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A RELIABLE PROCEDURE FOR RECONSTRUCTION OF THE STERNUM DEFECTS: THE PECTORALIS MAJOR MUSCLE FLAP COMBINATION WITH NEGATIVE PRESSURE WOUND THERAPY

STERNUM DEFEKTLERİNİN REKONSTRÜKSİYONUNDA GÜVENİLİR BİR YÖNTEM: PEKTORALİS MAJOR KAS FLEBİ İLE NEGATİF BASINÇLI YARA BAKIM KOMBİNASYONU

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Abstract

Objective: Sternotomy defects may present mildly as isolated skin separation or severely as mediastinitis. A combination of treatment options can support treatment.
Methods: Patients who were treated with pectoralis major flap with the combination of negative pressure wound therapy (NPWT) between 2016-2020, were retrospectively reviewed. Demographic features, microorganisms causing wound infection, flap reconstruction preference, time of hospitalization, remission, recurrence and associated morbidity and mortality data were evaluated.
Results: Thirteen patients were included with a mean age of 65.4 years. All patients previously underwent coronary artery bypass graft surgery. Wound cultures from patients were positive in nine (69%). Isolated microorganisms were *Staphylococcus spp.* (n=4), *Klebsiella pneumoniae* (n=3) and *Acinetobacter baumannii* complex (n=2). The most common comorbidities were hypertension (76%) and diabetes mellitus (46%). The average hospital stay was 23.4 days. One patient died on the seventh postoperative day, two had seromas at the flap donor site, and one had hematoma.
Conclusion: Pectoralis major muscle flap and NPWT after complete removal of dead tissues is an effective method to repair and treat sternum defects.

Keywords: *Mediastinitis, negative pressure wound therapy, pectoral muscle flap, sternal reconstruction*.

Öz

Giriş: Sternotomi defektleri izole cilt ayrılması gibi hafif ya da mediastinit gibi ağır tablolarla karşımıza çıkabilir. Tedavi seçeneklerinin kombinasyonu tedaviyi destekleyebilir.
Yöntem: 2016-2020 yılları arasında pektoralis majör flebi ve negative basınçlı yara bakımı (VAC) kombinasyonuyla tedavi edilen hastalar retrospektif olarak incelendi. Demografik özellikler, yara kültüründe üreyen mikroorganizmalar, flep rekonstrüksiyonu tercihi, ameliyat sonrası hastanede kalış süresi, tam iyileşme, nüks ve ilişkili morbidite ve mortalite verileri değerlendirildi.
Bulgular: Toplam 13 hasta çalışmaya dahil edildi. Ortalama yaş 65.4 idi. Tüm hastaların koroner arter greftlenmesi ameliyatı hikayesi vardı. Hastaların 9 tanesinde yara kültürlerinde üreme vardı. Dört hastada *Staphylococcus* türleri, üçünde *Klebsiella pneumoniae* ve ikisinde *Acinetobacter baumannii* üredi. En sık eşlik eden hastalıklar %76 hipertansiyon ve %46 diabetes mellitus idi. Ortalama hastanede kalış süresi 23,4 gündü. Bir hasta ameliyat sonrası 7.günde öldü, ikisinde flep donör sahasında seroma, birinde hematom görüldü.
Sonuç: Ölü dokuların tamamen temizlenmesi sonrası pectoral defektin kombine pektoral kas flebi ve negative basınçlı yara bakımı ile onarılarak tedavi edilmesi etkili bir yöntemdir.

Anahtar Kelimeler: *Mediastinit, negatif basınçlı yara tedavisi, pektoral kas flebi, sternal rekonstrüksiyon*.

Introduction

The median sternotomy incision was first proposed by Shumacker and Lurie in the 1950s and is the most commonly used incision for cardiac operations, including coronary artery bypass grafting (CABG) and valvular procedures[1]. Regardless of the surgical procedure, the probability of developing severe infection after median sternotomies is between 1% and 4%. Although the incidence of this complication is low, mortality and morbidity rates are 20-50% and 50% respectively, and it is therefore suggested that median sternotomy infections should be treated aggressively in the early period[2]. Risk factors for deep wound infection in the sternum are: weakness of surgical sterilization; long operation time; retrosternal hematoma and need for re-exploration; poor surgical technique; excessive foreign substances used during closure; obesity; diabetes mellitus; hospital-acquired pneumonia; dialysis; prolonged history of mechanical ventilation; and a history of previous CABG operation[3]. There are many factors that play a role in the etiology of deep sternal infection, but the most common microorganisms are *Staphylococcus aureus* and coagulase negative *Staphylococcus* species[4,5]. With the increase in the proportion of the population being elderly, increasing rates of obesity, diabetes and other comorbid diseases globally, the rate of complications after open-heart surgery has increased. In the face of such high morbidity and associated mortality rates, early diagnosis, correct surgical management, and prompt and timely reconstruction become life-saving.

Sternal wound infections, one of the most clinically worrying complications after cardiac surgery, have become manageable in the light of medical advances that have developed over time[3], such that the treatment of sternal wound complications, with a mortality rate of 50% before the use of muscle flaps, has improved significantly over the last 40 years[6,7]. Ascherman *et al.* show that immediate reconstruction after radical debridement procedure has the 30 day perioperative death rate as %7,9[7].

Traditional treatment methods include radical debridement, irrigation and dressing, and surgical revision or reconstruction options with well-vascularized, soft tissue flaps[8]. Among the soft tissue reconstruction options available for wound closure in the sternal region are; unilateral Pectoralis Major muscle "turn over" (PM-TO) flap, unilateral Pectoralis Major muscle rotation advancement flap (PM-RotA), rectus abdominus muscle flap, bilateral PM muscle flaps, latissimus dorsi muscle flap, omental flap, free flaps, vacuum assisted closure (VAC) or negative pressure wound therapy (NPWT) and combinations of these techniques[9,10]. It is also possible to use fasciocutaneous perforator flaps, based on the intercostal artery, in wide and uncomplicated defects that are self-limiting[11].

PM muscle flap can be used easily and safely for wounds in the sternum, such as a PM-RotA flap with thoracoacromial artery pedicle or a PM-TO flap, fed from internal mammarian artery branches, as seen in Figure 1. The aim of this report is to share the early and late results of patients who were treated by the combination of PM muscle flap and VAC therapy.

Methods

Thirteen patients, who were treated at a single center for mediastinitis after sternotomy performed in the cardiovascular surgery department between February 2016-May 2020, were reviewed retrospectively.

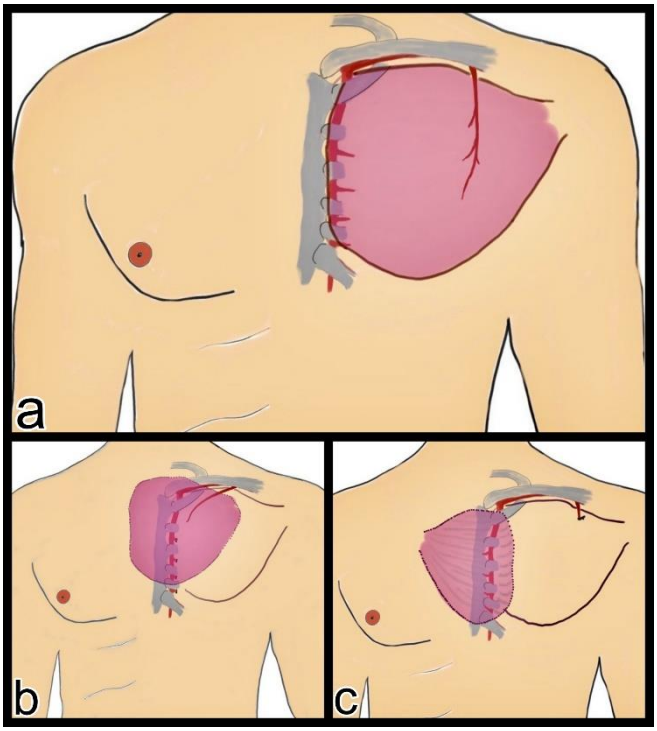

Figure 1. The schema of arterial vascular anatomy of pectoralis major (PM) muscle is seen. a) Thoracoacromial artery is major pedicle and perforators from internal mammarian artery (IMA) are minor pedicles. b) PM rotasyon advancement muscle flap harvesting requires sacrificing IMA perforators and saving thoracoacromial pedicle. c)PM turn over muscle flap harvesting requires sacrificing thoracoacromial pedicle and saving whole IMA perforators.

This study was performed with the approval of the local ethics committee in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and all subsequent revisions. All patients provided written informed consent to participate. Demographic features, microorganisms causing wound infection, flap reconstruction preference, postoperative length of hospital stay, remission, recurrence and associated morbidity and mortality data were evaluated in all patients. The diagnosis of deep sternum infection was made in accordance with the diagnostic criteria defined by the Centers for Disease Control and Prevention (CDC)[12].

After the sternotomy, with the joint decision of the Department of Cardiovascular Surgery and the Department of Infection, intravenous empirical antibiotic treatment, often meropenem and teicoplanin, was started simultaneously with the removal of tissue swab cultures. Radical surgical debridement was performed as soon as possible, and ideally immediately, under general anesthesia in each patient whose general condition was stable. All foreign matter, such as wires or plaques in the sternum and bone tissues that appeared nonviable, was removed. Swab culture samples were taken from the infected tissue and sternum bone for wound culture in the perioperative period. After reaching healthy tissue after radical debridement, the size and shape of the defect was evaluated (see Figure 2a).

Depending on the shape of the defect and the use of internal mammary arteries (IMA) in previous operations, PM-RotA flap or PM-TO flap was used.

Since the PM-TO flap is fed through multiple minor pedicles originating from branches of the IMA, it should be ensured that the ipsilateral IMA is intact. A detailed patient surgical history is invaluable for ascertainment of the status of the ipsilateral IMA.

Figure 2. a) 63 year-old female patient (Case-6) who had mediastinitis and soft tissue infection in the sternotomy area on the 21st day postoperatively. Figure here shows the site of sternal defect after radical debridment of infected areas of sternal region osseos and soft tissues. After debridement of sternal bone, mediastineal tissue is seen at the center of the defective area. b) Right pectoral "turn over" flap is harvested with perforators from the right IMA and adapted to the defect

In surgery, the tissue above the PM muscle is elevated to the axillary line as a fasciocutaneous flap and the pectoral muscle is fully exposed. Then, the dissection is continued from the inferior edge of the PM muscle to the posterior, and the muscle is removed from the ribs at the inferior edge and can then begin to be lifted. After releasing the pectoral muscle from the inferior and lateral borders, the muscle fibers are followed from the medial to the lateral for the connection of the muscle with the humerus. In the axillary region, at the place corresponding to the humeral connection of the muscle, a new skin incision is made and the humeral connection is exposed; this connection of the muscle is then released. The clavicular connection of the muscle is dissected from the lateral to the medial, and it is then possible to turn the muscle over. Dissection is continued medially, the thoracoacromial artery and vein are located, first knotted and than sacrificed. The author preferred to knot the thoracoacromial pedicle with 2-0 polyglactin. Since materials such as vascular clips and silk will remain on the most superficial side after flipping over the flap, an absorbable suture is preferred due to the fact that non-absorbable objects may have undesirable results, such as foreign body exposure. In order to fully close the sternal defect, it is necessary to make maximum use of muscle volume, and for this it is critical to release the muscle from its superior, inferior and lateral borders at the closest distances to the sternum. For flap viability, care should be taken not to damage the perforators in the lateral costosternal junction area. One of the important steps in closing the sternal defect successfully is careful dissection of the medial edge of the flap while increasing the mobilization of the muscle flap. At this stage, using small, precision-tipped scissors supports careful dissection of the perforator area. The pectoral flap is properly adapted after being turned over the defect (see Figure 2b). This flap, planned as a "Turn over" flap, can be used as a one-sided or double-sided repair, depending on the size of the defect. A PM muscle flap is frequently used in most plastic surgery clinics in patients with staged breast reconstruction. In PM-RotA flap surgery, the flap is dissected from the inferomedial to the superolateral, below and above the muscle, in the avascular plane. Then, the medial, inferior and lateral connections of the muscle are released and, if necessary, the clavicular part is carefully released by preserving the thoracoacromial pedicle, IMA and intercostal artery (ICA) perforators are tied or coagulated. Then, the muscle is mobilized over the major pedicle and adapted to the defect.

The main target in reconstruction of the sternal region is to cover the exposures of bone and mediastinal structures. In some cases, extreme purulent discharge from the mediastinal region can be trapped in the dead space under the flaps, causing a risk of re-infection. In order to prevent this, it is recommended that VAC combined treatment is beneficial in order to keep any possible gaps under negative pressure. The same type and brand of VAC device (Smith & Nephew Medical Ltd., Hull HU3 2BN, UK) was used in all patients. After the surgical interventions, traditional sponges were used as a standard approach, and the standard pressure range was between 75-100 mmHg and was maintained in terms of bleeding risk without any washing solution (Table-1). The recommended amount of pressure for optimal healing in traditional wound healing is 100-125 mmHg, but a relatively lower negative pressure may be preferred to minimize the risk of collapse of large vascular structures in the mediastinal region. VAC dressings were changed at every 4 days. If there were no problems in terms of bleeding from wound bed at the second dressing change, the pressure was increased to 125 mmHg and the alternating program was changed to 5 minutes of negative pressure and 2 minutes of rest which was used routinely.

Results

Thirteen patients were evaluated with a mean age of 65.4 years, ranging from 58 to 77 years and 7 of them (54%) were female. All patients underwent CABG surgery by the cardiovascular surgery department. PM-RotA flap was performed in three women and three male patient with a mean age of 64 years. PM-TO flap was performed in the remaining 4 women and 3 men. Wound cultures from patients were positive in nine (69.2%). Organisms cultured included *Staphylococcus* spp. (n=4, 44.4%), *Klebsiella pneumoniae* (n=3, 33.3%) and *Acinetobacter baumannii* complex (n=2, 22.2%) (Table 1). The most common comorbidity in this cohort was hypertension (n=10, 76%) while diabetes mellitus was present in six (46%) preoperatively. Bilateral IMA was not used in previous operations in any case, but the left IMA was used in four patients. The average length of hospital stay after reconstruction with the flap was 23.4 days. One patient was referred as an emergency for revision operation by the cardiovascular surgery team. They subsequently required extracorporeal membrane oxygenation (ECMO) treatment in intensive care. Unfortunately, the patient died on the seventh postoperative day due to heart and respiratory failure. Two patients had minimal seroma at the flap donor site. The pectoral muscle flap in one case had marginal necrosis that was conservatively managed with observation because of unstable vital parameters. One patient had haemorrhage after VAC treatment. Six patients underwent combined flap surgery and VAC treatment, while the remaining seven underwent VAC treatment between 24-48 hours after hemostasis was observed. VAC sessions were continued until the drainage volume obtained from VAC decreased to less than 60 cc/day for two consecutive days. Patients were treated with VAC dressing at 3-4 day intervals. After VAC treatment, which ranged from three sessions to a maximum of six sessions, wounds were repaired primarily or with skin grafts.

Table 1. The characteristics of patients who were treated with the combination of pectoral muscle flap and VAC therapy.

No	Age, Sex	N Comorbidity	Culture Results	Skin Deficiency	Flap Choice	VAC dressing timing and pressure	Complication	Duration of Hospitalisation after Reconstruction
1	60,F	HT	-	-	Bilateral PM-RotA	Postop 1 day 75 mmHg	-	15 days
2	77,F	HT CHF	*Staphylococcus aureus*	-	Bilateral PM-RotA	Postop 2 days 75 mmHg	-	20 days
3	58,M	-	-	-	Left PM-RotA	Intraop 100 mmHg	-	28 days
4	66,F	HT DM	*Klebsiella pneumoniae*	-	Left PM-TO	Intraop 75 mmHg	Minimal seroma on the flap donor site	30 days
5	72,M	HT DM	*Acinetobacter baumannii* complex	+	Bilateral PM-TO	Postop 1 day 75 mmHg	Marginal necrosis	7 days (ex)
6	63,F	HT COPD CHF	*Staphylococcus haemolyticus*	-	Right PM-TO	Intraop 75mmHg	-	29 days
7	59,F	HT	-	+	Bilateral PM-RotA	Postop 1 day 75 mmHg	-	17 days
8	70,M	HT CHF	*Staphylococcus haemolyticus*	-	Bilateral PM-RotA	Postop 2 days 75 mmHg	Haemorrhage	21 days
9	60,M	DM	-	-	Left PM-RotA	Intraop 100 mmHg	-	25 days
10	64,F	HT DM	*Klebsiella pneumoniae*	-	Left PM-TO	Intraop 75 mmHg	Minimal seroma on the flap donor site	32 days
11	72,M	HT DM	*Acinetobacter baumannii* complex	+	Bilateral PM-TO	Postop 1 day 75 mmHg	-	22 days
12	61,F	HT CHF	*Staphylococcus aureus*	-	Right PM-TO	Intraop 75 mmHg	-	29 days
13	68,M	DM	*Klebsiella pneumoniae*	-	Left PM-TO	Postop 2 day 100 mmHg	-	19 days

[CABG - coronary artery bypass graft; COPD - chronic obstructive pulmonary disease; HT - hypertension; CCF - congestive cardiac failure; DM - diabetes mellitus; PM-RotA – Pectoralis Major muscle rotation and advancement; PM-TO – Pectoralis major turn-over]

Complete remission was achieved in all surviving patients, and no recurrence occurred during the follow-up period (Figure 3 and 4). Follow-up times were between 5 months and 2 years. On physical examination, shoulder and arm mobility and muscle strength of patients were evaluated. No patient complained of shoulder pain or limited mobility. A detailed shoulder strength assessment test was not performed in the patients.

Figure 3. a) A small soft tissue area left untreated for VAC application although the patient (Case-6) skin flaps are not insufficient. It is thought that VAC application is critical for drainage of remaining purulent fluid. After mediastineal exposure is closed with double layer soft tissue coverage on the superior part of sternal region, negative pressure application using VAC, helps to decrease the volume of dead spaces between the mediasten, muscle and fasciocutaneous flaps. b) Five months after the operation is shown. After five VAC application, inferior soft tissue area of sternal region has been closed primarily, there was no need for any skin graft for final covering. There is a long vertical scar on the sternal area and short scar on the right preaxiller area.

Figure 4. a) 66 year-old female patient (Case-4) who had mediastinitis and soft tissue infection in the sternotomy area on the 14th day postoperatively. Figure here shows the sternal region after removing the first VAC therapy materials on postoperative 4 days. b) Split thickness skin graft usage was essential for final wound covering on postoperative 15 days. It is shown four months postoperatively.

Discussion

Mediastinitis, which occurs after a median sternotomy, is a life-threatening complication in cardiac surgery, but after the introduction of muscle flaps for reconstruction, mortality rates and length of hospital stay have decreased. It has been reported that PM muscle flaps are one of the leading options among muscle flaps because they provide better stability to the sternum, do not disrupt pulmonary function, are the closest wide flap that can be used to close sternal defects and provide good cosmetic results [1]. Jones et al. reported 13% morbidity and 0% mortality rates with repairs made with pectoral muscle flaps, and shortened the length of hospital stay to 18.6 days compared to conservatively treated patients[9]. In our study, the average length of hospital stay was

23.9 days. The difference in stay duration may be due to intravenous antibiotherapy and VAC therapy in the presented cohort.

Hypertension was the most common comorbidity in our study and was present in ten patients, although all patients had undergone CABG. Six patients had diabetes mellitus and one patient had Chronic Obstructive Pulmonary Disease (COPD). These comorbidites are known to impair immunity and lead to delayed wound healing due to ischemia[13].

A PM-TO flap may be inadequate to close defects occurring in the bottom third of the sternum. A range of techniques have been used to solve this problem. Brown *et al.* [14] divided the muscle fibers into two in the middle, and reported that the defect can be closed successfully by using the upper part as a rotation flap and the lower part as a 'turn over' flap. Wu *et al.* [15] reported 19 patients who underwent bilateral PM flap for deep sternal wound infections. In four (21%) the rectus abdominis flap was additionally needed to close the defect because the pectoral flaps could not be adapted to the inferior area of the defect. In contrast, our experience using pectoral muscle flap for deep sternal infection showed that the turnover flap or VAC application on a well-debrided mediastinal region was sufficient to close lower sternal defects. In relatively large defects with blood supply insufficiency, when even the sternal bone is affected, using one side of the pectoral flap as a PM-RotA flap and the other side as a PM-TO flap can close most of the defect. None of our study patients needed additional flaps, but bilateral pectoral muscles were used in three patients due to the large defect size.

Empirical antibiotic therapy was used in all patients during postoperative hospitalization. Antibiotic treatment can be modified once culture results are available. After discharge, intravenous antibiotics can be replaced with oral treatment. Oral treatment was completed in around two weeks.

Even when skin debridement was not performed during debridement, there may be skin loss due to skin circulatory failure. This can be predicted during surgery after sternal infection. Skin deficiency or contraction can cause evident tension during skin closure during surgery. Skin closure with tension can cause both circulatory and wound healing problems, as well as dehissence and recurrence. Foad *et al*.[16] showed that approximately 30% of post-mediastinitis reconstructions had difficulty in primary healing in the sternal region, and the majority of these patients recovered in 4 weeks with secondary healing. In our study, primary repair of the wound was not preferred in patients who were predicted to exhibit skin tension, and split thickness skin grafts were applied on the PM flap after completion of VAC therapy. Ennker *et al.*[8] demonstrated that VAC therapy can be an important contribution to post-sternotomy mediastinitis after aggressive debridement. Damiani *et al.*[17] performed a meta-analysis of six observational studies and evaluated the differences in hospital stay and mortality rates. These authors reported that VAC treatment reduced hospital stay by 7.18 days compared to other forms of dressing. In our study, three patients had extreme purulent fluid discharge from the mediastinum before surgery. Since this drainage may continue after reconstruction and cause infection recurrence, VAC was applied to the wound after the closure of the defect with a flap. Purulent fluid drainage ended after a maximum of six VAC sessions in our cohort. An additional benefit of VAC treatment is the reduction of potential dead space under the muscle flap due to negative pressure. This, in turn, accelerates flap adhesion to the wound floor. It is thought that complications such as recurrent wound dehiscence, which may occur after a pectoral flap, will decrease with routine VAC application.

Ennker *et al.* found that long-term respiratory function remained unchanged compared with preoperative values[8]. When these authors evaluated shoulder and arm mobility, they showed a slight decrease in arm muscle strength. However, it was also reported that there was no deterioration in quality of life due to chronic pain. In our study, shoulder and arm mobility of patients was evaluated by physical examination, and none of the patients complained of shoulder pain or movement limitation.

Bilateral PM flap reconstruction is a safe and technically relatively simple technique for postoperative sternal infection. The advantages of this procedure are early wound closure, adequate chest stability, almost no deterioration in respiratory function, and good long-term functional and cosmetic results[18]. Careful planning of the operation is recommended so that the sternal defects are closed with a one-sided flap, if at all possible. This not only shortens the operation time but also prevents additional comorbidity. Jang *et al.*[19] reported that delayed debridement or defect closure may lead to dead spaces, permanent or recurrent infections, especially nosocomial infections caused by a long hospital stay, and requirement for intensive care unit can be extended when the ideal time for wound management is missed. Therefore, empirical antibiotic therapy should be initiated as soon as these infections are diagnosed, and reconstruction should be performed with flaps immediately after adequate debridement.

The fact that the pectoral flap can be elevated over IMA perforators is particularly useful for defect reconstructions at the lower third of the sternum. However, this procedure is time-consuming compared to the rotation advancement flap application. In our study, bilateral IMA had not been used in previous operations in any case. Thus, the clinical choice of pectoral flaps use in our patients was determined by the defect and surgeon preference.

Ascherman *et al*. showed that keeping the borders of flap dissection areas as low as possible and performing hemostasis control after flap removal helped reduce the hematoma rate from 5.4% to 0%[7]. Our experience confirmed that routine use of hemovac drainage under the skin and provision of adequate hemostasis is an aid to prevention of postoperative hematoma.

Conclusion

Patients with sternal defects with a common comorbid disease history have high morbidity and mortality rates. Sternal region upper half defects can be closed using a pectoral muscle rotation advancement flap and lower half defects can be closed sub-totally with a turnover muscle flap. The pectoral flap has a high degree of benefit in these patients because it is the closest flap option to the region, it can be easily and quickly harvested, the mobility can be increased by preserving minor pedicles during harvesting, and it does not cause significant morbidity. We suggest that the combination of VAC therapy with PM muscle flaps, which we use for all patients with sternal defect reconstruction, is the complementary treatment of choice, especially for extreme purulent discharge from the mediastinal region.

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Conflict of Interest
The authors have no conflicts of interest to disclose.

Compliance with Ethical Statement
This study was performed with the approval of the local ethics committee (KÜ GOKAEK-2021/08.17) in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and all subsequent revisions. All patients provided written informed consent to participate.

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Author Contributions
Study idea/Hypothesis: EKY, AAA; Study design: EKY, CİD, MŞA; Data preparation: EKY, HI; Literature search: EKY, HI; Manuscript writing: EKY, HI

References

1. Bagheri R, Tashnizi MA, Haghi SZ, et al. Therapeutic Outcomes of Pectoralis Major Muscle Turnover Flap in Mediastinitis. *Korean J Thorac Cardiovasc Surg*. 2015;48(4):258-264.
2. Francel TJ, Kouchoukos NT. A rational approach to wound difficulties after sternotomy: reconstruction and long-term results. *Ann Thorac Surg*. 2001;72(4):1419-1429.
3. Kaul P. Sternal reconstruction after post-sternotomy mediastinitis. *J Cardiothorac Surg*. 2017;12(1):94. Published 2017 Nov 2.
4. Jakob HG, Borneff-Lipp M, Bach A, et al. The endogenous pathway is a major route for deep sternal wound infection. *Eur J Cardiothorac Surg*. 2000;17(2):154-160.
5. Lepelletier D, Bourigault C, Roussel JC, et al. Epidemiology and prevention of surgical site infections after cardiac surgery. *Med Mal Infect*. 2013;43(10):403-409.
6. Schulman NH, Subramanian V. Sternal wound reconstruction: 252 consecutive cases. The Lenox Hill experience. *Plast Reconstr Surg*. 2004;114(1):44-48.
7. Ascherman JA, Patel SM, Malhotra SM, Smith CR. Management of sternal wounds with bilateral pectoralis major myocutaneous advancement flaps in 114 consecutively treated patients: refinements in technique and outcomes analysis. *Plast Reconstr Surg*. 2004;114(3):676-683.
8. Ennker IC, Pietrowski D, Vöhringer L, et al. Surgical debridement, vacuum therapy and pectoralis plasty in poststernotomy mediastinitis. *J Plast Reconstr Aesthet Surg*. 2009;62(11):1479-1483.
9. Jones G, Jurkiewicz MJ, Bostwick J, et al. Management of the infected median sternotomy wound with muscle flaps. The Emory 20-year experience. *Ann Surg*. 1997;225(6):766-778.
10. Hugo NE, Sultan MR, Ascherman JA, Patsis MC, Smith CR, Rose EA. Single-stage management of 74 consecutive sternal wound complications with pectoralis major myocutaneous advancement flaps. *Plast Reconstr Surg*. 1994;93(7):1433-1441.
11. Hamdi M, Van Landuyt K, de Frene B, Roche N, Blondeel P, Monstrey S. The versatility of the inter-costal artery perforator (ICAP) flaps. *J Plast Reconstr Aesthet Surg*. 2006;59(6):644-652.
12. Garner J, Jarvis W, Emori T, Horan T, Huges J. CDC definitions for nosocomial infections 1988. *Am J Infect Conntrol*. 1988;16:128–40.
13. Gårdlund B, Bitkover CY, Vaage J. Postoperative mediastinitis in cardiac surgery - microbiology and pathogenesis. *Eur J Cardiothorac Surg*. 2002;21(5):825-830.
14. Brown RH, Sharabi SE, Kania KE, Hollier LH Jr, Izaddoost SA. The Split Pectoralis Flap: Combining the Benefits of Pectoralis Major Advancement and Turnover Techniques in One Flap. *Plast Reconstr Surg*. 2017;139(6):1474-1477.
15. Wu S, Wan F, Gao YS, et al. Sternal reconstruction of deep sternal wound infections following median sternotomy by single-stage muscle flaps transposition. *Chin Med Sci J*. 2014;29(4):208-213.
16. Nahai F, Morales L Jr, Bone DK, Bostwick J 3rd. Pectoralis major muscle turnover flaps for closure of the infected sternotomy wound with preservation of form and function. *Plast Reconstr Surg*. 1982;70(4):471-474.
17. Yu AW, Rippel RA, Smock E, Jarral OA. In patients with post-sternotomy mediastinitis is vacuum-assisted closure superior to conventional therapy? *Interact Cardiovasc Thorac Surg*. 2013;17(5):861-865.
18. Klesius AA, Dzemali O, Simon A, et al. Successful treatment of deep sternal infections following open heart surgery by bilateral pectoralis major flaps. *Eur J Cardiothorac Surg*. 2004;25(2):218-223.
19. Jang YJ, Park MC, Park DH, Lim H, Kim JH, Lee IJ. Immediate debridement and reconstruction with a pectoralis major muscle flap for poststernotomy mediastinitis. *Arch Plast Surg*. 2012;39(1):36-41.