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Management of the extensive thoracic defects after deep sternal wound infection with the rectus abdominis myocutaneous flap

A retrospective case series

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Abstract

Deep sternal wound infection is a severe complication after open heart surgery. According to the different severity and dimensions of the deep sternal wound infection, the treatment method is different. In this study, we aimed to describe our experience with the rectus abdominis myocutaneous flap for large sternal wound management, especially when 1 or 2 internal mammary arteries were absent.

Between October 2010 and January 2016, a retrospective review of 9 patients who suffered from the extensive thoracic defects after deep sternal wound infection was conducted. All of these sternal defects encompassed almost the full length of the sternum after debridement. Defect reconstruction was achieved by covering with a rectus abdominis myocutaneous flap. When the ipsilateral or bilateral internal mammary artery had been harvested previously, we took advantage of the inferior epigastric artery to provide additional blood supply to the rectus abdominis myocutaneous flap. Thus, this flap had a double blood supply.

There was no recurrent infection in all 9 patients. Three patients received the rectus abdominis myocutaneous flap with a double blood supply. Flap complications occurred in 2 patients (22%). One patient who did not have the double blood supply flap suffered from necrosis on the distal part of the flap, which was then debrided and reconstructed with a split-skin graft. The other patient had a seroma at the abdomen donor site and was managed conservatively. None of the patients died during the hospital stay.

This study suggests that the rectus abdominis myocutaneous flap may be a good choice to repair the entire length of sternal wound. When 1 or 2 internal mammary arteries have been harvested, the inferior epigastric artery can be anastomosed to the second intercostal artery or the internal mammary artery perforator to provide the rectus abdominis myocutaneous flap with a double blood supply.

Abbreviations: ASA = American Society of Anesthesiologists, CABG = coronary artery bypass grafting, DSWI = deep sternal wound infection, IEA = inferior epigastric artery, IMA = internal mammary artery, RAMF = rectus abdominis myocutaneous flap, SEA = superior epigastric artery.

Keywords: deep sternal wound infection, flap reconstruction, rectus abdominis myocutaneous flap

1. Introduction

Deep sternal wound infection (DSWI) is a rare but serious and potentially fatal complication after median sternotomy for cardiac surgery, with an incidence rate 0.5% to 4% and an associated mortality rate between 14% and 47%.[1–3] Presently, management of this problem is still controversial. Some reports emphasize that more efforts should be taken to prevent it rather than to treat it, especially for those patients who have high risk factors such as obesity, comorbidities of diabetes mellitus, or chronic obstructive pulmonary disease.[4,5] However, the introduction of various flaps has led to a significant decrease in morbidity and mortality over the past 30 years.[6] According to the severity and dimensions of the DSWI, the therapeutic methods range from conservative treatment to radical surgical debridement followed by negative pressure wound therapy or 1-stage flap coverage. Current sternal wound management involves debridement of any devitalized infected soft tissues and bones, administration of culture-specific antibiotics, and the use of a vascularized flap to fill the wound cavity.[7]

At present, the pectoralis major muscle or myocutaneous flap remains the most common method for closing the majority of the infected median sternotomy wound. However, this flap does not have the capacity to resurface the entire length of the sternal defect when the thoracic defects are larger than half of the sternum.[8] The greater omentum has the ability to cover the entire wound and control the sternal infection, but perhaps, leads to the spread of the infection to the abdomen. The rectus abdominis myocutaneous flap (RAMF) has the major advantages

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of easy dissection, proximity to the infected sternal wound, and provision of ample skin island to repair the extensive thoracic skin deficit.[9] However, several authors reported that this flap may not be considered as a viable option for sternal defects reconstruction when the ipsilateral or bilateral internal mammary artery (IMA) had been harvested for coronary artery bypass grafting (CABG).[10,11] In this situation, can we make full use of the inferior epigastric vessels? When the RAMF is rotated by 180° into the thoracic defects, the inferior epigastric artery (IEA) can be anastomosed to the intercostal artery or the IMA perforator. Thus, this flap possesses a double blood supply.

In this study, we aimed to describe our experience with the RAMF for large sternal wound management, especially in the absence of 1 or 2 internal mammary arteries. To our knowledge, this is the first introduction of the particular RAMF with a double blood supply.

2. Methods

2.1. Patients

Between October 2010 and January 2016, 9 consecutive patients who had received sternal reconstruction with the RAMF after radical surgical debridement were referred. All of these sternal defects encompassed almost the full length of the sternum. The general data (Table 1) was collected by reviewing the medical records of the patients. According to the American Center of Disease Control norm,[12] DSWI was defined as clinical infection requiring surgical debridement up to and including the sternum, with or without positive microbiology. Patients with superficial infections were excluded from the study. This study was approved by the Institutional Review Board of Xijing Hospital.

The 9 patients in this study included 7 males and 2 females, with a mean age of 59 years (range: 48–65 years). Patients' weights ranged from 43 to 95 kg, with a mean weight of 78 kg. Eight patients had received CABG, and 1 patient had cardiac valve replacement. All selected patients were received at least 2 debridements (range: 2–4 times) before sternal defect closure, and did not undergo any other flap procedures to repair the defects before the RAMF procedure which was performed by the same surgeon (Zhao Zheng).

2.2. Surgical technique

All procedures were performed under general anesthesia. The second intercostal artery or the second IMA perforator was identified with the handheld Doppler probe preoperatively and marked (to decide which artery was anastomosed to the IEA). Next, the superior epigastric artery (SEA) and the IEA were marked, then the SEA–IEA axis was drawn out. After microbiological specimens were collected, all infected necrotic tissues and bones were removed until healthy solid bone with bleeding margins was found. We carefully protected the internal mammary vessels during resection of the infected bones and cartilaginous structures.

The dimensions of the thoracic defects were templated made and marked on the abdominal skin and off the midline. The RAMF was carefully raised by blunt dissection. During this process, the inferior epigastric vessels were viewed as a pedicle left at the inferior axis of the flap and the pedicle length was about 8 to 10 cm. Then, the flap was rotated by 180° and filled into the sternal defects over suction drains. The abdominal donor defects were repaired by suturing the margin of the remaining anterior rectus sheath to its lateral component and then the skin was closed by relaxation suture. The IEA was anastomosed to the second intercostal artery or the second IMA perforator. At the same time, the inferior epigastric vein was anastomosed to the concomitant vein. Therefore, the RAMF had a double blood supply (the anastomotic artery and the SEA). The IEA anastomosis was selected according to the following indication: the ipsilateral or bilateral IMA had been harvested previously or the contralateral IMA was ligated during previous CABG and the wound almost encompassed the full length of the sternum. After the operation, an abdominal bandage was applied for 6 weeks.

3. Results

Nine patients who had the extensive thoracic defects were treated by the plastic surgery team during the study period. Overall preoperative status was reflected by the American Society of Anesthesiologists (ASA) grade. Six patients were in ASA grade 3 and 3 patients in ASA grade 4 (Table 1). Of the 8 patients who received the CABG, 7 patients had been harvested of 1 or 2 internal mammary arteries and 1 patient had aorto-coronary arterial saphenous vein bypass grafting (Table 1). Three patients received RAMF with a double blood supply. The mean operation time was 176 minutes (range: 155–228 minutes) including the vascular anastomosis and the debridement.

There was no recurrent infection after the thoracic defects were covered with the RAMF combined with antibiotic therapy. Flap complications occurred in 2 patients (22%). One patient who did not have the double blood supply flap suffered from a distal part necrosis of the flap 7 days later and was taken back to the operation room. Then, the distal 10% of the flap was debrided and reconstructed with a split-skin graft. The other patient had a seroma at the abdomen donor site and was managed conservatively.

Table 1

General patients data.

Patient no	Sex	Age, y	Original cardiac intervention	Defect size (cm×cm)	ASA grade	IMA harvest	Defects reconstruction	Complication
1	Male	60	CABG	25 × 10	3	Bilateral	RAMF+IEA anastomoses	None
2	Male	56	CABG	22 × 9	3	Ipsilateral	RAMF+IEA anastomoses	Seroma at the abdomen
3	Female	63	Cardiac valve replacement	18 × 6	4	No	RAMF	None
4	Male	48	CABG	20 × 8	3	Contralateral	RAMF	None
5	Male	62	CABG	24 × 9	4	Contralateral	RAMF	Distal skin necrosis
6	Male	65	CABG	21 × 11	3	Contralateral	RAMF+IEA anastomoses	None
7	Female	56	CABG	20 × 9	3	Contralateral	RAMF	None
8	Male	61	CABG	19 × 8	4	Contralateral	RAMF	None
9	Male	58	CABG	22 × 7	3	No	RAMF	None

ASA = American Society of Anesthesiologists, CABG = coronary artery bypass grafting, IEA = inferior epigastric artery, IMA = internal mammary artery, RAMF = rectus abdominis myocutaneous flap.

The mean overall hospitalization time was 32 days (range: 23–56 days) after referral to the plastic surgery department. Whether or not a complication occurred, all patients were discharged satisfactorily. The mean follow-up time was 6 months (range: 3–12 months). None of the patients died during the hospital stay. The representative case is revealed in Fig. 1. The schematic diagram of the double blood supply RAMF for coverage of the entire sternum is shown in Fig. 2.

4. Discussion

Treatment of the DSWI has improved significantly over the past half century. During the 1960s, the infected sternal wound was managed by local debridement with closed catheter antibiotic irrigation, which led to mortality rate up to 20%.[13] In 1976, the greater omentum was first reported to cover the extensive thoracic defects after extensive bone and cartilage debridement.[14] Later, various muscle or myocutaneous flaps became the primary treatment for reconstruction of the sternal defects. In the 1990s, vacuum-assisted closure dressings occurred and was readily viewed as an adjunct to facilitate sternal wound healing, even as the sole method for definitive treatment in specific cases.[15,16] Today, repairing the wound with well-vascularized muscle or myocutaneous flap after the early radical surgical debridement becomes an effective method.

In this study, we used the RAMF to repair the extensive thoracic defects containing almost the entire sternum, especially in those patients whose ipsilateral or bilateral IMA had been divided for reasons such as CABG. The rectus abdominis received dual-dominant blood supply from the superior and inferior

Figure 1. A 60-year-old man received coronary artery bypass grafting and his bilateral internal mammary artery had been harvested. After this operation, deep sternal wound infection occurred and 2 debridements were performed by cardiac surgeons. Because of the large defect area (25 cm × 10 cm), the patient was recommended into our department. Defect reconstruction was achieved by rectus abdominis myocutaneous flap combined with the inferior epigastric artery anastomosed to the second intercostal artery perforator. (A) Large sternal defect after 2 debridements by the cardiac surgeon. (B) Mediastinal organs were exposed after radical surgical debridement (C) Defect reconstruction with a double blood supply rectus abdominis myocutaneous flap (the inferior epigastric artery was anastomosed to the second intercostal artery perforator). (D) At a 6-month follow-up, no wound infection was found and the patient was satisfied with his own state.

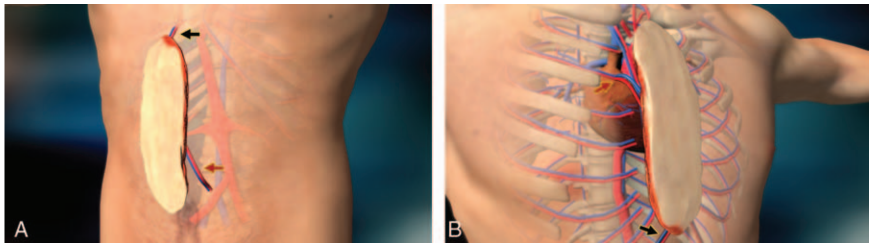

Figure 2. The schematic diagram shows the double blood supply rectus abdominis myocutaneous flap for coverage of the entire sternum. (A) The red arrow indicates the inferior epigastric vessels, which were left at the inferior axis of the rectus abdominis myocutaneous flap. The black arrow indicates the superior epigastric vessels. (B) When the rectus abdominis myocutaneous flap was rotated by 180° into the sternal defects, the inferior epigastric artery (the red arrow) was anastomosed to the second intercostal artery. At the same time, the inferior epigastric vein was anastomosed to the concomitant vein. Thus, this flap had a double blood supply.

epigastric arteries, which consisted of a complex perfusion pattern. The SEA is a continuation of the IMA and the IEA comes from the external iliac artery. With the superior epigastric vessels as the sole blood supply, the rectus abdominis with or without the overlying skin can be raised as a local flap to repair the sternal wound from the manubrium sterni to the xiphoid. This method has been previously reported by many articles.[1,2,9,17,18] The most common complication is the distal part necrosis of the flap because the distal flap cannot receive enough blood supply from the pedicle. However, this complication did not occur when the IEA was anastomosed to the second intercostal artery or the second IMA perforator in our case series.

Several studies reported that prior harvesting of ipsilateral or bilateral IMA may preclude the use of the RAMF.[9,19] Indeed, we can speculate that the collateral circulation will be strengthened from the anterior intercostal arteries when the IMA has been ligated previously. Furthermore, the IMA divides distally behind the sixth or seventh interspace into the SEA and the musculophrenic artery. If the IMA is ligated on the distal bifurcation point, the musculophrenic artery will provide a rich supply of collateral circulation to the SEA. Based on this, some previous studies reported that the rectus abdominis muscle or the myocutaneous flap was used successfully for median sternotomy wounds after ipsilateral IMA ligation.[20,21] However, this flap is limited to repair the lower half of small sternal wound, which requires a pectoralis major muscle flap for the superior part of the wound. In our study, the entire sternal wound was repaired successfully when we took advantage of the IEA to provide additional blood supply to the RAMF.

There are also other alternative methods to reconstruct the extensive thoracic defects which comprise almost the entire sternum and the significant skin defect after radical surgical debridement. For example, pectoralis major muscle advancement for upper sternum with rectus abdominis muscle turn-over for the coverage of lower sternum is another choice for the entire sternal wound reconstruction.[22] However, we rarely consider the combined use of 2 or more local flaps in our study when a single local flap is sufficient to repair the defect. The greater omentum flap is also a useful reconstructive option because it contains rich vascular supply and large amount of available soft tissues which can reach the entire sternal defects and fill irregular defects sufficiently. The emergence of laparoscopic omental harvest has gained great attention on omental flap use in extensive thoracic defects after DSWI. In addition, several previous literatures suggested that the use of omentum may be associated with lower mortality and fewer complications when compared with the pectoralis muscle flap.[23,24] However, an abdominal wall hernia will occur if the omentum is passed subcutaneously. Moreover, omentum may not be available in those patients with intra-abdominal adhesion after previous surgery. Lastly, secondary split-thickness skin graft is necessary when compared with the RAMF. More recently, the free myocutaneous flap has been described for sternal wound closure and viewed as a new choice to repair the extensive thoracic defects after DSWI.[7,10]

In our case series, there were no flap failures and the functional results were excellent. No patients complained the aesthetic results in the follow-up time. The complication rate of 22% (2/9) is comparable to that found in previous studies of 25% to 30%.[8,9] The tip necrosis is the major complication associated with the RAMF, which has been reported in a lot of literatures.[2,9] But this complication did not occur in our patients whose IEA had been anastomosed to the second intercostal artery or the IMA perforator. The reason is that the particular RAMF has a double blood supply. Furthermore, even when the ipsilateral or bilateral IMA has been harvested, the particular RAMF also has enough blood supply and heals well.

Despite the satisfactory results that all patients were healed and did not have recurrent infection, we have to consider the limitations of our study. First, because of the small number of patients included in the study, we cannot have enough data for further analysis and make a stronger conclusion. In fact, the small number of eligible patients is largely due to the rare prevalence of the extensive thoracic defects after DSWI. Second, we cannot ignore the retrospective nature of our analysis. In addition, when the bilateral IMA and 1-sided IEA are harvested, it may decrease the abdominal wall perfusion and increase the risk of abdominal wall herniation.[25]

In conclusion, our study suggests that the RAMF may be suitable to repair the large sternal wound up to the entire sternum. When one or both internal mammary arteries have been ligated for CABG or other reasons, the IEA can be anastomosed to the second intercostal artery or the IMA perforator to provide the flap with a double blood supply.

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