

Case Report

Treatment of sternal osteomyelitis after open heart surgery with combined negative pressure wound therapy with rectus abdominis myocutaneous flap transfer: a case report

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Abstract: The effectiveness of combination of negative pressure wound therapy with rectus abdominis myocutaneous flap transfer in treating sternal osteomyelitis associated with open heart surgery is not clear. Here we reported a case. A 57 years old male with past medical history of Diabetes underwent coronary artery bypass grafting surgery (CABG) in our hospital. After CABG, the wound was infected and dehiscent, postoperative osteomyelitis of sternum was diagnosed. There was no significant improvement in the wound condition after conservative treatment with topical antibiotics and dressing change for one week. Thus combinatory negative pressure wound therapy with rectus abdominis myocutaneous flap transfer was performed sequentially. Briefly, after thorough debridement and removal of sequestrum, continuous negative pressure wound therapy was applied; then phase II wound repair with rectus abdominis myocutaneous flap transfer was performed to heal the wound. The combined treatment was successful. After the treatment, clean wound and growth of fresh granulation were observed, and the rectus abdominis myocutaneous flap survived and the wound was found to heal well during postoperative follow ups. In conclusion, we found that combinatory application of negative pressure wound therapy with rectus abdominis myocutaneous flap transfer could effectively control wound infection, promote the shedding of necrotic tissue, and accelerate wound healing.

Keywords: Negative pressure suction wound therapy, osteomyelitis of sternum, debridement, wound repair, flap transplantation

Introduction

After cardiac surgery, there are increased risks of various postoperative complications. Although sternal osteomyelitis is relatively rare among all the complications, the number of sternal osteomyelitis cases following cardiac surgery has increased recently, along with the increase of the numbers of cardiac surgery performed [1]. It has been reported that the incidence of subcutaneous infection of sternotomy incision after open heart surgery was 0.4%-8% [2-4]. If the subcutaneous infection was not effectively treated, it could result in sternal infection and mediastinitis, which might be further worsened leading to sepsis, cardiac incision infection or even heart rupture, or it could also cause secondary infection of the artificial material used

leading to cardiac surgery failure. From the year 2005 to 2013, 15 cases of sternal osteomyelitis associated with open heart surgery were treated in our department with phase I debridement, followed with negative pressure wound therapy. When the wound appeared fresh, the infection was under good control, phase II wound repair with rectus abdominis myocutaneous flap transfer was performed with satisfactory outcomes. General characteristics of the patients enrolled in this study was shown in **Table 1**. Here we reported a typical case.

Case

This is a 57 years old male with past medical history of Diabetes who underwent coronary artery bypass grafting surgery (CABG) in our

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Table 1. General characteristics of the patients enrolled in this study

Case	Age	Sex	Abx use	Steroid use	Heart surgery	Complications	Nutritional status	Smoking	Postoperative complications	Treatment (days)
1	51	M	Yes	No	CABG	Diabetes	Good	Yes	No	17
2	57	M	Yes	No	CABG	Diabetes	Good	No	No	10
3	60	F	Yes	No	CABG	Diabetes	Fair	Yes	Yes*	14
4	65	F	Yes	No	CABG, Valve replacement	Diabetes	Good	No	No	15
5	67	M	Yes	Yes	Valve replacement	Diabetes, renal failure	Poor	No	No	39
6	59	F	Yes	No	CABG	SLE	Fair	Yes	No	15
7	55	M	Yes	No	Valve replacement	Diabetes	Good	No	No	21
8	66	M	Yes	No	CABG, Valve replacement	Diabetes	Fair	Yes	No	16
9	67	M	No	No	CABG	Diabetes	Good	Yes	No	20
10	55	F	Yes	Yes	Valve replacement	SLE	Good	Yes	No	30
11	71	M	Yes	No	CABG	Vascular lesions	Poor	No	No	30
12	77	M	Yes	No	CABG	Diabetes, renal failure	Poor	Yes	Yes*	21
13	72	F	Yes	Yes	Valve replacement	RA, Diabetes	Fair	Yes	No	18
14	68	M	Yes	No	CABG	Diabetes	Good	Yes	No	22
15	75	F	Yes	No	CABG	Diabetes	Good	Yes	No	24

Note: CABG: Coronary artery bypass grafting; Abx: antibiotics; RA: rheumatoid arthritis; SLE: systemic lupus erythematosus. *: in these two cases with postoperative complications, after phase II flap transfer operation, poor wound healing was found in the distal part of the transferred flap due to liquefaction, with lesion sizes of 2*3 cm and 3*5 cm, respectively. After active dressing change, the wound healed eventually and no further surgical intervention was performed.

hospital. After CABG, the wound was infected and dehiscenced (**Figure 1A**), and there was no significant improvement in the wound condition after conservative treatment with topical antibiotics and dressing change for one week. The condition of wound infection was then assessed comprehensively, including three-dimensional CT scan and sternal reconstruction to clarify the range and extent of the infection. Then phase I debridement was performed (**Figure 1B**). Under general anesthesia and in collaboration with cardiac surgeon, the infected tissues were removed completely, and the sternum was also removed bilaterally. The residual pacemaker wire left from previous cardiac surgery was cut and removed as much as possible. Then the wound was rinsed with a large volume of saline, after bleeding was stopped, side holes were cut every 2 cm in the silicone tube, which was then pierced out from the sponge. The sponge was placed into the wound cavity on the front chest, and to be attached to the wound surface as close as possible; then the sponge was covered with sterile Gauze and cotton pad, and a sterile surgical film was used to seal the dressing with the edge of the surgical film being at least 5 cm over the edge of the dressing to ensure tight sealing; finally, the silicone drainage tube was pierced out from in-between the film and the normal skin and was connected to a negative pressure drainage device. The pressure was maintained at -13 Kpa, under which, the dressing should be

observed to shrink and tightly attach to the wound. The dressing should be felt hard by touching; and there should be liquid outflow in the draining tube. Care was taken to ensure that the negative pressure was maintained, the drainage was unblocked and tight sealing of the surgical film. Wound secretion was drained adequately to stimulate granulation tissue growth. The dressing for the closed negative pressure suction device was changed every 48 hours, during which time, the wound situation was checked, necrotic tissue was removed appropriately, and the granulation tissue secretions was gently scraped with a scissor till fresh blood exudation was seen to stimulate the growth of granulation tissue.

After 1 week of treatment, the volume of the drainage was decreased from more than 300 ml/day to 100 ml/day. Then, the dressing change was switched from every 48 hours to every 72 hours, and the volume drainage continued to decrease to less than 20 ml/day. After 10 days of treatment, the bacterial culture of the wound turned negative. Then phase II rectus abdominis myocutaneous flap transfer surgery was performed (**Figure 1C** and **1D**). Under general anesthesia, once again the wound was explored to see whether there was sequestrum or necrotic tissues, and if found, they were completely removed. The rectus abdominis musculocutaneous flap was incised and the right abdominal artery was retained as the

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Figure 1. The treatment procedure for the patient reported in case 1. A. The wound after CABG surgery was infected and dehiscent; B. After debridement and two rounds of negative pressure suction therapy, the wound granulation tissue appeared fresh, and necrosis was significantly reduced; C. The design of the rectus abdominis myocutaneous flap before phase II surgery; D. Phase II rectus abdominis myocutaneous flap was transferred to repair the front chest wound; E. The transferred flap survived well and the outcome of chest wound repair was satisfactory.

vascular pedicle. The incised musculocutaneous flap was rotated 180 degrees to cover the sternal wound, and the cavity was filled tightly with the muscle. Polypropylene mesh was used to fill the rectus abdominis defect in the abdomen to prevent postoperative abdominal hernia formation.

The patient was followed up at 1, 3, 6 and 12 months after phase II surgery, the condition of wound healing was observed. The transferred flap was checked for any signs of infection or necrosis, and the patient was surveyed about satisfaction with the surgery outcome. Postoperative follow-up results showed that the transferred flap survived well and the outcome of chest wound repair was satisfactory to the patient (**Figure 1E**).

Discussion

There are many causes of sternal osteomyelitis after cardiac surgery. Firstly, diabetes can lead to microvascular lesion and decreased im-

mune function, and microvascular lesion can cause microcirculation dysfunction and tissue hypoxia, which prone to infection [5]. Secondly, during heart surgery, internal mammary artery transplantation was often performed which will reduce more than 90% of the blood supply to the ipsilateral sternum, thus affecting the postoperative sternal healing and leading to sternal necrosis and infection. Thirdly, surgery time is negatively proportional to sternal healing. Long time surgery could increase the chance of intraoperative contamination, and long cardiopulmonary bypass could weaken the body's defense mechanisms and increase the risk of postoperative infection [6]. Fourthly, if intraoperative bleeding is not complete, or postoperative drainage was inadequate, blood could be accumulated behind the sternum which would easily cause osteomyelitis [7]. Fifthly, if electric knife was used too frequently, or the power was too strong, the skin and subcutaneous tissue would be damaged, and if the skin was not well-healed, infection could invade from shallow to

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deep to cause sternal osteomyelitis. Sixthly, sternal fixation was loose. If sternum was not properly fixed with steel wire, it will be hard for mobile sternum to heal [8]. In addition, there were also other reasons such as old age, poor health, poor nutrition, etc, which could also increase the risk of postoperative sternal infection.

In the early stage of sternal infection when the infection was limited and tissue necrosis was mild, conservative treatment could be applied, where dressing was changed regularly to keep the wound clean and promote the growth of fresh granulation, and if necessary, phase II suture could be applied on fresh wound. The most common conservative treatment protocol for sternal infection is closed flushing drainage [9], where the post-sternal cavity was rinsed repeatedly with antibiotics to kill bacteria in the wound. Although sternal infection could be eliminated this way, however, the infection relapse rate could be as high as 15% to 60%; meanwhile, the course of this treatment was long, and the mortality rate was also relatively high (about 20%). For patients with a long history of infection and severe sternal damage, phase I debridement should be performed followed with rectus abdominis myocutaneous flap grafting. The scope of debridement should include most of the sternum and part of the ribs, and chest wound should be repaired with rectus abdominis myocutaneous flap [10]. For patients who received multiple rounds of debridement, dressing change and drainage were usually ineffective; the disease course was usually longer than 4 months, because a thick fibrous plate had already been formed locally, so even after removal of the sternum and ribs, the thoracic could still play a supportive role like a scaffold, so that respiration was not affected. The flap has good blood supply and can be tension-free sutured when repairing the wound of the chest, so as to ensure a good healing of the wound. The rectus abdominis musculocutaneous flap has good integrity and extensibility to ensure adequate length and width, so that when removing the infected and necrotic tissues, the surgeons did not need to worry whether the wound was too large to be repaired.

In a pilot study, we had tried to perform phase I rectus abdominis myocutaneous flap transfer

surgery to repair chest wound immediately after debridement, but in some patients, myocutaneous flap infection occurred which led to blood supply obstruction and necrosis of distal flap, and eventually failure of the surgery. So we decided to divide the surgery into two phases, namely, phase I debridement surgery and phase II flap transfer surgery, so that the duration and trauma of each surgery was relatively short and small, and the wound could also be explored adequately to find residual necrotic tissues to be removed.

The negative pressure wound therapy (NPWT), also known as vacuum-assisted closure (VAC), topical negative pressure (TNP) or vacuum sealing technique (VST), has been widely used in treatment of various acute and chronic wounds after it was developed for more than 10 years [11]. The filling dressing used in NPWT can wrap the drainage tube with multiple side holes to play a filtering and buffering role. Commonly used filling dressing includes medical gauze and foam dressing. Through comparing the composition of medical gauze and foam dressing, Malmsjo *et al.* [12] studied the role of the two filling dressings played in wound contraction and pressure transmission, and the results showed that: 1) In terms of wound contraction, when the pressure was between 0-50 mmHg, wound contraction was most obvious, and with the increase of pressure, the change of wound contraction range was not significant. 2) The negative pressure both dressings applied on the wound was linearly correlated with the negative pressure conducted to the wound bed, that is, the two had similar pressure conduction property. But McNulty *et al.* [13] had a different opinion regarding use of medical gauze. In a study performed in an environment to simulate the wound, they used medical gauze and foam dressing to fill the wound respectively, treated the wound with -125 mmHg negative pressure, and then collected the wound exudate and tissue from the two groups of patients to perform immunohistochemical study. The results showed that in the group treated with medical gauze, the tissue and cell activity were decreased, and apoptosis was increased, suggesting that when used in negative pressure wound therapy, medical gauze could inhibit cell activity and stimulate cell apoptosis, was not conducive to cell proliferation and wound healing. Foam dressing with

open molecular structure was a better wound-dressing, it has been approved by the US FDA and widely used in clinical including negative pressure wound therapy.

There are many theories to explain the mechanism for NPWT to promote wound healing, including debridement, control of edema, decrease exudate, decrease the amount of local bacteria and improve local blood supply [14]. Closed vacuum suction therapy can continuously drain the large amount of exudate from the wound surface to alleviate local edema; since these exudates carry a large number of necrotic material and bacteria, thereby continuous drainage can effectively reduce the number of local bacteria, improve local blood circulation, and eventually improve the local wound conditions [15, 16]. The mechanical traction produced by negative pressure is able to stimulate cell proliferation in replacement of extracellular matrix, and local cell proliferation indicates that the body starts the process of wound healing [17]. Furthermore, there is a large number of proteolytic enzymes in the wound exudates, especially metalloproteins and cytokines, which can weaken the stimulatory effect of extracellular matrix on wound healing, and closed vacuum suction can remove such toxic substances in time and provide conditions for wound healing [18].

The case reported here showed that negative pressure wound therapy after phase I debridement combined with phase II rectus abdominis myocutaneous flap transfer could effectively control wound infection, promote the fall off of necrotic materials, and accelerate wound healing. The transferred flap survived, and the patient was satisfied with the treatment outcomes. This combinatory approach is proved to be an effective method to treat sternal osteomyelitis associated with open heart surgery.

Disclosure of conflict of interest

None.

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