DEEP MEDIAN STERNAL WOUND INFECTION: MANAGEMENT AND RECONSTRUCTION

Hamid-Reza Davari,* MD and Mohammad-Bagher Rahim,** MD

Abstract During a 30-month period, 25 patients with deep infected median sternotomy wounds were managed surgically. Fifteen patients had chronic sternal osteomyelitis with associated costochondritis, 7 patients had only costochondritis, and 3 patients had dehiscence and/or mediastinitis. Twenty were male and 5 were female. Their ages ranged from 11 to 71 years. Nine patients had 11 failed previous attempts by other physicians. Debridement of bone or sternectomy with removal of infected cartilage and soft tissue following primary reconstruction was carried out. A total of 35 operations were done. Twenty-one patients were successfully treated in one session, however, in 4 patients with recurrent infection, a total of 10 additional operations were done. Inadequate debridement was the most common cause of recurrence. Recurrent infections were managed with another muscle or omental flap, in addition to debridement or resection. We conclude that muscle transposition after adequate debridement or resection is an excellent method for deep and chronic sternal wound infections.

Acta Medica Iranica 33 (1&2): 1-11; 1995

Key words: mediastinitis; median sternal wound infection; sternal osteomyelitis; costochondritis

INTRODUCTION

The median sternotomy first advocated by Julian and associates in 1957 is now the incision of choice for most cardiac and mediastinal surgical procedures. Although wound complications after sternotomy are rare, infection remains the most threatening problem because of the potential for mediastinal sepsis with extension to aorto-coronary grafts, cardiotomy incisions, and intracardiac prostheses (1). Deep infection of the sternotomy wound occurs with a reported incidence of 0.3% to 5% (2,3,4). Improved surgical techniques and antibiotic prophylaxis have subsequently reduced the incidence of infection to 1% to 2% in most series (5).

Although associated with significant morbidity, mortality, and prolonged hospitalization, treatment of the infected sternotomy incision was best accomplished by debridement and open granulation until 1963. At that time, Shumaker and Mandelbaum described the technique of closed-catheter irrigation of the mediastinum, following debridement and reclosure of the sternum (6). This technique was further modified by Bryant, Spencer, and Thrinkle, reducing the mortality of post-sternotomy mediastinitis to 20% (7). In 1976, Lee et al (8) offered the first alternative to open granulation in those patients whose infections were not resolved by catheter irrigation. Following wide debridement of bone and cartilage, the greater omentum was transposed to eliminate mediastinal dead space with vascularized tissue (8). Jurkiewicz and associates revolutionized management of this complication by reporting excellent results in patients treated by vigorous sternal debridement and obliteration of dead space with healthy, viable muscle (9). By extending this concept to the role of primary therapy, mortality was reduced from 18% to zero, and morbidity and duration of hospitalization were significantly minimized. In 1984, Pairolero and Arnolds reported similar excellent results (10).

The purpose of this report was to review our past experience with deep infected sternotomy wounds.

PATIENTS AND METHODS

Between April 30, 1993 and November 1,1995, twenty-five consecutive patients with deep infected median sternotomy wounds were managed in General Thoracic Surgical Ward at Imam-Khomeini Hospital.

*Assistant Professor, Department of Surgery, Faghihi Hospital, Faculty of Medicine, Shiraz University of Medical Sciences, Shiraz ; **Assistant Professor, Department of Surgery, Imam-Khomeini Hospital, Faculty of Medicine, Tehran University of Medical Sciences, Tehran, Iran.

Twenty were male and 5 were female. Ages ranged from 11 to 71 years. Sternotomy was performed for cardiac disease (Table 1). In 20 patients who had coronary artery by-pass graft, 4 patients had diabetes mellitus (NIDDM), and one patient had early reoperation for postoperative bleeding. Nine patients had 11 failed attempts by other physicians. Sternal drainage or symptoms occurred between 2 weeks to 1 year after sternotomy. The interval time from the onset of symptoms and definitive reconstruction by us was between 1 month to 2 years. Patients had various symptoms and signs including: (a) single or multiple chronic sinus tract with purulent discharge; (b) pain, tenderness, skin erythema and/or bulging over chest; (c) dehiscence with frank pus (Table 2). Two interesting cases were seen in this study. A 13-year-old girl with aortic valve replacement conjoined ascending aortic conduit (AVR + Dacron ascending aortic prosthesis) was presented with a chronic sinus tract with purulent discharge. In sinography, dye was seen in mediastinum and an opacified cavity was found around the prosthesis (Fig. 1). Another patient was an 11-year-old girl who had partial dehiscence of sternotomy, mediastinitis, total opacification of left hemithorax, and localized right sided pneumothorax after median sternotomy for total correction of tetralogy of Fallot.

Preoperative evaluation.

All patients had routine laboratory exams, wound culture, CXR, EKG, pulmonary function test, and arterial blood gas analysis. Cardiologist consultation was done on all patients. Sinography was done in patients who had chronic sinus tract (Fig. 2). This is a reliable method for diagnosis of infected deep median sternotomy wounds when retrosternal extension of dye or visible costal cartilage tract is demonstrated. However, we used CT scan occasionally for evaluation of extension of the infection. Preoperative diagnosis of chondritis in 2 patients who had only pain in right costal arch was confirmed accurately by seeing deep necrotic mass on CT scans (Fig. 3). In the patient who had total correction of tetralogy of Fallot, CT scan and MRI were performed for evaluation of opacified left hemithorax. She had a patent left main bronchus, but had left lung pneumonitis with partial collapse, and loculated left-sided pleural effusion. Also, localized right-sided pneumothorax happened due to opening in right mediastinal pleura by dehiscence and infectious process.

Methods of operation

In chronic sternal osteomyelitis with sinus tract, methylene blue was injected into each sinus tract against the gravity before the skin incision was reopened.

In patients in whom the methylene blue injection demonstrated only limited cartilaginous involvement, with stable sternum intra-operatively, the sternum was left intact and the involved costal cartilages were excised completely. In patients with involvement of any fifth to ninth costal cartilages, a major resection for cure was performed. Also, xiphoid was removed to prevent possible bilateral spread of the infection (11).

Patients in whom preoperative radiographic studies had demonstrated extensive cartilaginous involvement, radical sternectomy was performed through the H-shaped incision (Fig. 4) (11). The upper portion of the manubrium and each sternoclavicular ligament were preserved, when possible, to prevent postoperative shoulder instability. All infected costal cartilages were debrided back to bleeding ribs (Fig. 5). Immediate reconstruction of the chest wall was performed in patients who had infection which was clearly limited to the excised bone and cartilage. In patients with extensive involvement of mediastinal soft tissue and deep sinus tract

Table 1. Indication for median sternotomy.

Indications	No. of patient
CAD[a]	20
Valve disease	2
CHD[b]	3
Total	25

[a]Coronary artery disease
[b]Congenital heart disease

Table 2. Summary of symptoms and signs of patients with deep infected sternotomy wounds.

Description	No. of patient
Chronic sternal osteomyelitis	
Single or multiple sinus tract with associated costochondritis	14
Single sinus tract with infected aortic Dacron graft prosthesis	1
Chronic costochondritis	
Localized pain, tenderness, and skin erythema	4
Chest wall pain and mass with normal appearing skin	2
Chronic chondrocutaneous fistula	1
Sternal dehiscence and mediastinitis	3
Total	25

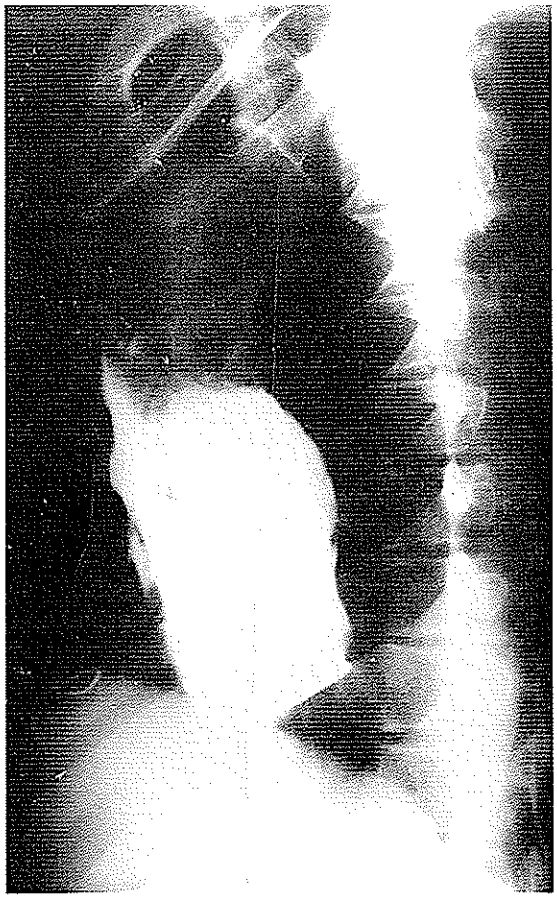


Fig. 1. Sinography of patient with AVR and infected aortic Daeron graft prosthesis.

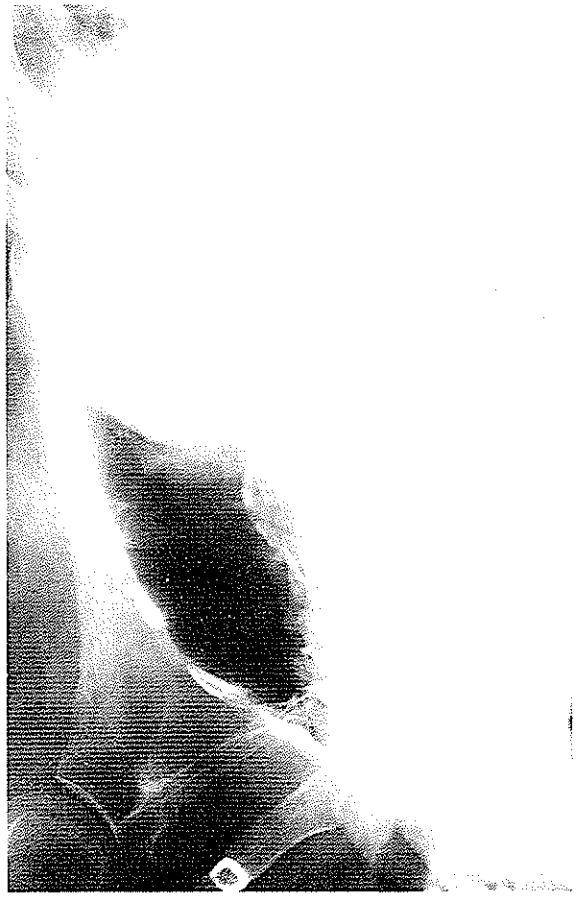


Fig. 2. Sinography of patient with chronic sternal osteomyelitis and associated costochondritis.

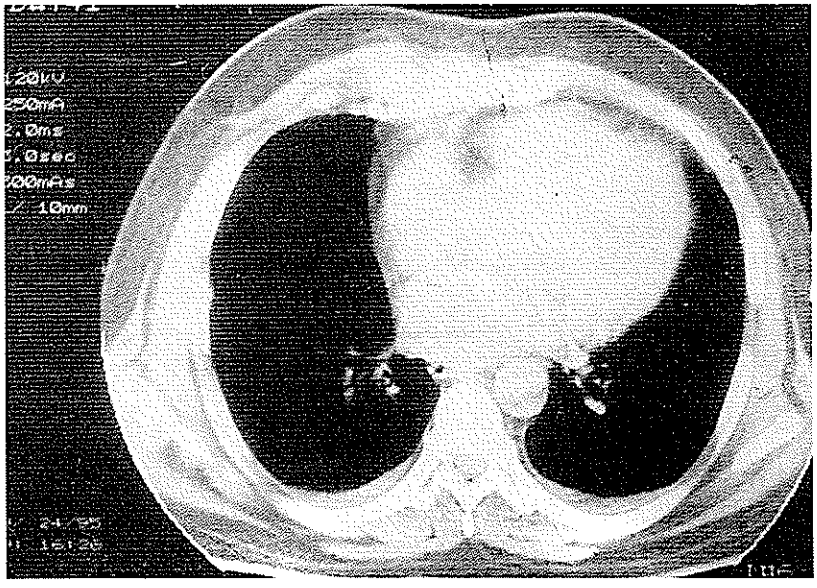


Fig. 3. Patient with chronic costochondritis with chest wall mass.

Fig. 4. Radical sternectomy in a patient with chronic sternal osteomyelitis and chondritis.

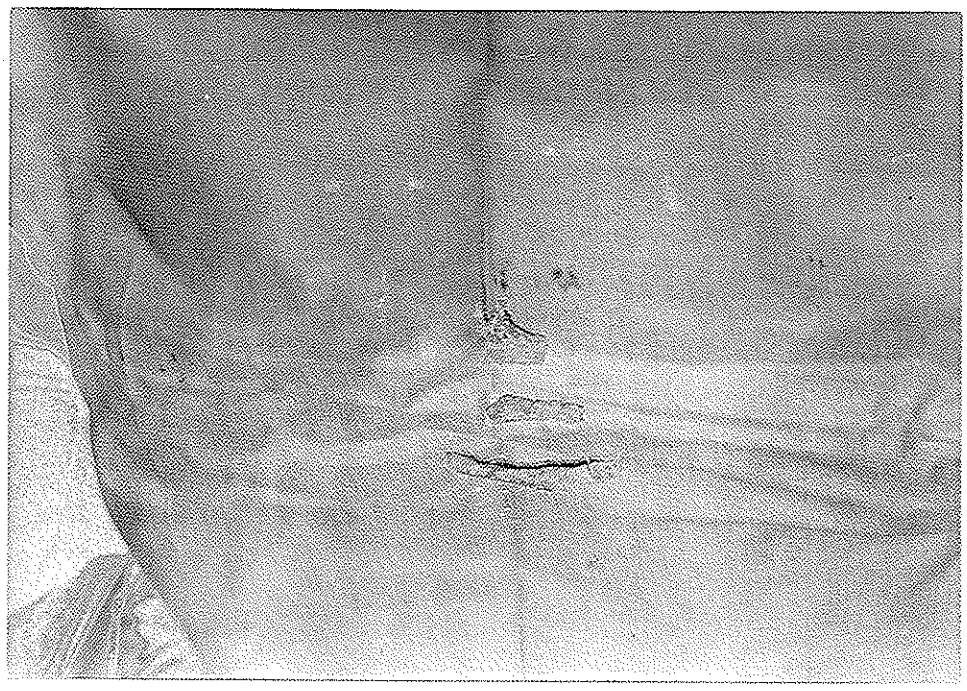
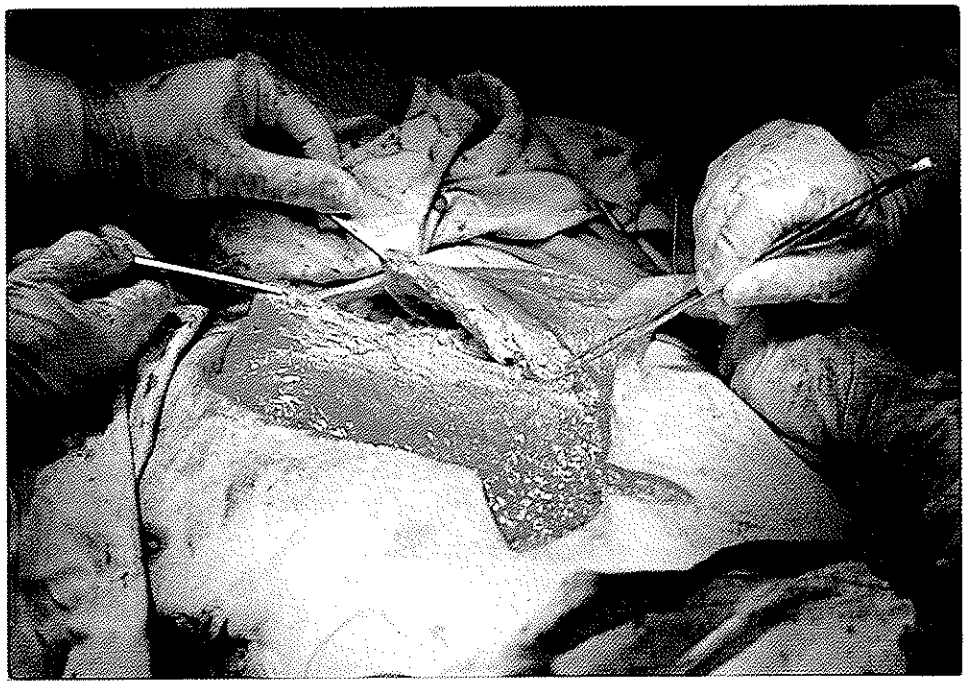


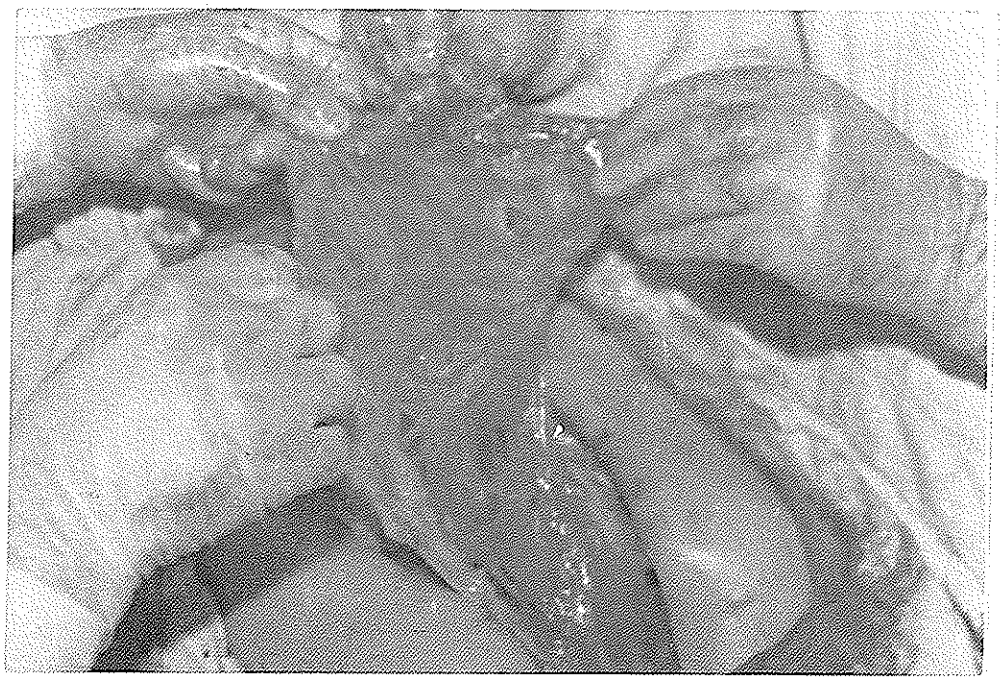
Fig. 5. Moth eaten appearance of infected cartilage.



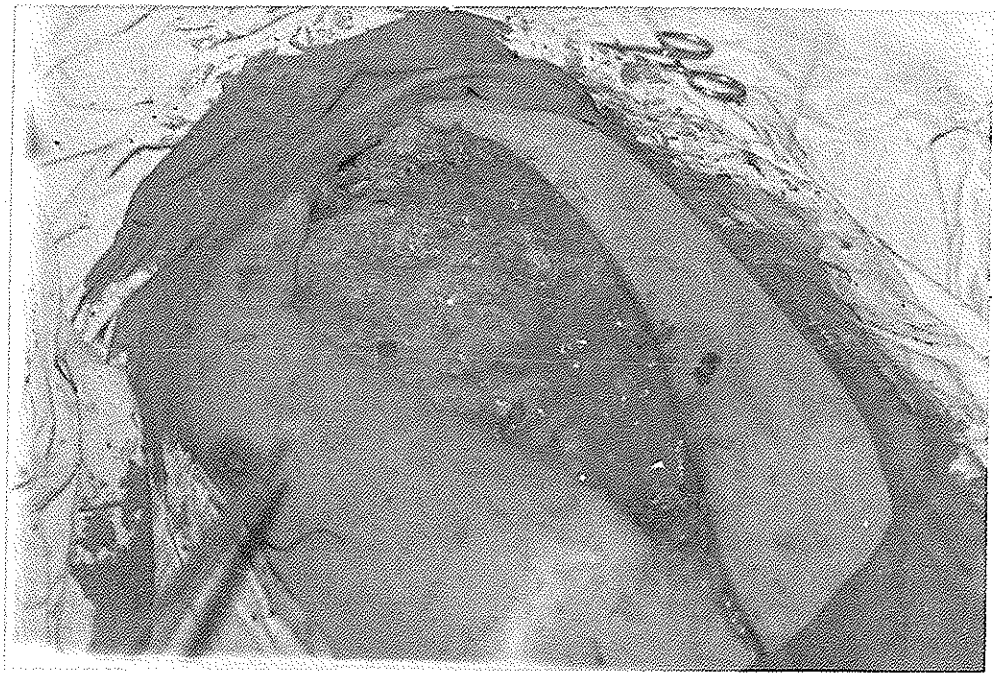
A

B

Fig. 6. Bilateral pectoralis major muscle flap after radical sternectomy. Prepared bilateral pectoralis major muscle flap (A) and mediastinal coverage (B).



A



B

Fig. 7. Omental flap after radical sternectomy. Prepared omental flap (A) and mediastinal coverage (B).

around the heart, delay closure was done, after a healthy granulation tissue had developed.

We utilized three flaps in our approach to mediastinal reconstruction: (a) unilateral or bilateral pectoralis major muscle flap based on the thoracoacromial artery, (b) a rectus abdominis muscle flap contralateral to any interrupted internal mammary arterial axis, and (c) the omentum pedicled on one or both gastroepiploic arteries (12,13,14). The most commonly used reconstruction was bilateral pectoralis major muscle flap (Fig. 6). Our indications for omental flap use in reconstruction were the same as those of others (Fig. 7)(13).

OPERATIVE RESULTS

A total of 35 operations were done. Twenty-one patients were successfully treated in one session, however, in 4 patients with recurrent infection, a total of 10 additional operations were carried out. All recurrences occurred in the beginning of this study and in patients who had inadequate debridement or resection. Recurrent infections were managed with another muscle or omental flap in addition to debridement or resection.

Radical sternectomy was done in 10 patients. In 3 patients, bilateral sternoclavicular joints were removed but in the remaining 7 patients it was possible to preserve these joints and also up to one third of manubrium. In 7 patients with stable sternum and chronic costochondritis all infected cartilages were removed. Eight patients had removal of up to body of the sternum maximum, xiphoid, and lower costal cartilages. In this group, a total of 6 unilateral and 6 bilateral pectoralis major muscle advancment flaps, 8 omental flaps and also a total of 7 local advancement muscle flaps were performed (Table 3). A young girl who had osteomyelitis of manubrium and infected aortic Dacron graft prosthesis, was managed successfully by omental flap wrapping, after debridement and curettage of bone, with excellent result. Another patient with dehiscence, mediastinitis, and opacification of the left hemithorax had excellent outcome by debridement of mediastinal soft tissue, curettage of bone, decortication of the left lung, and rewiring of sternum.

There were no loss of flaps and mortality in this study. All patients had a follow-up between 1 month to 30 months. Complications that occurred included: 2 epigastric incisional hernia in patients with omental flap, 3 seroma and 1 hematoma in patients with muscle flap.

DISCUSSION

Prior to the advent of open heart surgery, sternal infections and costochondritis were almost uniformly secondary to tuberculosis or fungi and rarely due to pyogenic organisms (2). Following popularization of the median sternotomy incision by Julian in 1957, the commonest cause of sternal osteomyelitis and associated chondritis after open heart surgery has been contamination of sternotomy wound with pyogenic or fungal organisms (2,4).

While the incidence of superficial wound infection after median sternotomy is no different than that after thoracic incision, the incidence of deep sternal wound infection ranges from 0.4% to 5%; for comparison, a summary of reports by different investigators is provided in Table 4. Improved surgical technique and antibiotic prophylaxis have subsequently reduced the incidence of infection to 1 to 2% (5).

Imperfect aseptic technique in the operating room is the basic cause of infected median sternotomy wounds (8). An undrained retrosternal hematoma, prolonged operation time and inaccurate, and insecure sternal closure increase the incidence of sternal wound infections (2,8).

Exploration for hemorrhage figures prominently among risk factors has been reported in mediastinal infections, however, this finding is based on a series from one institution (2,15). Patients reported by Talamonti and associates, who were explored within 7 hours did not become infected whereas all patients who were explored after prolonged bleeding (> 13 hours or more) became

Table 3. Definitive operations in 25 patients with deep infected sternotomy wounds.

Procedure	No. of patient
Unilateral pectoralis major muscle flap	3
Bilateral pectoralis major muscle flap	6
Omental flap	5
Omental flap + unilateral pectoralis major muscle flap	3
Local advancement flap	
Pectoralis major	2
Pectoralis major + external oblique	2
Rectus abdominis	1
External oblique + rectus abdominis	1
Debridement—open dressing, secondary intention	1
Debridement of sternotomy wound and mediastinum + decortication + rewiring of sternum	1
Total	25

Table 4. Incidence of mediastinal and deep sternal wound infection.

Reference	No. of patient	Overall incidence (%)	Specific incidence (%)		
			CABG[a]	Repair CHD[b]	Valve replacement
Ochsner et al (27)	750	0.4	–	–	–
Engelman et al (28)	1042	1.6	2.5	0.7	1.4
Thurer et al (29)	645	2.2	–	3.2	–
Grmoljez et al (30)	1550	0.8	1.2	0.5	0.1
Culliford et al (2)	2594	1.5	1.9	0.4	2.2
Sutherland et al (31)	904	–	1.4	–	–
Jimenez-Martinez et al (32)	257	5.0	–	–	–
Sarr et al (4)	824	0.7	0.2	–	1.5
Grossi et al (21)	7949	0.97	–	–	–
Loop et al (3)	6504[c]	1.1	1.1	–	–

[a]Coronary artery bypass grafting
[b]Congenital heart disease
[c]All patients had CABG

infected (11). Reoperation in contrast to primary coronary artery by-pass grafting has been linked to sternal wound complication, however, there is some controversy in this aspect (3,15). Prolonged low-cardiac output is reported frequently as a causative factor in wound complications and can herald other complications (2,16).

Obesity is clearly a risk factor for infection. The combination of diabetes, obesity, and harvesting of both internal mammary arteries (IMAs) has increased the prevalence of wound infections (3,15). Chronic obstructive lung disease and prolonged mechanical ventilation beyond 24 to 48 hours also increase the risk of infection in median sternotomy (3,15). Male gender is a risk factor, probably related to the common practice of shaving the day before operation when hair is present (15).

Corticosteroids greatly increase the risk of sternal wound infection. These drugs must therefore be discontinued completely or reduced to possibly the lower dose level for several weeks (ideally 6 or more) before operation (15). The increased risk of sternal wound complication after bilateral IMA grafting should be a strong incentive for strict aseptic measures during operation, restricted personnel circulation in the operating room, cautious use of the electrocautery for preparing the IMA graft, and minimal use of intramedullary bone wax (3). In addition, bilateral IMA grafting should probably be avoided in patients at risk for sternal wound complication, such as diabetic patients, elderly patients, and patients with chronic obstructive pulmonary disease (3).

All sternotomy incisions should be inspected daily. Spreading erythema, superficial drainage, sternal instability, or excessive incisional pain was considered to be a harbinger of potential sternal infection. The occurrence of spiking fever, marked leukocytosis, positive blood cultures, or signs of systemic sepsis prompted more intensive investigation of sternal wounds while other sources of infection were excluded.

Conventional imaging techniques are of limited value in diagnosing postoperative complications (17,18). It is difficult to diagnose the depth of infection on the basis of clinical examination with conventional imaging techniques. For example, purulent wound drainage is frequently attributed to superficial wound infection when, in fact, it may represent an early manifestation of mediastinitis. Even when a small amount of frank pus drains from the wound, mediastinitis should not be assumed to be present unless the sternum becomes unstable; a retrosternal collection of fluid is demonstrated by CT scan, or drainage can be shown to be coming through the sternum, from the retrosternal space area by sinography. Even sternal dehiscence is not an indication of infection, because very occasionally the dehiscence is a sterile one (19). Frank dehiscence with purulent drainage was an absolute indicator of sternal infection.

CT scanning seems to be an ideal technique for evaluation of the sternum, the presternal soft tissues, and the anterior mediastinum (17,18). The advantage of the CT scan is that it can help classify wound infection as superficial (presternal) or deep (retrosternal). This classification is of particular value in patients in whom clinical diagnosis is difficult (e.g., patients with minor sternal instability and purulent wound drainage). Needle aspiration of the anterior mediastinal space was employed when a diagnosis of sternal infection was highly suspected but not established by other means (2).

The most common pathogen causing postoperative mediastinal infection remains Staphylococcus (2,16). Gram-negative organism primarily Ecoli, Klebsiella,

Serratia, Proteus, and Enterobacter, are less common etiological agents in the development of mediastinal wound infections. Mixed infections with both Gram-positive and Gram-negative isolates are found in up to 40% of patients (4). Although Bacteroid fragilis has been implicated in at least two cases of mediastinitis, the potential of other anaerobes as primary pathogen remains unknown (2,4,20). Candida species have been cultured occasionally from areas of mediastinal suppuration, but these organisms have proven to be a more common pathogen in the chronic cartilaginous infections (2,21). Continuous assessment of bacterial and fungal agents responsible for these infections is required to adequately manage antimicrobial therapy. Results of aerobic cultures in 17 of our 25 patients were tabulated (Table 5).

It is extremely important to recognize that varying patterns of sternal wound infection exist. Prognosis is best for that group which is recognized and treated at the earliest (usually within one month of sternotomy) and poorest when treatment is delayed beyond this interval (2).

Recognition of involvement of adjacent cartilaginous tissues at an early date and prompt institution of treatment curtails prolonged morbidity. Such involvement is often detected accidentally and, in retrospect, is suggested by a clinical history of pain or tenderness over the involved areas of cartilage. Attention to such physical finding is extremely important since chondritis and late appearing sternal infections are not accompanied by the usual stigmata of systemic illness and are therefore elusive in their clinical presentation.

Several approaches have been described to treat sternal wound infections. These include: (a) debridement, dressing changes, and closure by secondary intention, (b) debridement, sternal reclosure, and closed irrigation, (c) debridement, and immediate or delayed closure with muscle and/or omental flaps (9). Clearly not all infected median sternotomy wounds require aggressive operation. Superficial infections may be treated successfully by adequate drainage, specific parenterally administered antibiotics, local wound care and simple secondary closure. Deeper infections that involve the sternum and anterior mediastinum, however, require exploration and thorough debridement.

The decision to debride or resect the sternum is based on the extent of sternal infection (10). If the infections occur early after sternotomy, sinus tract usually dose not form within the bone, and reopening of the sternotomy wound and debridement of the sternal edges are usually sufficient. In contrast, chronic osteomyelitis frequently manifests with the formation of sinus tract throughout the bone. In such patients, debridement alone is generally inadequate, and resection of all infected bone back to healthy tissue is indicated. Similarly, when costo-chondritis is also encountered, complete removal of all cartilaginous tissue back to adjacent ribs is required (10). If, however, preoperative radiographic studies and operative findings demonstrate extensive cartilaginous or sternal involvement, radical sternectomy is indicated (22).

The open method involves debridement, and open packing of the sternum with healing by secondary intention. Hospitalization has been prolonged, with complete healing reported to take as long as sixteen months. Mortality with the open technique has ranged from 20% to 45% (23).

The technique of debridement and sternal reclosure followed by mediastinal antibiotic irrigation, has been used since Shumaker and Mandelbaum reported two cases in 1963 (6). Postoperatively, the mediastinum was irrigated with a wide variety of preparations including antibiotic or 0.5% Betadine solution. The biggest advantage to the irrigation method was a shortened length of hospitalization. Grossi and co-workers reported a mean hospital stay of 43 days after sternal closure over the irrigating catheter system (16). Sternal closure turned stability to the thoracic cavity and improved pulmonary function. Cosmetic results have also been more pleasing. However, this technique is more successful when there is a soft and pliable mediastinum. Several complications of this technique have been reported. Sternal wounds closed with the irrigation method can create a potentially undrained cavity. Reexploration for a loculated infection has been required in 13% to 66% of patients. Mediastinal catheters have become occluded, with seepage of irrigation solution through the incision, creating management difficulties. Mediastinal catheters have eroded through adjacent tissue, and have resulted in life-threatening hemorrhage. Antibiotic solutions can also predispose to superinfections (23).

Muscle flap closure of sternotomy wound is reserved in most centers for cases of chronic infection or as a substitute to open granulation when closed-catheter irrigation fails to eradicate infection.

Mediastinal reconstruction has utilized 3 flaps: unilateral or bilateral pectoralis major muscle, a rectus abdominis muscle, and the omentum (5,12,13,14). The first choice to obliterate the mediastinal space is the pectoralis major muscle. Frequently both pectoralis major muscles are mobilized. If the epicardium is exposed, the omentum may be transposed to obliterate any pericardial and mediastinal space and cover the heart before transposition of bilateral pectoralis major muscles.

According to Loop and associates, the first line of defence for coverage of the upper two thirds of the mediastinum is selection of one or both pectoralis muscles, however, rectus abdominis muscle flap and omental flap are ideal to cover defect in the lower third of

the mediastinum (3). In our experience, adequate mobilization of bilateral pectoralis major muscle flaps with division of nondominant humeral attachment has been sufficient to cover the mediastinal defect. We used the more versatile pectoralis major muscle in which the humeral attachment is divided, and the vascular pedicle is fully mobilized to cover the lower sternal wound defect. The other pectoralis major muscle was reconstructed to cover the upper sternal wound defect in patient with radical sternectomy. Also, bilateral pectoralis major myocutaneous flap as described by Johnson and associates was used frequently (22). Pairlero and Arnold also preferred to close the lower portion of the wound with skin and subcutaneous tissue after sternectomy rather than the rectus abdominis muscle because recurrences, in their experience, were not related to the lower portion of the wound (24).

Muscle flaps may be applied immediately or after an open period of saline dressing. In Pariolero's experience it is the wound condition, not the time of discovery, that dictates whether muscle transposition should be used (10).

Advantages of using the greater omentum with its angiogenesis factor, and bulk, are offset somewhat by the need for laparotomy, potentially for epigastric hernia, and less stabilizing effect compared with muscle flaps(10).

Mediastinal wound complications may develop in infants and children undergoing complex cardiac and thoracic surgical procedures. Baker and associates recommend the early use of vascularized muscle flaps, particularly the pectoralis major muscle and rectus abdominis, however the dissection of the flaps is more difficult in children (25).

Inadequate debridement is the most important cause of recurrent infection which is mostly present with single or multiple sinus tracts (10). Maddern and associates found that any persistent or recurrent collection beyond the first month on CT scan is suggestive of infection (26).

Table 5. Pathogens isolated in 17 patients with deep infected sternotomy wounds.

Organism	No. of patient
Staph aureus	6
Staph aureus + Enterobacter	1
Staph epidermis	1
Staph epidermis + Pseudomonas	1
Acintobacter	2
Enterobacter	1
Ecoli + Staph epidermis	1
Negative culture	4
Total	17

If clinical and imaging findings are at odds, imaging-directed needle aspiration can help determine whether a fluid collection is infected and in need of further treatment. Recurrent infections often were managed with another muscle transposition in addition to debridement or resection. Most transpositions involved the same pectoralis major muscle in that the previously transposed muscle was remoblized to allow debridement or resection and then retransposed (10).

Measurable impairment of pulmonary function, and the need for mechanical ventilation in the early post-op were reported. However, long term respiratory failure after successful wound healing has been unlikely. Instead, progressive shortness of breath was related more commonly to late cardiac failure (4,22).

CONCLUSION

Deep infection of median sternotomy wound, although infrequent, is serious. Improved surgical techniques and antibiotic prophylaxis have subsequently reduced the incidence of infection to 1% to 2%. The goal of treatment is to debride all infected and avascular tissue and to obliterate dead space. Early diagnosis is crucial to successful treatment of sternal wound infection. If diagnosis can be established within 20 days, 80% of infection can be eradicated by debridement and closed irrigation (25). If diagnosis is delayed, however, prompt debridement and / or resection followed by muscle flaps is the procedure of choice.

REFERENCES

1. Sanfelippo PM, Danielson GK. Complications associated with median sternotomy. J Thorac cardiovas Surg. **63:** 419-423; 1972.

2. Culliford AT et al. Sternal and costochondral infections following open-heart surgery. J Thorac Cardiovas Surg. **72:** 714-725; 1976.

3. Loop FD et al. Sternal wound complications after isolated coronary artery bypass grafting: early and late mortality, morbidity, and cost of care. Ann Thorac Surg. **49:** 179-194; 1990.

4. Sarr MG et al. Mediastinal infection after cardiac surgery. Ann Thorac Surg. **38:** 415-423; 1984.

5. Nahai et al. Primary treatment of the infected sternotomy wound with muscle flaps: a review of 211 consecutive cases. Plast Reconstr Surg. **84:** 434-441; 1989.

6. Shumacker HB, Mandelbaum I. Continuous antibiotic irrigation in the treatment of infection. Arch Surg. **86:** 54-57; 1963.

7. Bryant LR, Spencer FC, Thrinkle JK. Treatment of median sternotomy infection by mediastinal irrigation with an antibiotic irrigation. Ann Surg. **169:** 914-920; 1969.

8. Lee AB, Schimer TG, Shatkin S. Total excision of the sternum and thoracic pedicle transposition of the greater omentum; useful strategems in managing sever mediastinal infection following open heart surgery. Surgery **80:** 433-436; 1976.

9. Jurkiewicz MJ et al. Infected median sternotomy wound: successful treatment by muscle flaps. Ann Surg. **191:** 738-744; 1980.

10. Pairolero PC, Arnold PG. Management of recalcitrant median sternotomy wounds. J Thorac Cardiovas Surg. **88:** 357-364; 1984.

11. Locicero J. Infections of the chest wall. In: Shield TW, ed. General thoracic surgery, 4th Edition. Baltimore: Williams and Wikin; 1994: 559-561.

12. Coleman III JJ, Bostwick J. Rectus abdominis muscle-musculocutaneous flap in chest wall reconstruction. Sur Clin Nor Am. **69:** 1007-1027; 1989.

13. Fix RJ, Vaconez LO. Use of the omentum in chest-wall reconstruction. Sur Clin Nor Am. **69:** 1029-1045; 1989.

14. Tobin GR. Pectoralis major muscle-myocutaneous flap for chest wall reconstruction. Sur Clin Nor Am. **69:** 991-1006; 1989.

15. Kirklin JW, Barratt-Boyes BG. Postoperative care. Infection. In: Kirklin JW. Barratt-Boyes BG, eds. Cardiac surgery, 2nd edition. New York: Churchill and Livingstone; 1993: 224-226

16. Grossi EA et al. A survey of 77 major infectious complication of median sternotomy: a review of 7949 consecutive operative procedures. Ann Thorac Surg. **40:** 214-223; 1985.

17. Goodman LR et al. Complications of median sternotomy: computed tomographic evaluation. A J R. **141:** 225-230; 1983.

18. Kay HR et al. Use of computed tomography to assess mediastinal complications after median sternotomy. Ann Thorac Surg. **36:** 706-714; 1983.

19. Stoney WS et al. Median sternotomy dehiscence. Ann Thorac Surg. **26:** 421-426; 1978.

20. Scully E et al. Comparison between antibiotic irrigation and mobilization of pectoral muscle flaps in treatment of deep sternal infections. J Thorac Cardiovas Surg. **90:** 523-529; 1985.

21. Thomas FE. et al. Candida albicans infection of sternum and costal cartilages: combined operative treatment and drug therapy with 5 - fluorocytosine. Ann Thorac Surg. **23:** 163-166; 1977.

22. Jonhson P et al. Management of chronic sternal osteomyelitis. Ann Thorac Surg. **40:** 69-72; 1985.

23. Johnson JA et al. Delayed primary closure after sternal wound infection. Ann Thorac Surg. **47:** 270-273; 1989.

24. Pairolero PC, Arnolod PG. Harris JB. Long term results of pectoralis major muscle transposition for infected sternotomy wounds. Ann Sur. **213:** 583-590; 1991

25. Backer et al. Vascularized muscle flaps for life-threatening mediastinal wound in children. Ann Thorac Surg. **57:** 797-802; 1994.

26. Maddern IR et al. CT after reconstructive repair of the sternum and chest wall Radiol. **186:** 665; 1993.

27. Ochsner et al. Disruption and infection of the median sternotomy incision. J Cardiovas Surg. **13:** 394-399; 1972.

28. Engelman et al. Mediastintis following open-heart surgery: review of two year experience. Arch Surg. **107:** 772-778; 1973.

29. Thurer et al. The management of mediastinal infection following cardiac surgery. An experience utilizing continuous irrigation with povidone-iodine. J Thorac Cardiovas Surg. **68:** 902-968; 1974.

30. Grmoljez et al. Major complications of median sternotomy. Am J Surg. **130:** 679-681; 1975.

31. Sutherland et al. Postoperative chest wound infections in patients requiring coronary bypass: a controlled study evaluating prophylactic antibiotics. J Thorac Cardiovas Surg. **73:** 944-977; 1977.

32. Jimenez M et al. Anterior mediastinitis as a complication of median sternotomy incisions: diagnostic and surgical considerations. Surg. **67:** 929-934; 1970.

■■