT potentially serves as a more attractive treatment in the field of dialysis vascular access in the future.
Figure 4. Drape used for the NPWT.

Figure 5. Soft port used for the NPWT.

Figure 6. (a) Polyurethane ether used for the NPWT. (b) Polyvinyl alcohol used for the NPWT.

4. Conclusions

Hemodialysis patients often experience delayed wound healing due to immunodeficiency and chronic edema, which results in long-term admission. The present case exhibited that the use of NPWT potentially offers clinical benefits for compromised wound healing in these patients.

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