The Heart Surgery Forum #2007-1089
10 (5), 2007 [Epub September 2007]
doi: 10.1532/HSF98.20071089

Online address: http://cardenjennings.metapress.com

Sternal Closure Reinforced with Rib Heads: A Novel Technique for Prevention and Treatment of Sternal Dehiscence

A. Hakan Vural,[1] Serhat Yalçinkaya,[2] Tamer Türk,[1] Alpaslan Öztürk,[3] Mustafa Sezen,[1] Senol Yavuz,[1] Ahmet Özyazıcıoglu[1]

Departments of [1]Cardiovascular Surgery, [2]Thoracic Surgery, and [3]Orthopaedics and Traumatology, Bursa Yüksek Ihtisas Education and Research Hospital 16330 Bursa, Turkey

ABSTRACT

Background. When a sternotomy cannot be performed at the midline and/or there is infection at the operation site, sternotomy revision can cause problems that increase the mortality and morbidity of the patients. There is no agreement on the best treatment method. In this paper we present a modified wiring technique.

Methods. This technique consisted of wrapping wires twice around each rib head and placing standard circumferential wire sutures, thus providing full stability by decreasing the load on the sternum using only steel wires. The study group included 23 patients with sternal dehiscence because of inappropriate sternotomy (n = 10) and/or mediastinitis (n = 13). Two mediastinal tubes were placed for irrigation in 13 patients with mediastinitis and/or wound infection, and mobilization and interposition of omentum as an axial graft was performed in 2 patients. Irrigation and antibiotherapy were continued for 4 to 6 weeks.

Results. Complete wound healing was obtained in all patients. Twenty-two patients treated with this technique survived. One patient died on postoperative 42nd day because of renal insufficiency and multi-organ failure.

Conclusion. Early and aggressive debridement of infected and necrotic tissue, irrigation, and antibiotics are necessary for successful treatment, but we believe that the most important factor is full stabilization of the sternal tissue with minimal use of foreign stabilization material. Despite the limited number of cases, we suggest that our stabilization technique seems to be successful in achieving full stabilization even in infected and fragile sternal bony tissue in patients with sternal dehiscence and/or inappropriate sternotomy

Received April 15, 2007; accepted May 29, 2007.

Correspondence: Dr. A. Hakan Vural, Department of Cardiovascular Surgery, Bursa Yüksek Ihtisas Education and Research Hospital, 16330 Bursa, Turkey; 90-224-3605050; fax: 90-224-3605055 (e-mail: ahvural@gmail.com).

INTRODUCTION

Median sternotomy developed by Julian in 1957 is the preferred approach for cardiac surgery [Julian 1957]. It provides excellent exposure and a wide surgical maneuvering area. Steel wires for sternal closure were first used by Milton [1944]. Since then, median sternotomy and sternotomy closure with steel wires has been the standard approach for the cardiac surgery. Sternal dehiscence and mediastinitis are among the most severe complications of median sternotomy. Predisposing factors of sternal complications include old age, osteoporosis, diabetes, obesity, steroid treatment, reoperation, early postoperative resuscitation, and the use of bilateral internal thoracic arteries [Ottino 1987; Loop 1990].

A secure, stable sternal closure is the most important factor in avoiding these complications. In the case of wound infection or mediastinitis, secure fixation may not be achieved and sternal dehiscence can occur by the wire untwisting or breaking and the wire cutting through the bone [Sharma 2004]. The wire sutures used in sternal closure may result in an unsuccessful revision by dissecting the sternal bony structure that has already lost its characteristics and resistance due to infection. Occasionally sternotomy cannot be performed at the midline, leading to uneven dissection of the bone. Thus, none or few sternal tissues may remain at one side. In such situations the wire sutures may not pull the sternum together, consequently resulting in sternal dehiscence. This situation increases the mortality and morbidity rate as well as prolongs the hospitalization period, decreases the patients' comfort, increases the financial load.

We would like to introduce a new, modified technique for full sternal stability with the support of rib heads by decreasing the load on the sternum and dispersing it uniformly on the ribs and the thoracic cage in patients with mediastinitis and/or inappropriate sternotomy.

METHODS

Patients

Between January 2005 and December 2006, 1317 patients underwent cardiac surgery at our institution and sternal

Table 1. Demographic and Clinical Data*

Male/female	14/9
Sternal dehiscence without infection	10
Wound infection	6
Mediastinitis	7
Risk factors	
Age, y	61 ± 9
Obesity, body mass index ≥30	9
Diabetes mellitus	4
Previous surgery	2
Bilateral internal mammary artery graft	2
Chronic obstructive pulmonary disease	3
Steroid use	1
Postoperative resuscitation	2
Emergency operation	1
Smoking	5
Cross-clamp time, min	64 ± 28
Renal insufficiency	1
Operation	
CABG	16
Off-pump CABG	2
AVR	1
MVR	2
Aortic root replacement	1
Septal defect closure	1

*Data are given as mean ± standard deviation or numbers. CABG indicates coronary artery bypass graft; AVR, aort valve replacement; MVR, mitral valve replacement.

dehiscence developed in 29 patients (2.2%) and all of them were surgically revised. In this study period, 6 patients were revised with modified Robicsek technique and excluded from the study. The remaining 23 patients (9 female and 14 male) with sternal dehiscence and inappropriate sternotomy revised using our technique were included in the study. Thirteen patients were accompanied with wound infection and mediastinitis. This technique was used in all cases of inappropriate sternotomy, osteoporosis, fragile bones, mediastinitis, and morbid obesity. Demographic and clinical data are shown in Table 1. In 4 morbidly obese patients with inappropriate sternotomy, the technique was used during the first operation.

Surgical Technique

The prior median sternotomy incision was reopened completely and all sutures and sternal wires were removed. Rib heads and sternal tissue were mobilized with sharp dissection. Infected and/or necrotic sternal tissue was removed with curettes and rongeurs bilaterally until viable bone was visible. The wound was copiously irrigated with a combination of warm saline and povidone-iodine solution. After the completion of debridement and irrigation, wires were wrapped around rib heads twice in a caudal to cranial direction with No. 5 steel wires (Figure 1A). The same procedure was repeated on the contra-lateral side. A 16 F aspiration tube was placed superiorly for irrigation and a 28 F conventional thoracic drainage tube was placed inferiorly for drainage. Conventional circumferential wire sutures were placed (Figure 1B). Afterward, the free ends of parasternal wires both caudally and cranially were tightened carefully along with circumferential wires (Figure 2).

RESULTS

No sternal closure problem was encountered. The sternum was fixed and solid in all patients. In patients with proven infection, intravenous antibiotics were given for at least 4 weeks with an additional 2 weeks of oral therapy. One patient died due to sepsis and multi-organ failure on the 42nd postoperative day.

The time period between the index operation and reoperation was 16 to 49 days, with a mean of 23.6 days. Blood cultures were positive in 7 cases and wound cultures were positive in 6 cases. Associated microorganisms are shown in Tables 2 and 3. Antibiotics were selected according to blood and wound cultures.

The patients were extubated at an average of 7.3 hours postoperatively (range, 4-21 hours). All patients with

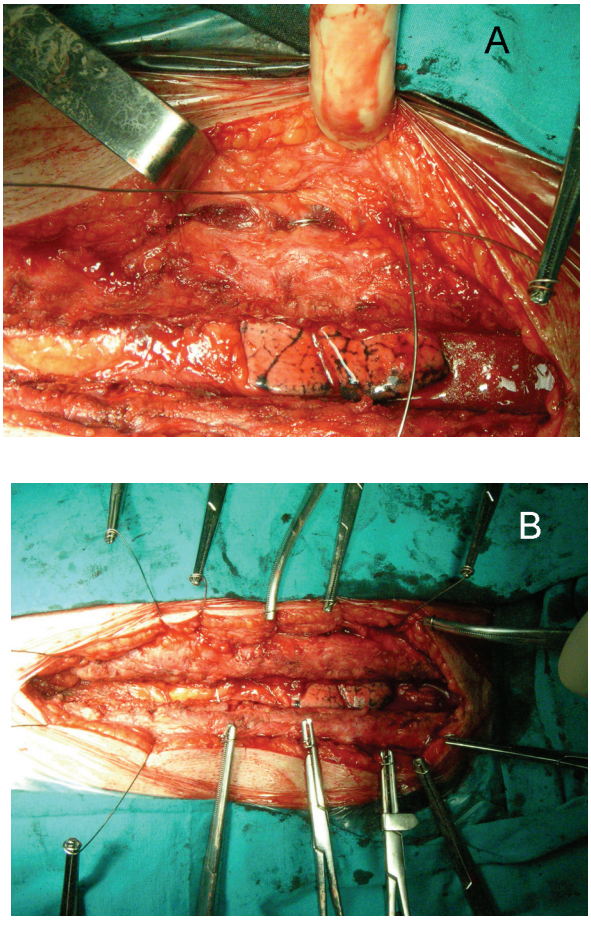

Figure 1. A, Steel wires circled around the rib heads twice in a caudal to cranial direction parasternally on both sides of the sternum. B, Circumferential-placed conventional wire sutures

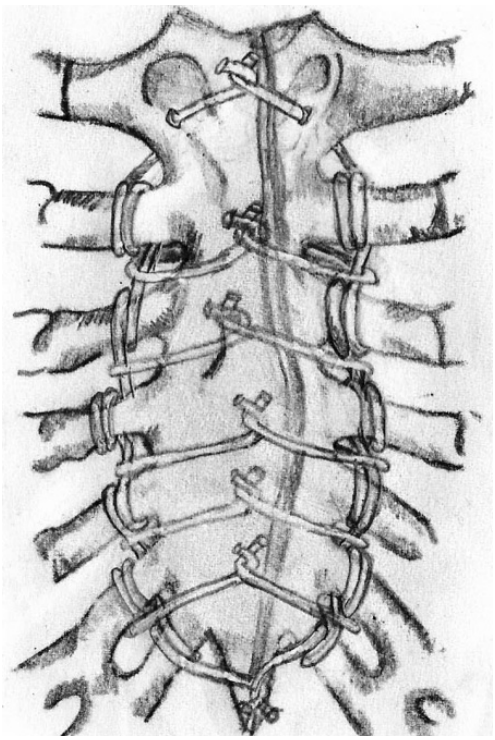

Figure 2. Free ends of parasternal wires were caudally and cranially tightened along with circumferential wires.

mediastinitis were irrigated with 500 mL of saline solution two times a day for 7 to 9 days. Intravenous antibiotics based on culture and sensitivity data were administered for 4 to 6 weeks postoperatively. Mean duration of hospital stay after intervention of sternal closure was 19.7 days (range, 10-48 days).

Omentum mobilization was performed in two cases with wide sternal and soft tissue defects. In the postoperative period there were no intestinal and abdominal problems encountered caused by omentum mobilization.

DISCUSSION

The management of sternal dehiscence is a challenging problem and the choice of treatment method is not yet clear. To prevent this clinic entity, a stable sternal closure is essential as only properly approximated halves heal efficiently. Various techniques with different materials such as wire sutures, nylon bands, plate-screw constructs, and custom-made titanium-H plates with screws have been described with their own advantages and disadvantages [Sanfellipo 1972; Sherman 1988; Di Marco 1989; Tavilla 1991; Hendrickson 1996]. Circumferential wire sutures are used in conventional sternal closure provided that the sternal periosteum is intact and healthy. Achieving sternal stability is very difficult especially in two situations: (1) the presence of infection that naturally impairs bone and causes the wires to smash the sternum, which becomes weaker; and (2) cases with inappropriate sternotomy in which one sternal half mostly becomes less than one fourth of the total width. Robicsek introduced a technique that consisted of placing interlocking steel wires parasternally on both sides and then including them in the usual circumferential wires for the treatment of sternal dehiscence [Robicsek 1977]. They concluded that interlocking wires prevent sternal cuts by circumferential wires. However, we have experienced some stability problems such as stripping of the rib heads leading to dehiscence in cases with poor or insufficient bone mass even though a Robicsek technique was performed.

Table 2. Associated Microorganisms in Blood Cultures

Staphylococcus aureus	4
Acinetobacter baumannii	1
Pseudomonas aeruginosa	1
Mixed	1

Table 3. Results of Wound Cultures

Staphylococcus aureus	3
Acinetobacter baumannii	2
Mixed	1

The bands and custom-made plates have limited availability, may lead to an increase in the cost of surgery, and may it be problematic to implant foreign material in an area with infection and defective wound healing. Drilling the holes to screw the plate in the sternum may actually cause small fractures, especially in thin and osteoporotic sternums, and the fractured segments may act as foci for infection. Besides, when a reoperation is needed, the delay to "unscrew" and remove plates could be potentially catastrophic. All these procedures also add to the cost of surgery. Our technique, on the other hand, leads to maximal stabilization with the use of minimal foreign material insertion.

In cases of mediastinitis, periosteum and bony tissue of sternum cannot withstand the forces applied with any fixation material. The presence of infection affecting bony tissue precludes the application of internal fixation materials such as plate and screw constructs [Gristina 1994; Costerton 1999]. Some of the infectious agents identified in mediastinitis as listed above are high virulence microorganisms. They produce some glycoprotein and glycolipid molecules to form a so-called biofilm that covers the implants and diminishes the antibiotic activity. The treatment of infection in the presence of that biofilm is extremely hard to achieve without removing the membrane and its predisposing materials; eg, titanium plates, etc. [Costerton 1999].

Wire fixation techniques have proven to be more stable than other methods of sternal closure [Cheng 1993]. Still, there may be incidences of sternal wire closure failure due to composite play of forces affecting these sutures that ultimately results in wires cutting through the bones transversely. This

leads to sternal separation because of increased movements between the two halves, increased pain at the sternotomy site, and various respiratory complications. Electromechanical studies using sternal models showed inappropriate sternotomy was the most predominant risk factor for sternal dehiscence. Dispersion of the lateral traction is the most important point in avoiding dehiscence [Zeitani 2006].

The advantage of our technique is that it reinforces the rib heads and thoracic cage to allow a tight closure. These parasternal wires act as a metal "strut" for the transversely placed wires, so that the disrupting forces are distributed over a wider surface of the sternum, rib heads, and thoracic cage. By wrapping the parasternal wire sutures twice in our technique, it seems that stripping from the rib heads is prevented, which rarely can be seen in the Robicsek technique. Because of the parasternal augmentation that we do with wires, circumferential wires cannot cut the sternal tissue. In addition to this, wrapped wires around the rib heads reinforce the sternum and reduce the instability. The knotting of the left and right parasternal wire at the cranial and caudal ends provides an additional support mechanism with two extra transversely supporting wires along with the 5 transverse wires. This modified technique was successfully used for the prevention of sternal wound complications in patients with sternal dehiscence.

We conclude that early results of our technique of parasternal wires placement indicate that it is a safe and easily reproducible method for prevention and treatment of sternal dehiscence. We therefore recommend this technique for sternal closure in patients who are at high risk for sternal wound complications and also in patients who undergo reoperation for sternal dehiscence.

REFERENCES

Cheng W, Cameron DE, Warden KE, Fonger JD, Gott VL. 1993. Biomechanical study of sternal wire techniques. Ann Thorac Surg 55:737-40.

Costerton JW, Stewart PS, Greenberg EP. 1999. Bacterial biofilms: a common cause of persistent infections. Science 21;284:1318-22.

Di Marco RF, Lee MW, Bekoe S, Grant KJ, Woelfel GF, Pellegrini RV. 1989. Interlocking figure-of-8 closure of the sternum. Ann Thorac Surg 47:927-9.

Gristina AG, Shibata Y, Giridhar G, Kreger A, Myrvik QN. 1994. The glycocalyx, biofilm, microbes, and resistant infection. Semin Arthroplasty 5:160-70.

Hendrickson SC, Koger KE, Morea CJ, Aponte RL, Smith PK, Levin LS. 1996. Sternal plating for the treatment of sternal nonunion. Ann Thorac Surg 62:512-18.

Julian OC, Lopez-Bellio M, Dye WS, Javid H, Grove J. 1957. The median sternal incision in cardiac surgery with extracorporeal circulation: a general evolution of its use in heart surgery. Surgery 42:753-61.

Loop FD, Lyttle BW, Cosgrove DM, et al. 1990. Sternal wound complications after isolated coronary artery bypass grafting: early and late mortality, morbidity and cost of care. Ann Thorac Surg 49:179-87.

Milton AF. 1944. Tradata de teccura operatoria generally especial. Barcelona: Editorial Labor 4:756-60.

Ottino G, De Paulis R, Passini S, et al. 1987. Major sternal wound infection after open heart surgery: a multivariate analysis of risk factors in 2,579 consecutive operative procedures. Ann Thorac Surg 44:173-9.

Robicsek F, Daugherty HK, Cook JW. 1977. The prevention and treatment of sternum separation following open heart surgery. J Thorac Cardiovasc Surg 73:267-8.

Sanfellipo PM, Danielson GK. 1972. Nylon bands for closure of median sternotomy closure of median sternotomy incisions. Ann Thorac Surg 13:404-6.

Sharma R, Puri D, Panigrahi BP, Virdi IS. 2004. A modified parasternal wire technique for prevention and treatment of sternal dehiscence. Ann Thorac Surg 77:210-3.

Sherman JE, Salzberg A, Raskin NM, Beattie EJ. 1988. Chest wall stabilization using plate fixation. Ann Thorac Surg 46:467-9.

Tavilla G, van Son JAM, Verhagen AF, Lacquet LK. 1991. Modified Robiscek technique for complicated sternal closure. Ann Thorac Surg 52:1179-80.

Zeitani J, Penta de Peppo A, Moscarelli M, et al. 2006. Influence of sternal size and inadvertent paramedian sternotomy on stability of the closure site: a clinical and mechanical study. J Thorac Cardiovasc Surg 132:38-42.