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The Modified Sternoplasty: A Novel Surgical Technique for Treating Mediastinitis

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Summary: Deep sternal wound infection (DSWI) is one of the most complex and devastating complications post cardiac surgery. We present here the modified sternoplasty, a novel surgical technique for treating DSWI post cardiac surgery. The modified sternoplasty includes debridement and sternal refixation via bilateral longitudinal stainless-steel wires that are placed parasternally along the ribs at the midclavicular or anterior axillary line, followed by six to eight horizontal stainless-steel wires that are anchored laterally and directly into the ribs. On top of that solid structure, wound reconstruction is performed by the use of bilateral pectoralis muscle flaps followed by subcutaneous tissue and skin closure. We reported mortality rates and length of hospitalization of patients who underwent the modified sternoplasty. In total, 68 patients underwent the modified sternoplasty. Two of these critically ill patients died (2.9%). The average length of hospitalization from the diagnosis of DSWI was 24.63±22.09 days. The modified sternoplasty for treating DSWI is a more complex surgery compared with other conventional sternoplasty techniques. However, this technique was demonstrated to be more effective, having a lower rate of mortality, and having a length of hospitalization lower than or comparable to other techniques previously reported in the literature.
(Plast Reconstr Surg Glob Open 2022;10:e4233; doi: 10.1097/GOX.0000000000004233; Published online 29 April 2022.)

INTRODUCTION

Deep sternal wound infection (DSWI), also known as post-sternotomy mediastinitis, is a potentially devastating complication following cardiac surgery, as it is associated with a significant increase in patient morbidity and mortality, prolonged hospitalization, and heavy economic burden.[1–3] DSWI is prevalent in 2% of patients following cardiac surgery and up to 8% in high-risk patients, with mortality rates as high as 40%–47% in the last 50 years[4–6] and significant impacts on patient outcomes.[7–18]

Current treatment includes negative pressure wound therapy, which can serve both as an adjuvant therapy to treat DSWI as well as bridge these patients to final surgical closure.[19,20] In large and complicated sternal defect cases, surgical approaches may be warranted and include wound reconstruction by muscle flaps, most commonly through bilateral pectoralis muscle as sliding or "turn over" techniques, or by a rectus abdominus muscle or omental flap.[21–24] We present here the novel modified sternoplasty technique for treating severe DSWI following cardiac surgery, which involves a unique method for sternal reconstruction combined with the use of bilateral pectoralis muscle flaps.

METHODS

Between September 2010 and January 2020, 68 patients following cardiac surgery (2.5% of patients, which is similar to levels reported globally)[7–18] developed DSWI according to the Center for Disease Control definitions,[25] with wide sternal dehiscence and total exposure of the heart and great vessels. These patients failed to heal with conservative treatment, and therefore underwent the modified sternoplasty surgery.

Disclosure: *All authors have no financial interest to declare in relation to the content of this article.*

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Received for publication February 9, 2021; accepted February 7, 2022.

DOI: 10.1097/GOX.0000000000004233

SURGICAL TECHNIQUE

The modified sternoplasty technique consists of two main steps: the first step includes removal of all previous wires and foreign bodies, followed by surgical debridement of the infected skin, subcutaneous tissue, mediastinal fluid, and sternal bone, which are subsequently sent for cultures. The sternum is aggressively debrided using an oscillating saw, or other surgical instruments. At this stage, if a patient is unstable, the wound is dressed with VAC, and the patient is transferred to the cardiac surgical intensive care unit (CSICU) for continued monitoring and support.

Once hemodynamically stable, which typically occurs within 2–5 days, the debrided sternal bone is dissected from the adhered heart below, great vessels and any underlying bypass grafts from top down and bilaterally at the midclavicular line, which allows the insertion of bilateral longitudinal stainless-steel sternal wires along the healthy ribs. If extensive adhesions prevent safe mobilization of the heart, we initiate femoral-femoral cardiopulmonary bypass to decompress the heart and allow a much safer dissection, as well as lung decompression during wire and chest tube placement.

The longitudinal wire insertion technique includes insertion of the wires as laterally as possible to the midclavicular line instead of adjacent to the sternum, and into the middle of each healthy rib instead of the intercostal space. Following this, six to eight horizontal sternal wires are inserted laterally to the longitudinal wires and directly into the middle of each rib (Fig. 1). This ensures that the sternal tension is now based on both the longitudinal and horizontal wires and the ribs and not only on the fragile remaining sternum (Fig. 2).

The second step, assisted by the plastic surgeons, involves mobilizing and advancing pectoralis muscle flaps, superiorly from the clavicles, inferiorly at the level of ribs 10–12, and laterally to the anterior axillary line. In this sliding muscle flaps technique, the pectoralis muscle blood supply is based on the thoracoacromial arteries, which should be carefully spared during flap elevation. Once fully harvested, both flaps are sutured together on top of the solid reconstructed chest with 15–20 single 2-0

Takeaways

Question: Is the modified sternoplasty effective for treating mediastinitis?

Findings: The modified sternoplasty for treating DSWI is a more complex surgery compared with other conventional sternoplasty techniques. However, this technique was demonstrated to be more effective, having a lower rate of mortality, as well as having a length of hospitalization lower than or comparable to other techniques previously reported in the literature.

Meaning: The modified sternoplasty surgery provides a solution for this devastating complication affecting this specific group of DSWI patients with wide-open sternal wounds with exposed heart and great vessels.

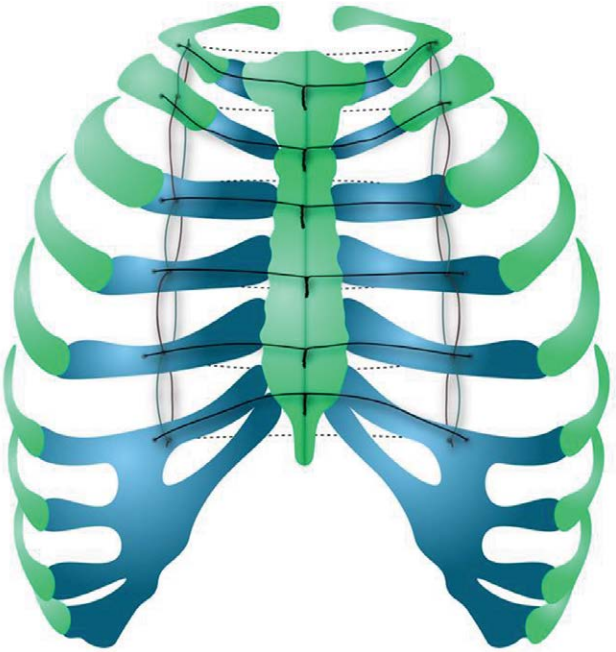

Fig. 1. Illustration of bilateral longitudinal stainless-steel sternal wires along the healthy ribs, and illustration of horizontal sternal wires, which insert laterally to the longitudinal wires and directly into the middle of each rib.

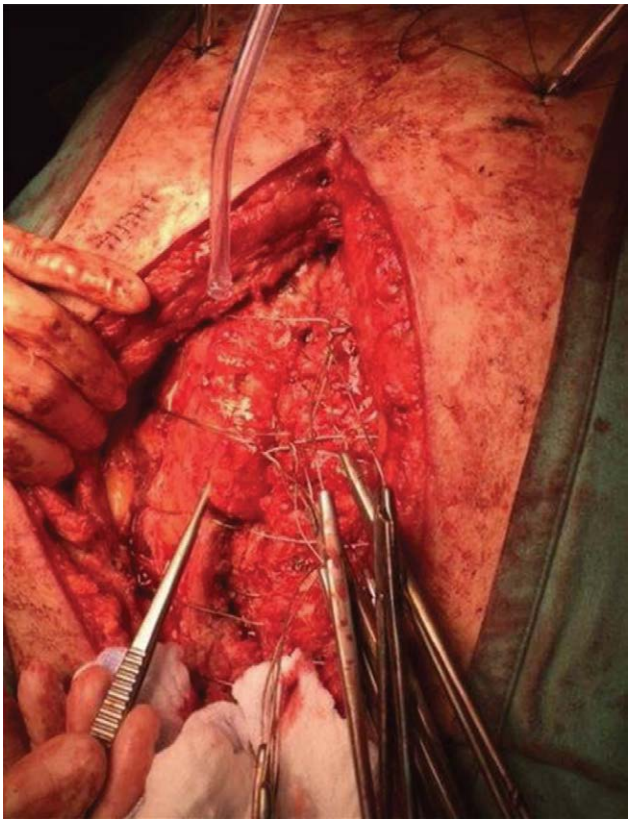

Fig. 2. Sternal fixation using bilateral longitudinal wires and horizontal sternal wires.

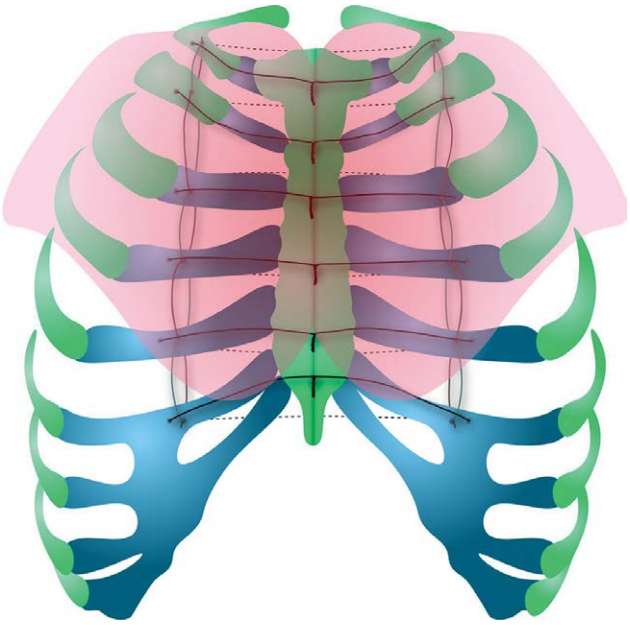

Fig. 3. Bilateral pectoralis muscle flaps cover the sternal bone reconstruction.

Vicryl sutures followed by one continuous layer of Vicryl 1–0 sutures subcutaneously (Fig. 3). The skin is closed with Monocryl 4-0 sutures and adequate surgical dressing is placed for 48 hours.

We leave two Jackson-Pratt (JP) 10 mm drains between pectoralis muscle flaps and the reconstructed chest wall, which remain until drainage is less than 10 cm^3 per day, as well as chest drains in both pleural spaces and the mediastinum below. The patients remain intubated and under general anesthesia for 48 hours postoperatively, and IV antibiotics are continued for 6 weeks.

CLINICAL OUTCOMES

In total, 68 patients underwent the modified sternoplasty surgery. Patients' baseline characteristics are presented in Table 1. The average length of hospitalization was 24.94 + 22.09 days, and the mortality rate was 2.9% (n = 2). One patient died during the surgery due to damage to the left internal thoracic artery graft of the prior coronary artery bypass grafting (CABG) surgery (which supplied the left anterior descending artery with a right internal thoracic artery T graft to two marginal arteries) as a result of severe mediastinal adhesions. As a result, this case led to the decision that cardiopulmonary bypass will be initiated before separating severe adhesions. A second patient died due to septic shock and multisystem failure secondary to aspiration pneumonia on day 16 postoperatively.

Table 1. Baseline Characteristics of Patients

Variable Label	Total Cohort
Demographic characteristics	
Age (y)	69.02 ± 9.89
Gender, men, n (%)	72.5% (n = 50)
Medical comorbidities	
Diabetes mellitus, type 1, n (%)	1 (1.4%)
Diabetes mellitus, type 2, n (%)	43 (62.3%)
Hypertension, n (%)	59 (85.5%)
Hyperlipidemia, n (%)	59 (85.5%)
Cardiac-surgery procedure	
CABG, n (%)	39 (56.5%)
Valvular surgery, n (%)	15 (21.7%)
Combined CABG and VR, n (%)	12 (17.4%)
Other procedure, n (%)	3 (4.3%)
Cardiopulmonary bypass, n (%)	12 (17.6%)
Clinical outcomes	
Length of hospitalization (d)	24.94 + 22.09
Mortality, n (%)	2 (2.9%)

Data are presented as mean and SD (Mean ± SD) or number and percentages.

DISCUSSION

This study presents the modified sternoplasty surgery, a novel surgical technique to treat DSWI complicated by a large sternal defect and exposure of the heart and mediastinal vessels. In our patient cohort, 2.9% of the patients died (2/68), which is lower than the rate reported in the literature.[21,26,27] To the best of our knowledge, this cohort of patients with complicated DSWI is one of the largest described.

The modified sternoplasty surgery combined horizontal sternal wires leaning on longitudinal wires for sternal stabilization followed by a pectoralis major flap covering. This provides complete chest wall stabilization and mediastinal fixation to allow eradication of the infection and promote wound healing through a vascularized tissue flap. This complete structure helps balance the shear forces loaded on the chest wall during coughing, deep breaths, and mobilization that may complicate patients in the immediate and long-term postoperative period. The redistribution of forces helps prevent dehiscence, reinfections, and fistulas, and is the main reason for reducing postoperative morbidity, mortality, and length of postoperative hospitalization compared with those reported in the literature.[3,28–31]

CONCLUSION

The modified sternoplasty surgery provides a solution for this devastating complication affecting this specific group of DSWI patients with wide-open sternal wounds with exposed heart and great vessels.

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