Treatment of Deep Mediastinal Infections Following Cardiac Surgery with Pectoral Muscle Flap

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ABSTRACT

Introduction: Mediastinitis is a rare occurrence following cardiac surgeries; however, it is a significant cause of both mortality and morbidity. Given the significance of mediastinal infections, early diagnosis, and treatment become of paramount importance. The management of this condition necessitates a multidisciplinary approach, involving collaboration and coordination among various medical specialties.

Patients and Methods: 21 patients with a diagnosis of deep mediastinal infection who were treated at Eskişehir Osmangazi University Medical Faculty Hospital between January 2015 and May 2021 were included in the study. Broad-spectrum antibiotic therapy, serial debridement, and vacuum-assisted closure were applied to all patients. Among the patients who exhibited negative blood cultures and developed granulation tissue, those with tissue losses that did not extend to the sternum incision sites were assessed for potential flap procedures in conjunction with plastic and reconstructive surgery. In such cases, closure of the wound was achieved using a pectoral muscle flap. All patients were followed for one year.

Results: Among the patients, 14 (66.6%) were female and seven (33.3%) were male, with a mean age of 62.7 ± 6.5 (range: 41-76 years). Three of the 21 patients included in the study had type I, two had type II, and 16 had type IIIA mediastinitis. *Staphylococcus aureus* (*S. aureus*) was the most commonly isolated microorganism with 11 patients (52.3%). The right pectoralis major muscle was used in four patients (19%), the left pectoralis major muscle in four patients (19%), and the bilateral pectoralis major muscle in 13 patients (62%). There was no need for re-intervention in the follow-up of the patients. No mortality because of infection, surgical muscle flap closure, and/or cardiac causes was observed in any of the patients who were treated.

Conclusion: Mediastinitis is a costly treatment, requiring prolonged hospitalization and carrying the risk of mortality. The main objective is to prevent the occurrence of mediastinitis. We believe that this objective should be pursued through a multidisciplinary approach involving cardiovascular surgery, infectious diseases, and plastic and reconstructive surgery units.

Key Words: Mediastinitis; debridement; pectoralis flap

Kalp Cerrahisi Sonrası Görülen Derin Mediastinal Enfeksiyonların Pektoral Kas Flebi ile Tedavisi

ÖZET

Giriş: Mediastinit, kalp cerrahisi sonrası nadir görülmesine rağmen ciddi bir mortalite ve morbidite sebebidir. Bu nedenle derin mediastinal enfeksiyonların erken tanı ve tedavisi çok önemlidir. Bu durumun yönetimi ise multidisipliner yaklaşım gerektiren bir süreçtir.

Hastalar ve Yöntem: Eskişehir Osmangazi Üniversitesi Tıp Fakültesi Hastanesinde Ocak 2015-Mayıs 2021 tarihleri arasında görülen 21 derin mediastinal enfeksiyon tanılı hasta çalışmaya dahil edildi. Hastaların tamamına geniş spektrumlu antibiyoterapi, seri debridman ve vakum yardımlı kapama sistemi tedavileri uygulandı. Kültür sonucu negatifleşen ve yara yerinde granülasyon dokusu gelişen hastalardan sternum insizyon yerlerinde doku kaybı olan hastalara pektoral kas flebi ile yara yeri kapama yapıldı. Tüm hastalar bir yıl boyunca takip edildi.

Bulgular: Hastaların 14'ü kadın (%66.6), yedisi erkek (%33.3) olup yaş ortalamaları 62.7 ± 6.5 (dağılım: 41-76 yaş) idi. Çalışmaya dahil olan 21 hastanın üçü tip I, ikisi tip II, 16'sı ise tip IIIA mediastinit olgularıydı. En çok izole edilen mikroorganizma 11 hastada görülen *Staphylococcus aureus*tu (*S. aureus*). Dört hastada (%19) sağ pektoralis majör kası, dört hastada (%19) sol pektoralis majör kası, 13 hastada (%62) ise bilateral pektoralis majör kası flep olarak kullanıldı. Hastaların takiplerinde tekrar girişim ihtiyaçları olmadı. Tedaviye alınan hiçbir hastada enfeksiyon nedenli, cerrahi kas flebi ile kapamaya bağlı ve/veya kardiyak nedenlere bağlı mortalite gözlenmedi.

Cite this article as: *Ovalı C, Kocaoğlu AS, Güçlüer Kocaoğlu MN, Koçman AE. Treatment of deep mediastinal infections following cardiac surgery with pectoral muscle flap. Koşuyolu Heart J 2023;26(2):88-95.*

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Submitted: 05.05.2023
Accepted: 13.06.2023
Available Online Date: 10.07.2023

Sonuç: Derin mediastinal enfeksiyonların tedavisi yüksek maliyetli, uzun süreli yatış gerektiren ve ölüm ile sonuçlanabilen bir durumdur. Öncelikli amaç kalp cerrahisi sonrasında mediastinit gelişmesine engel olmaktır. Mediastinit gelişen hastalarda kalp damar cerrahisi, enfeksiyon hastalıkları ve plastik ve rekonstrüktif cerrahi hekimlerinin multidisipliner yaklaşımı ile tedavi sürecini yönetmenin daha olumlu sonuçlar sağlayacağını düşünmekteyiz.

Anahtar Kelimeler: Mediastinit; debritman; pektoral flep

INTRODUCTION

Sternal wound infections are rarely observed following cardiac surgeries, yet they continue to be serious complications increasing mortality and morbidity and causing high hospitalization costs[1-3]. Given the significance of mediastinal infections, early diagnosis, and treatment become of paramount importance. When sternal wound infections are limited to the skin and subcutaneous tissue, they are categorized as superficial wound infections. However, if the infection progresses to affect the muscle, fascia, sternum, and mediastinum, they are classified as deep wound infections[4]. Despite efforts in developing antibiotics and implementing preoperative and postoperative care protocols to mitigate the risk of such infections, it is important to note that complete prevention of these infections is currently not possible. Following cardiac surgery, the probability of developing mediastinitis varies between 0.4% and 5%[5]. Mediastinitis is influenced by numerous risk factors, which can be categorized into preoperative, intraoperative, and postoperative factors. Preoperative risk factors include conditions such as diabetes mellitus (DM), congestive heart failure, advanced age, smoking, low Ejection Fraction (EF), kidney failure, and obesity[6-9]. Intraoperative risk factors encompass various factors including emergency surgeries, prolonged surgical procedures, compromised sternum structure, inadequate sternotomy techniques, excessive use of electrocautery and bone wax, and the utilization of the internal mammary artery[6-9]. Reoperations, incompatibility of patients and deficiencies in personal care, need for repetitive blood transfusion, and prolonged mechanical ventilation support are some of the risk factors in the postoperative period[7-12].

The initial step involves the identification and isolation of the causative agent, followed by the administration of appropriate antibiotic therapy. The process requires a multidisciplinary approach including antibiotics, debridements, and postoperative follow-up in cardiac surgery. Subsequent steps in the standard treatment of mediastinitis may involve serial debridements, mediastinal irrigation, negative-pressure wound therapy, and partial sternum removal. In cases where standard treatments prove ineffective, closure techniques utilizing muscle flaps are employed. The advancement of these methods has substantially reduced morbidity and mortality associated with mediastinitis[13].

The purpose of the present study was to investigate the impact of the muscle flap closure method on the reduction of morbidity and mortality associated with deep mediastinal infections following cardiac surgery. These infections are known to pose significant risks in terms of morbidity and mortality.

PATIENTS and METHODS

The approval of the Eskişehir Osmangazi University Faculty of Medicine Non-Invasive Clinical Research Ethics Committee was obtained for the study (Approval Date: 26.07.2022, and Approval Number: E-25403353-050.99-364120). The data of 982 patients who underwent cardiac surgery with sternotomy by the same surgical team at Eskişehir Osmangazi University Medical Faculty Hospital between January 2015 and May 2021 were analyzed retrospectively. During this study period, a total of 36 patients with a preliminary diagnosis of deep mediastinal infection were treated at our clinic. Patients who exhibited discharge at the sternum incision site but showed no growth in culture, patients whose initial antibiotic therapy was modified due to allergic reactions, patients with superficial infections, and patients who could undergo primary closure after using a vacuum-assisted closure system due to minimal tissue loss were excluded from the study. After exclusion, 21 patients were found eligible for the study and classified according to the Mediastinitis Classification made by El Oakley and Wright (Table 1)[5]. Greig et al., on the other hand, classified sternum infections according to their localizations and stated the grafts suitable for use according to this classification (Table 2)[14].

After the cultures were taken from the wounds and the discharges of the patients at the sternum incision, broad-spectrum antibiotic therapy was started (Vancomycin + Meropenem) in all patients with the recommendation of the infectious diseases unit. The antibiotic treatment for patients with determined culture results was arranged based on the antibiograms. Tigecycline + Meropenem treatment was initiated for two patients. Acute phase reactants and kidney and liver function tests were closely monitored during the medical treatment of the patients. The patients underwent serial debridements under the supervision of the plastic and reconstructive surgery clinic. The sternum incisions were fully opened (Figure 1), and debridement was performed on the

Table 1. The mediastinitis classification of El Oakley and Wright

Types	Characteristics
Type I	Mediastinitis occurring in the first postoperative two weeks without a risk factor
Type II	Mediastinitis occurring within postoperative 2-6 weeks without risk factors
Type IIIA	Type I Mediastinitis with one or more risk factors
Type IIIB	Type II Mediastinitis with one or more risk factors
Type IVA	Type I, II, or III Mediastinitis after an unsuccessful treatment attempt
Type IVB	Type I, II, or III Mediastinitis after multiple unsuccessful treatment attempts
Type V	Mediastinitis seen for the first time six weeks or more postoperatively

Table 2. The classification of sternal infections by anatomical region and recommended muscle flap

Wound type	Sternal wound site	Recommended muscle flap
Type A	Upper half of the sternum	Pectoralis major muscle
Type B	Lower half of the sternum	Pectoralis major muscle and rectus abdominis muscle
Type C	Entire sternum	Pectoralis major muscle and rectus abdominis muscle

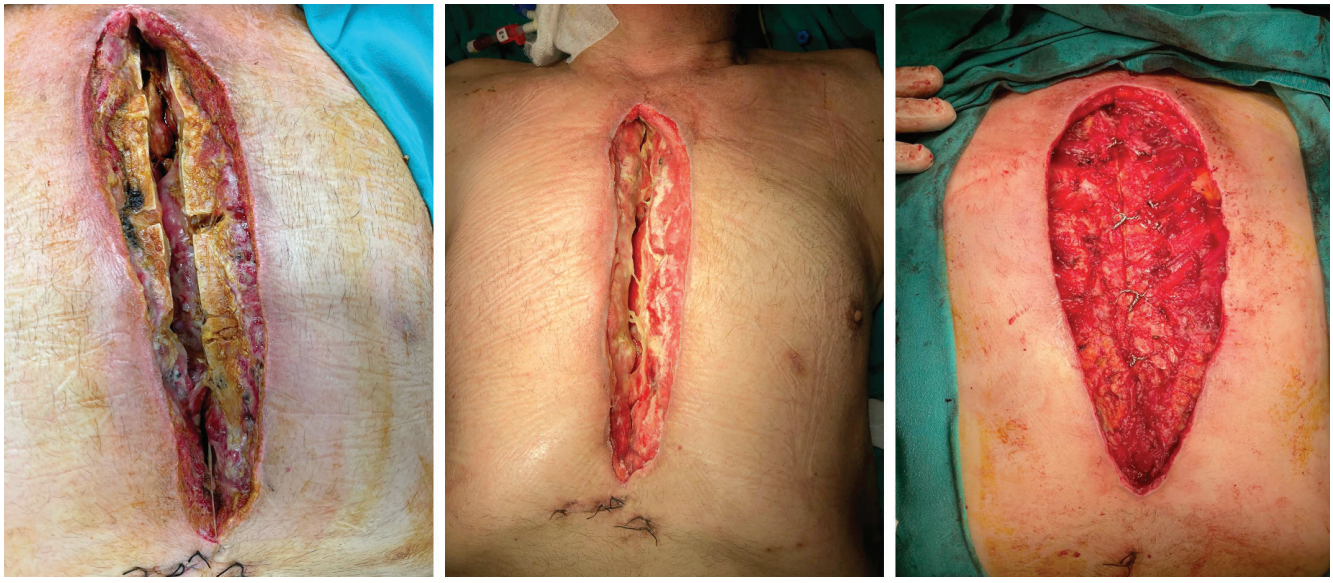

Figure 1. Preoperative photos of different patients with deep mediastinal infection before serial debridement.

subcutaneous tissues and sternum. Cultures were obtained from both the bone tissue and subcutaneous tissue during the initial debridement. Vacuum-assisted wound closure system was used in all patients after the debridement. Repeated debridements were performed at 48-72 hour intervals and vacuum-assisted wound closure systems were renewed. The application of a vacuum-assisted wound closure system was continued until a negative culture result was detected and granulation tissue developed in the wound in clinical terms. Among the patients who had negative blood cultures and developing granulation tissue, those with tissue losses that did not reach the sternum incision sites were evaluated in terms of flaps together with plastic and reconstructive surgery, and wound closure was performed with a pectoral muscle flap (Figure 2). The rectus abdominis muscle was also used as a flap in two patients. The pectoral muscle was separated from the area where it was attached to the sternum up to the level of the nipple during the preparation of the pectoral muscle flaps,

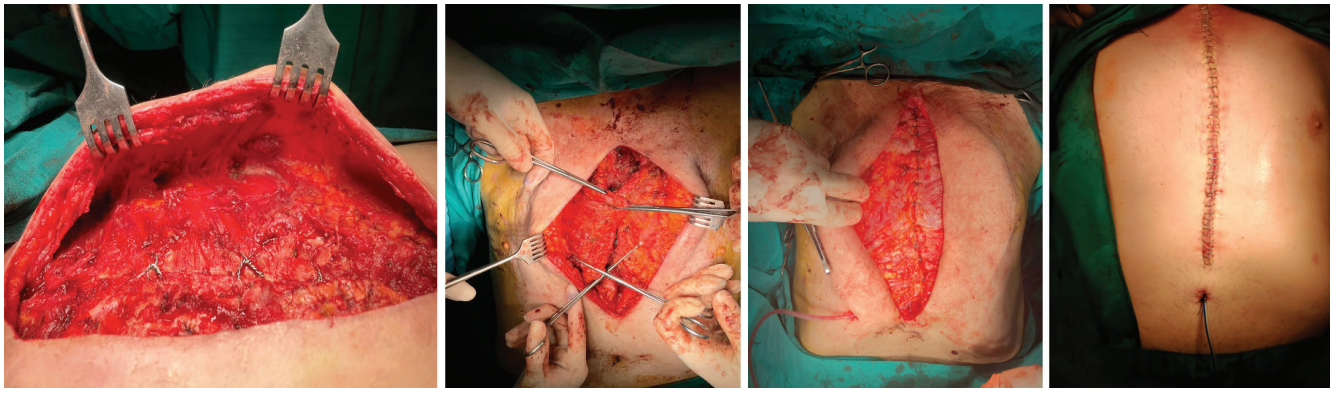

Figure 2. Treatment of pectoral muscle flap.

and the area of attachment to the humerus was preserved. The sternum incision was extended towards the umbilicus, the anterior rectus fascia was opened and the muscle was released during the preparation of the rectus muscle flap. In the right and left chest where the muscle flaps were taken, a hemovac drain was applied under the skin, and a perforated gauze cloth saturated with soft Paraffin with 5% Chlorhexidine acetate was applied on the incision site. The hemovac drains were removed in patients without drainage and dressings were continued every other day. All patients were followed for one year.

Statistics

Continuous variables were represented as mean ± standard deviation (SD) in the present study and the SPSS 18.0 (SPSS Inc., Chicago, Illinois) package software was used for descriptive statistics.

RESULTS

Among the patients, 14 (66.6%) were female and 7 (33.3%) were male, with a mean age of 62.7 ± 6.5 (range: 41-76 years). According to the Classification of Mediastinitis defined by El Oakley and Wright, three of the 21 patients included in the study had type I, two had type II, and 16 had type IIIA Mediastinitis. According to the anatomical region classification, eight patients had type A, nine had type B, and four had type C mediastinitis. A total of 14 had coronary artery bypass surgery, four had a mitral valve replacement, two had an aortic valve replacement, and one had mitral valve replacement surgery with aortic valve replacement. Seventeen patients (81%) were operated on under elective conditions, and four patients (19%) were operated on under emergency conditions. Sternal separation was detected in three patients. The mean time to the onset of the signs of infection in the patients was 9.2 days. The clinical and demographic characteristics of the patients are summarized in Table 3.

In all patients who were included in the study, acute phase reactants were found to be high in the examinations performed. Although there was discharge at the incision site in all patients, fever was detected high in 15 patients, and fever was not observed in six patients during their follow-ups. Parameters on the follow-up and treatment of these patients are summarized in Table 4.

Out of the patients, four (19%) experienced serous discharge at the sternum incision sites, while 17 patients (81%) exhibited purulent discharge. Among the patients, three (14.3%) had growth in the culture from the discharge, 16 patients (76.2%) had growth in the culture from the subcutaneous tissue, and two patients (9.5%) had growth in the culture from the bone tissue. When the isolated pathogenic microorganisms were examined, *Staphylococcus aureus* (*S. aureus*) was the most isolated microorganism with 11 patients (52.3%) and coagulase-negative *staphylococci* (three patients, 14.3%), *Escherichia coli* (two patients, 9.5%), *Acinetobacter* spp. (two patients, 9.5%), *Klebsiella pneumoniae* (one patient, 4.8%), *Streptococcus pneumoniae* (one patient, 4.8%), and *Pseudomonas aeruginosa* (one patient, 4.8%) were isolated. Upon examining the antibiogram sensitivity of one of the two patients with isolated *Acinetobacter* spp. and the patient with isolated *Klebsiella* pneumoniae, the treatment regimen was switched from Vancomycin + Meropenem to Tigecycline + Meropenem due to the observed resistance.

Pectoral muscles were used as flaps in the treatment of patients to fill the tissue spaces formed after serial debridements and vacuum-assisted wound closure system applications and to enable the sternum incision to approach each other. Partial sternum resection was performed in two patients with growth in cultures taken from sternal tissue. The sternum was fixed by rewire in one patient with sternal dehiscence and partial sternum resection was performed in the other two patients, and the remaining sternum was fixed using steel wire. Depending on the size and location of the tissue spaces, the right pectoralis major muscle was used in four patients (19%), the left pectoralis major muscle in four patients (19%), and the bilateral pectoralis major

Table 3. The clinical and demographic characteristics of the patients

Characteristics	Number of patients (n)	Percentage (%)
Age	62.7 ± 6.5	
Gender		
Male	7	33.3
Female	14	66.7
Mediastinitis Type		
Type I	3	14.3
Type II	2	9.5
Type IIIA	16	76.2
Anatomical Mediastinitis Class		
Type A	8	38.1
Type B	9	42.9
Type C	4	19
Patient with Sternal Separation	3	14.2
Additional Disease and Risk Factors		
Smoking	16	76.2
DM	12	57.1
HT	14	66.7
Obesity (BMI>30 kg/m^2)	9	42.9
COPD	7	33.3
CRI	2	9.5
Peripheral artery disease	3	14.2
Type of Surgery		
Urgent	4	19
Elective	17	81
Surgery		
Coronary artery by-pass graft	14	66.7
Mitral valve replacement	4	19
Aortic valve replacement	2	9.5
Aortic valve replacement + Mitral valve replacement	1	4.8

DM: Diabetes mellitus, HT: Hypertension, COPD: Chronic obstructive pulmonary disease, CRI: Chronic renal insufficiency, BMI: Body mass index.

muscle in 13 patients (62%). The rectus abdominis muscle and pectoralis major muscle were used as flaps in two of four patients who were classified as type C Mediastinitis according to the anatomical classification. The use of the rectus abdominis muscle as a flap was not needed because the pectoralis major muscle flaps were sufficient to close the tissue space in type B Mediastinitis cases. Surgical flap closure was performed after an average of 16.7 days from the onset of the symptoms and emergency flap closure was not performed in any patient.

After the pectoral muscle flap surgery, the patients were followed up in the intensive care unit for one day, and during this period, one patient (4.8%) needed a repeat surgery because of bleeding in the area where the muscle flap was taken. No complications developed again after the bleeding control and no wound dehiscence/healing or re-infection were detected in any patient.

Table 4. The follow-up and treatment parameters of mediastinitis patients

Characteristics	Number of Patients (n)	Percentage (%)
Flow Type		
Serous	4	19
Purulent	17	81
Place of Sampling with Reproduction in Culture		
Flow	3	14.3
Subcutaneous tissue	16	76.2
Bone	2	9.5
Pathogen Microorganism		
Staphylococcus aureus	11	52.3
Coagulase-negative staphylococci	3	14.3
Escherichia coli	2	9.5
Acinetobacter spp.	2	9.5
Klebsiella pneumoniae	1	4.8
Streptococcus pneumoniae	1	4.8
Pseudomonas aeruginosa	1	4.8
Use of vacuum-assisted closing system	21	100
Flap Used		
Right pectoralis major	4	19
Left pectoralis major	4	19
Bilateral pectoralis major	13	62
Complication		
Bleeding	1	4.8
Wound separation/Non-healing	0	0
Re-infection	0	0
Treatment success	21	100
Mortality	0	0

Success was achieved in all 21 patients treated with pectoral muscle flap because of deep mediastinal infection and all patients were followed for one year. There was no need for re-intervention in the follow-up of the patients. No mortality was reported among the patients who received treatment, either due to infection, surgical muscle flap closure, or cardiac causes.

DISCUSSION

As a result of the development of advanced diagnosis and interventional examinations in patients with cardiac complaints, the number of patients undergoing cardiac surgery has also increased. The increased rate of cardiac surgery has naturally led to sternal wound infections becoming a more common condition in this patient population. These sternal infections may present with a serious manifestation such as mediastinitis, or they may be seen as superficial simple infections[15]. When the literature was reviewed, the incidence of deep sternal wound infections varies between 2% and 4%[16] and was found to be 3.6% in the present study.

The causative agent may be different pathogens in Mediastinitis cases. In a study on deep mediastinal infections by Sommerstein et al., *S. aureus*, coagulase-negative *staphylococci*, and gram-negative bacteria were the most common pathogens in etiology[16]. In a study that included 3896 patients who had undergone cardiac surgery, it was reported that the most frequently isolated microorganism in Mediastinitis cases was *S. aureus* with a rate of 32%, followed

by coagulase-negative *staphylococci* with a rate of 29.6%[17]. In another study that was conducted in our country, coagulase-negative *staphylococci* were in first place with 38.2% of microorganisms that were isolated from patients treated for mediastinitis, *Klebsiella* was in second place with 14.7%, and S. *aureus* was in the third place with 13.2%[18]. In the present study, similar to the literature, the most common pathogenic microorganisms were found to be *S. aureus* (52.3%) and coagulase-negative *staphylococci* (14.3%).

The treatment methods used in patients with Mediastinitis are debridement, open or closed drainage, antibiotherapy, partial sternal resection, vacuum-assisted wound closure system applications, and muscle flap closure applications[15]. The first step is the initiation of appropriate antibiotic therapy and removal of infected tissue from the area in treatment. In this way, the purpose is to protect heart tissue, vascular grafts, implanted valves, and used patches from infection. Although there are researchers who advocate early flap treatment in the treatment of deep mediastinal infections, there are also opinions advocating the use of vacuum-assisted therapies as bridging therapy before the flap treatment[19]. We used the vacuum-assisted wound closure system as a bridging treatment until the flap treatment by debridement in the early period. We believe that this bridging treatment is the reason for achieving a completely infection-free area and the absence of recurrent infections in all our patients.

In terms of mortality, in a study conducted in 2013, Aydın et al. applied negative vacuum therapy to 22 patients with deep mediastinal infection and closed mediastinal irrigation therapy was applied to 19 patients in addition to antibiotherapy. Although none of the patients who underwent vacuum-assisted therapy died, it was reported that three patients died[20]. It was reported in another study that three (16.6%) of 16 patients who underwent muscle flap treatment for Mediastinitis died[17]. In another study conducted with 7973 patients who underwent open heart surgery at Tampere University Hospital between 2006 and 2017, 129 (1.6%) of the patients had a deep mediastinal infection in the postoperative period, and 26 patients (20.2%) died in the one-year follow-up of these patients[21]. Kachel et al. reported that they used sternoplasty for the treatment of 68 mediastinitis patients and the mortality rate was 2.9%[22]. In the present study, all patients with deep mediastinal infection were debrided by starting antibiotherapy in the early period, and bridging treatment was applied to the patients with vacuum-assisted closure until negative wound culture and granulation tissue were detected. Then, closure was performed with a pectoral muscle flap. During the one-year follow-up period of our patients, no cases of re-infection, need for re-intervention due to wound deterioration, or mortality were observed among any of the patients. Effective antibiotherapy and debridement were started in the early period in patients with mediastinitis. We believe that the multidisciplinary approach involving infectious diseases, plastic, and reconstructive surgery has had a significant impact on the success of the treatment process. In the literature, studies report that closure with a pectoral muscle flap has unsuccessful results leading to re-separation in sternal wounds involving the lower 1/3 of the sternum[23]. Another study reported that the unilateral pectoralis major flaps have been a good option for the reconstruction of the sternal wound[24]. Elassal et al. reported that the pectoral flap is a less invasive method for most reconstructive procedures[25]. Although it is recommended for patients with type B mediastinitis, the researchers successfully performed the closure with the pectoralis major muscle without the need to use a rectus abdominis flap. Although the researchers were successful in this, the small number of patients and the fact that it was a single-centered study were the limitations of the study. We believe that conducting multicenter studies involving a larger number of patients can potentially yield more significant results in this regard.

In conclusion, although mediastinitis, in other words, deep sternal infections, is less common, it can cause high morbidity and mortality. Treatment and care of patients who develop Mediastinitis is a complex, long-term, and costly treatment requiring prolonged hospitalization, and may result in mortality. As a result, the primary objective should be to prevent the development of mediastinitis, and it is crucial to initiate prompt and effective treatment in patients who do develop mediastinitis. We believe that this process should be carried out through a multidisciplinary approach, involving collaboration between cardiovascular surgery, infectious diseases, and plastic and reconstructive surgery units.

Ethics Committee Approval: The study was approved by Eskişehir Osmangazi University Non-invasive Clinical Research Ethics Committee (Decision no: 18, Date: 26.07.2022).

Informed Consent: This is retrospective study, we could not obtain written informed consent from the participants.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept/Design - All of authors; Analysis/Interpretation - CO, ASK; Data Collection - CO, ASK, AEK; Writing - All of authors; Critical Revision - All of authors; Final Approval - All of authors; Statistical Analysis -CO, ASK; Overall Responsibility - CO.

Conflict of Interest: The authors have no conflicts of interest to declare.

Financial Disclosure: The authors declare that this study has received no financial support.

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