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The Management of Complicated Sternal Dehiscence following Open Heart Surgery

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ABSTRACT

Background. Wound infection after median sternotomy for cardiac or thoracic surgery is a serious complication, and there is a lack of agreement regarding the best treatment method. We present our results in patients with mediastinitis treated with longitudinally affixed titanium plates on sternal halves.

Methods. The technique was composite closure using titanium fixation plates to buttress the sternum in combination with circumferential stainless steel wires. The series included 21 patients who developed sternal non-union resulting from mediastinitis. Mobilization of muscular flaps was performed in 8 cases. This technique also consists of sternal and soft tissue debridement and wound closure over mediastinal tubes with continuous irrigation and drainage. Antibiotherapy based on culture and sensitivity data continued for 4 to 7 weeks.

Results. Twenty patients achieved complete wound healing without further operative intervention or major complication. Nineteen patients treated with this technique survived. One patient died from sepsis after developing residual focus of chondritis and undergoing wide resection of cartilage, and 1 patient died from complications of severe stroke.

Conclusion. We had good success using aggressive early debridement, closure of the sternal halves with titanium plates, mobilization of muscular flaps, high-volume mediastinal irrigation, and intravenous antibiotics. This approach was a successful salvage technique for revision cases in achieving sternal stability and union when standard methods of closure failed or were unlikely to succeed.

INTRODUCTION

Despite improvements in surgical techniques, anesthesia, and antibiotic treatment, postoperative wound reopening remains a significant and potentially lethal complication after cardiac operations. Sternal wound infection occurs in as many as 5% of patients, leading to sternal wound dehiscence, with a recently reported incidence of mediastinitis in 0.8% to 2.3% of patients [Finkelstein 2005; Fowler 2005; Upton 2005]. Postoperative mediastinitis is one of the most feared complications in patients who undergo cardiac surgery because of a mortality rate as high as 8.1% [Jones 1997].

Restoration of sternal integrity in sternal dehiscence is challenging, particularly when associated with deep-seated infection. A variety of treatment plans have been advocated over the years, and there is a lack of agreement regarding the best approach. Complete debridement of infected and/or nonviable soft tissue, bone, and cartilage followed by omental transposition and muscle flaps and eventually vacuum-assisted closure seems to be the accepted choice in such cases [Tang 2000; Shrager 2003; Klesius 2004]. The standard method of closure is parasternal weaving. Some surgeons suggest the use of fixation plates that achieve bony union, with plating across the median sternal osteotomy site [Chase 1999; Mitra 2004]. The stainless steel plates used in sternal plating resist bending stresses, and the cortical bone resists compressive forces [Hendrickson 1996]. The technique requires minimal dissection of the posterior sternal border, is not circumferential, and provides secure sternal approximation.

Here we present our experience with composite closure using titanium fixation plates to buttress the sternum in combination with early debridement, muscular flap mobilization, high-volume irrigation, and antibiotherapy in 21 patients experiencing complications with deep sternal infections.

PATIENTS

From 1999 through 2005, 2106 patients underwent cardiac surgery at our university hospital. Of these, 56 developed dehiscence without infection, and of that group, 21 (1% of the original group) developed mediastinitis. These 21 patients (13 female) who developed a deep sternal infection from 1999 through 2005 were included in this series. Demographic and surgical data are shown in Table 1. The diagnosis of mediastinitis was based on clinical findings, and all patients met the criteria for deep surgical wound infection as defined by the Centers for Disease Control [Garner 1988]. In each instance,

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Table 1. Demographic and Operative Data

Mean age, y	64.9
Sex, male/female	8/13
Body mass index	22 ± 4
New York Heart Association class III or IV	6 (28.5%)
Ejection fraction <40%	9 (43%)
Risk factors	
Smoking	9 (43%)
Diabetes	11 (52%)
Hypertension	16 (76%)
Hyperlipidemia	10 (48%)
Chronic obstructive pulmonary disease	5 (24%)
Previous surgery	3 (14%)
Dialysis	1 (5%)
Operation	
Coronary artery bypass graft	14
Valvular	5
Aortic root replacement	1
Post–myocardial infarction ventricular septal defect closure	1
Aortic cross clamp, min	68 ± 51
Extracorporeal circulation, min	96 ± 81
Off-pump	4
Prolonged ventilation	4 (19%)

patients exhibited erythema and swelling of the sternotomy incision accompanied by drainage of purulent fluid and sternal instability. These findings were usually accompanied by fever, tachycardia, and leukocytosis. Patients with superficial sternal wound infections or sterile sternal dehiscences were not included. Computed tomographic scanning of the chest was not routinely employed as a diagnostic technique.

Initial procedures included coronary artery bypass (14 patients), mitral valve replacement (4 patients), aortic root replacement (1 patient), aortic valve replacement (1 patient), and post–myocardial infarction ventricular septal defect correction with 1 vessel coronary artery bypass grafting (1 patient). None of the procedures except the post–myocardial infarction ventricular septal defect correction were performed as emergency. Left internal thoracic artery mobilization and grafting of the left anterior descending coronary artery were performed in all first-time coronary artery bypass cases. Two patients who underwent coronary artery bypass grafting required intraoperative insertion of an intra-aortic balloon pump. Four patients underwent re-exploration for bleeding, and 1 patient underwent revision for bypass graft failure.

Surgical Approach

All patients were returned to the operating room for definitive, single-stage treatment of the infected wound. The prior median sternotomy incision was opened completely and all sutures and sternal wires removed. The sternum was assessed for fractures, devitalized bone, osteoporosis, vascularity from the osseous edge, and the degree of sternal separation. Patients were classified in accordance with the criteria proposed by El Oakley and Wright [1996]. Briefly, this classification states that closed mediastinal irrigation can be successful in type 1 mediastinitis, but a major reconstructive operation is probably the treatment of choice for patients with mediastinitis types II to V. The sternal halves were sharply debrided with curettes and rongeurs or treated by resecting 1 to 2 mm of sternal bone bilaterally with an oscillating saw until viable bone was visible. Drainage, purulence, and debrided bone were cultured and Gram stained. The wound was copiously irrigated with a combination of warm saline and antibiotic solutions.

After careful inspection of the bone, sternal halves were plated longitudinally with 2.4-mm, dynamic, compressible titanium fixation plates tailor cut to the respective cephalic caudal dimension. The plates were positioned to rest in an area of thicker, more solid sternum rather than the often-friable sternal margin adjacent to the sternal wound. This positioning is important to ensure that optimal quality and density of bone are exploited for solid purchase with the fixation screws. The drill bit was chosen after visual estimation of the maximal depth of the sternal halves, and an appropriately sized drill stop was used. Drill holes were carefully created through the plate into the sternum, with care taken in placing the wide, malleable retractor deep into the posterior table to protect the underlying mediastinal structures. Internal fixation was then accomplished using screws supplied with the plating system (Figure 1).

Completing the screw fixation of the plate onto the sternal halves, typically #5 stainless steel wires were placed in a "figure 8" through the remnant plate holes to the sternal halves. Two or more drainage and irrigation catheters were placed in the mediastinum posterior to the sternal edges. The drainage and irrigation system consisted of a modified Mills sump tube or was composed of a multiple side-hole catheter for infusion accompanied by a regular mediastinal drainage tube. The stainless steel wires looped around the plate were then slowly tightened, drawing the 2 sternal halves toward the midline. The wires were then further tightened and cinched down, taking care to avoid wire

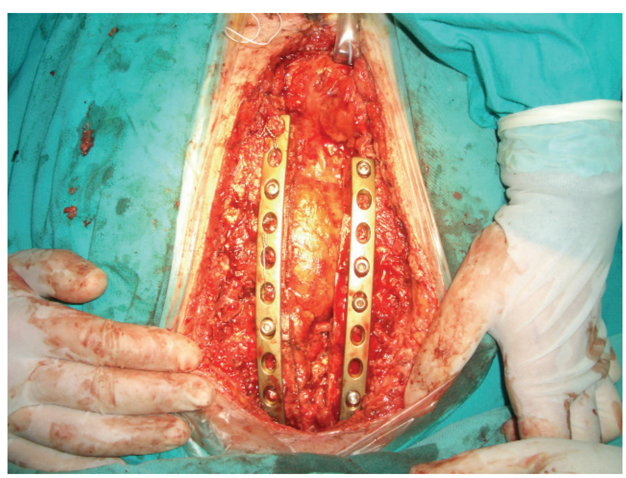

Figure 1. Composite titanium plate fixation to the destructed sternal halves.

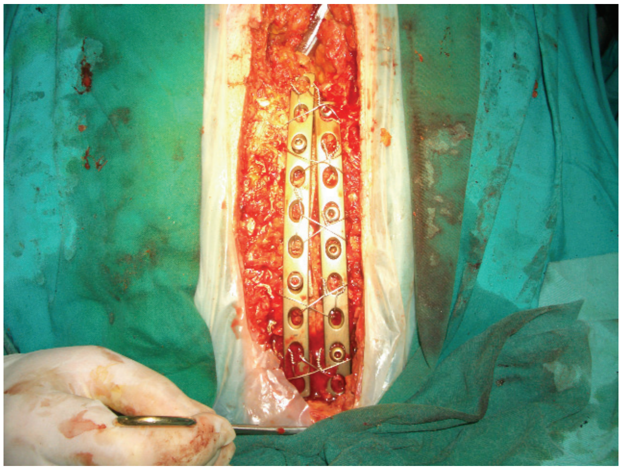

Figure 2. Sternal approximation.

kinking and excessive twisting, which can lead to stress concentration and wire fatigue and breakage (Figure 2).

Soft-tissue closure was easily performed in cases where the sternum had been adequately reapproximated. In 8 patients with severely degraded sternum and parasternal tissue, we created bilateral pectoralis major muscle flaps elevated from medial to lateral and sutured in the midline to provide a vascularized soft tissue cover for the sternal repair. Skin closure was performed in layers with 2-0 polyprolene in a vertical mattress orientation following re-enforced retraction sutures with #0 Ethibond (Ethicon, Somerville, NJ, USA).

All patients underwent high-volume mediastinal irrigation, at least 100 mL per hour, for a minimum of 6 days with antibiotic or antibacterial solution. Patients were administered dilute povidone (15 mL in 1000 mL normal saline) or a dilute antibiotic solution (vancomycin or cephalosporin 1000 mg in 1000 mL normal saline). The irrigation solution was adjusted subsequently depending upon culture results. Intravenous antibiotics based on culture and sensitivity data were administered for a 4- to 7-week course postoperatively, based on intraoperative microbiological studies. The patients were extubated when cardiorespiratory status had been stabilized for a mean duration of 12.3 hours.

RESULTS

Of the 21 patients treated, 20 achieved complete healing of the wound without further operative intervention or major complication as a result of this 1-stage intervention. Nineteen patients survived. Of the 2 who died, 1 patient had a recurrent infection and required reoperation due to a residual chondritis; this patient subsequently underwent wide resection of cartilage and whole sternum. Internal fixation of the adjoining ribs was performed with an individually measured segment of titanium mesh anchored to the surrounding bony edges with stainless steel wires. Standard closure with muscle flaps was achieved, but the patient died from sepsis 10 days after completion of the second intervention. The second patient developed a stroke on postoperative day 14 and died as a result of cardiopulmonary arrest. In this patient, we observed complete wound healing.

There were no other instances of delayed wound problems or necessity for additional intervention. We evaluated outcomes of mediastinitis in our patients based on clinical stability, white blood cell counts, sedimentation rates, and C-reactive protein levels, as well as control blood and drainage sample cultures. We observed no myocardial ischemic events during mediastinitis treatment, although graft patency after treatment for mediastinitis was not assessed angiographically.

The interval between the primary operation and reoperation for infection ranged from 9 to 22 days, with a mean of 13.6 days. The interval from operation for mediastinitis to discharge from the hospital ranged from 11 to 42 days, with a mean of 21.6 days. Blood culture results were positive in 24% of cases. Associated microorganisms cultured from debrided tissues are shown in Table 2.

DISCUSSION

In cardiac surgery, sternal wound infection remains one of the most serious postoperative complications [Mossad 1997], but advances in contemporary cardiothoracic surgery have led to significantly improved outcomes. Patient populations with comorbidities that once precluded their candidacy for cardiac intervention are now operated on more commonly than ever before [Astudillo 2001]. Before 1999, our incidence of postoperative mediastinitis was about 2%, and prior to 1999, we performed parasternal weaving as well as using conventional methods such as irrigation and antibiotherapy. Our success rate prior to 1999 was low, with about 88% survival. Our success with the current series of operations from 1999 through 2005 using the approach described here is notably better, with 20 of 21 cases achieving complete healing without further operative intervention and an average interval of 21.6 days from operation for mediastinitis to discharge. The success rate results are comparable to those of a study series of 50 patients in whom transverse fixation of titanium plates were used [Cicioliono 2005]; however, the range of days from operative reconstruction to discharge differed. In the series of 50 patients, the range was 1 to 38 days, and in the current series of 21 patients, it was 11 to 42 days. The average time to extubation was comparable in the 2 studies. The sex ratio in the series of 50 patients was 64 percent male; in our study, it was 38% male.

Table 2. Associated Bacteria with Deep Sternal Wound Infection

Microorganism	Number of Patients
Staphylococcus epidermitis	1
Staphylococcus aureus	11
Acinetobacter baumannii	2
Pseudomonas aeruginosa	1
Enterococcus	1
Mixed	3
None	1

The principles of rigid plate and screw osteosynthesis gained from craniomaxillofacial and orthopedic surgery have been advocated by several authors and applied to sternal closure. Several series have reported excellent results with respect to rigidity and strength of closure in both primary and secondary procedures, obviating many of the complications reported from wiring. This technique brings some problems, including difficulty in accessing the mediastinum in urgent situations, fractured screw holes, and loosened fixation plates, with resultant sternal separation. Furthermore, in cases of wide separation of the sternal halves, plate fixation alone can be mechanically difficult to achieve [Ozaki 1998; Smoot 1998; Imagawa 2004; Mitra 2004]. The plaque technique we used here combines the simplicity of wiring with the durable nature of plate fixation. Large titanium plates impart strength and rigidity to an otherwise poor bone quality sternum, converting the sternal halves into reinforced structures that readily accept rewiring and the attendant stresses placed across these wires. In all cases presented here, the bone quality was clinically considered to be quite poor due to osteoporosis, poor density, and/or areas of fracture, particularly at the medial borders.

We experienced no difficulty in reopening the sternum in 1 patient; the plates were placed longitudinally without crossing the midline, and the transfixation plate wires could easily be cut with conventional wire cutters. Fixation, reconstruction, and support plates that were placed longitudinally along sternal halves could be removed with available screwdriver and mechanized drills.

With aggressive debridement, pulsed lavage irrigation, closed suction drainage, transposition of muscle flaps, careful layered closure, and directed antibiotics, we had no problems with infections. Flap mobilization brought well-vascularized tissue to assist in achieving uncomplicated wound healing in our 8 patients in whom severe infection invaded all subcutaneous and mediastinal tissues. We contrast published results concerning vacuum-assisted closure usage [Obdeijn 1999; Fleck 2002; Abu-Omar 2003; Domkowski 2003; Luckraz 2003] with the current results in which the mean duration of hospital stay after intervention for mediastinitis was 21.6 days, compared to 29 days for the vacuum-assisted closure group. Complete wound healing was achieved with 1 intervention in 20 of 21 patients, and only 1 event in 1 patient complicating this technique occurred.

The primary limitation of this study was the relatively small number of patients in the series, precluding acceptance of these results as definitive; however, the excellent success rate suggests that a larger series would also produce promising results.

In summary, this simplified salvage technique with titanium reconstruction plates and standard stainless steel wiring offers prompt stabilization of the sternum to facilitate healing and promote normal chest wall dynamics, requires no dressing changes, and results in prompt wound healing in most instances. This closure method is a useful option in the management of particularly wide sternal separations and in cases where poor sternal bone quality would ordinarily not be conducive to rewiring because of mediastinitis. Using this approach resulted in a reduced length of stay and reduced need for additional surgery compared to vacuum-assisted closure, improved survival, and excellent intermediate freedom from deep sternal infection, with minimal patient dissatisfaction.

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