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Results of Omental Flap Transposition for Deep Sternal Wound Infection After Cardiovascular Surgery

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Objective
Our experience with omental flap transposition in the treatment of deep sternal wound infections is reviewed here with an emphasis on efficacy, risk factors for in-hospital mortality rates, and long-term results.

Summary Background Data
Even with improvements in muscle and omental flap transposition, the timing of closure and the surgical strategy are controversial.

Methods
Forty-four consecutive patients with deep sternal wound infections were treated using the omental flap transposition from 1985 through 1994. The strategies included debridement with delayed omental flap transposition or single-stage management, which consisted of debridement of the sternal wound and omental flap transposition. Methicillin-resistant *Staphylococcus aureus* was cultured from more than 50% of the wounds. A logistic regression analysis was used to identify the predictors of in-hospital death after omental flap transposition.

Results
There were seven (16%) in-hospital deaths. Univariate analysis demonstrated that hemodialysis and ventilatory support at the time of omental flap transposition were significantly associated with in-hospital mortality rates ($p = 0.0023$ and $p = 0.0075$, respectively). Thirty-seven patients whose wounds healed well were discharged from the hospital. Two patients with cultures positive for methicillin-resistant *Staphylococcus aureus* had recurrent sternal infections. Patients without positive methicillin-resistant *Staphylococcus aureus* cultures had good long-term results after reconstructive surgery.

Conclusions
Transposition of an omental flap is a reliable option in the treatment of deep sternal wound infections, unless the patients require ventilatory support or hemodialysis at the time of transposition.

Sternal wound complications after open cardiac surgery are a significant problem. Reported mediastinal and sternal infection rates after cardiac surgery range from 0.4% to 5.1%.[1–4] Subsequent sepsis or seeding of prosthetic valves, grafts, or suture lines can be life-threatening. Because it was first reported in 1980 by Jurkiewicz et al.,[5] aggressive treatment such as myocutaneous flap reconstruction has contributed to the improvements in the treatment of sternal wound infections. The omentum is a mobile structure that has been labelled the "policeman of the abdomen" because it has remarkable powers to repair through cellular proliferation, fibrous tissue formation, and adhesions.[6] Therefore, it has been used in the management of a variety of intraabdominal and cardiothoracic problems.[7] Despite the improvements in the mortality rate, which has resulted from the advances in reconstructive surgery, there are many controversies in the treatment of deep sternal wound infections with omental flap transposition. The increase in the number of diabetic, elderly, and critically ill patients, and the prevalence of methicillin-resisitant *Staphylococcus aureus* (MRSA), has made it difficult to achieve a good result in the treatment of this disease.[8] In addition, the proper timing of surgical intervention for sternal wound infections has remained a difficult clinical decision because major recon-

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Table 1. OPERATION PRECEDING DEEP STERNAL WOUND INFECTION

Procedure	Number
Coronary artery bypass grafting	20
Coronary artery bypass grafting and valve replacement	11
Prosthetic graft replacement	8
Mitral valve reconstruction	2
Prosthetic valve replacement	1
Ruptured Valsalva sinus aneurysm repair	1
Pulmonary embolectomy	1
Total	44

structive surgery does not always result in complete wound healing in the presence of active infection.

This article presents our experience in treating deep sternal wound infections while using the transposition of omental flaps, which has been superior in ability of defense against pathogens to muscle flaps.[9]

MATERIALS AND METHODS

Between July 1984 and June 1994, 47 consecutive patients with deep sternal wound infections were treated at our institution. This represented 2.3% of the 1958 cardiovascular procedures performed during this time period. Sternal wound infections were more common during the last 5 years than in the period from 1985 to 1989. During the last 5 years, MRSA has been remarkably prevalent in Japan. In addition, the number of patients in high-risk categories also has increased. Transposition of omentum was the primary treatment option for deep sternal infections. There were three patients who were excluded from this study; two who had previous gastrectomys underwent pectoralis major muscle flap transfers, and one who had coronary artery bypass grafting using the gastroepiploic artery.

The hospital records of the 44 patients were retrospectively reviewed. The average patient age was 60 ± 5 years (range, 20 to 75 years). Thirty-three patients were men, and 11 patients were women. There were five patients under treatment for diabetes mellitus and four in cardiogenic shock caused by acute coronary occlusion or hemorrhagic shock because of a ruptured aortic aneurysm before the initial cardiovascular surgery.

Median sternotomy was performed for cardiac disease in 36 patients and for aortic disease in 8 patients (Table 1). Extracardiac grafts (aortic tube grafts or saphenous vein and internal thoracic artery grafts) were used in 39 patients. Twenty patients required prolonged cardiopulmonary bypass time (more than 4 hours) because of a difficult intracardiac repair, severe bleeding from the suture lines, or left ventricular dysfunction. Native pericardial closure was possible in 18 patients. In the remaining patients, the pericardium was left open.

In all patients, prophylactic antibiotic therapy (cephalothin sodium) was routinely administered during the cardiopulmonary bypass and for the following 5 days thereafter. After the primary cardiovascular surgical procedure, 14 patients could not be weaned from the ventilator until the omental flap transposition because of cardiopulmonary failure. Seven patients had low output syndrome (defined as a cardiac index less than 2.0L/ min per uç or the need for intraaortic balloon counterpulsation). There were 5 patients who required a hemodialysis for acute renal failure (blood urea nitrogen ≥100 mg/dL and serum creatinine ≥5.0 mg/dL, or oliguria).

The variables studied included the time from the primary surgery to the onset of the deep sternal wound infection and the time from the initial surgery to the omental flap transposition.

Deep sternal wound infections were defined as osteomyelitis and retrosternal space involvement. All patients had purulent discharge from the sternal incision, persistent fever (≥38°C), sternal instability, and local pain. A laboratory examination revealed leukocytosis. Once a mediastinal infection became evident, appropriate antibiotics that were bactericidal to the organisms causing the infection were administered based on culture and sensitivity results.

In the early period (from 1985 through 1990), the patients were treated by open drainage with removal of wires and excision of necrotic tissue, daily dressing changes, and irrigation with dilute povidone-iodine solution, followed by a delayed closure with an omental flap. An omental flap transposition was attempted when the wound appeared clean, and the infection was thought to be under control. Since 1991, most of the patients underwent a single-stage procedure, which consisted of a thorough debridement and immediate closure with an omental flap within 3 days of the definitive diagnosis of deep sternal wound infection.[10]

The transposition of the omental flap was performed as follows. If simultaneous debridement was performed, the necrotic tissue was excised and the sternum was cut back to the actively bleeding tissue. The mediastinal wound was then irrigated with 3L of dilute povidone-iodine solution. A short upper midline incision was made from the previous sternotomy wound to the upper part of the abdomen. An omental pedicle was fully mobilized on the gastroepiploic artery by dividing the branches to the greater curvature of the stomach. The pedicle was brought up through a small incision in the diaphragm, placed on the mediastinum, and tacked in place. The sternum was not rewired. As our experience evolved, the skin and subcutaneous tissues were primarily closed over the omental flap without the need for skin grafting. Subcutaneous drains were placed.

In-hospital death was defined as death before hospital discharge regardless of the duration of hospitalization. The follow-up of hospital survivors was completed by direct contact with all of the patients and their family physicians. Hospital survivors were followed for a median of 48 months (range, 27 to 145 months).

Table 2. PATHOGENS IDENTIFIED IN 44 PATIENTS

	Number
Staphylococcus aureus (methicillin-resistant)	25
Pseudomonas aeruginosa	6
Staphylococcus epidermis	5
Enterobacter	3
Staphylococcus aureus (methicillin-susceptive)	3
Escherichia coli	2
Negative	3

Statistical Analysis

Results are reported as the mean ± the standard deviation. All data were analyzed with the Statistical Analysis System program (PC-SAS; SAS Institute, Cary, NC). Univariate logistic regression analysis was performed for the variables that were significantly related to the outcomes. The comparisons were made with Fisher's exact test and with Student's t test, as appropriate. The analysis was considered significant at a p value of less than or equal to 0.05. A multivariate analysis was not performed because of the small sample size.

RESULTS

The diagnosis of deep sternal wound infection was confirmed at 17 ± 10 days (range, 7 to 44 days) after the preceding surgery. Tissue cultures, which were obtained in all patients, were positive in 41 cases. A single organism was identified in 39 patients. There were two organisms in three patients. Culture results were negative in three patients, mainly because antibiotics were administered after the appearance of high fevers, and before the diagnosis of deep sternal wound infections. The pathogens cultured included MRSA, methicillin-susceptive *Staphylococcus aureus, Pseudomonas aeruginosa,* and other organisms (Table 2).

The omental flap transposition was performed 26 ± 14 days (range, 8 to 139 days) after the initial surery. Simultaneous debridement and omental flap transpositions were performed in 24 patients. All of the patients who did not require ventilatory support before the omental flap transposition were extubated on the evening of the surgery.

There were seven (16%) in-hospital deaths. Of these, six had uncontrolled infections, sepsis, and multiple organ failure. The remaining patient had undergone aortic valve replacement and had a massive hemorrhage from the aortic suture line. The interval between the second surgery and death was 10 ± 8 days (range, 4 to 42 days). Of the patients who had died, six had undergone a single stage procedure and one had undergone a two-stage surgery. This difference was not statistically significant. There was no evidence of peritonitis or intraabdominal abscess in the patients who had died in the hospital. There were 37 patients whose wounds had healed and these patients were discharged from the hospital. Recurrent infections occurred in two patients who had positive MRSA cultures. One patient had a purulent discharge from the lower edge of the sternal wound 2 months after discharge and after being successfully treated with antibiotics. However, this patient underwent another operation for a pseudoaneurysm of the ascending aorta 6 years after the omental flap transposition. In the other patient, a superficial wound infection developed 8 months after discharge, which was treated with local wound care. Three late deaths related to heart failure occurred at 12, 18, and 96 months, respectively, after the omental flap transpositions. No complications associated with the omental flap transpositions (peritoneal contamination, herniation, or gastric traction) were noted among the survivors. No limitations were noted because of the reconstructive surgery. When examined using an univariate logistic regression analysis, hemodialysis, and ventilatory support were predictors of hospital death after omental flap transposition ($p = 0.0023$ and $p = 0.0075$, respectively) (Table 3).

Although MRSA, a cause that can easily produce acute infectious endocarditis and widespread metastatic abscesses,[11] did not increase the hospital mortality rate after the treatment of deep sternal wound infections, it did affect the mortality and late recurrent rates, compared with other pathogens (Figure 1).

DISCUSSION

Ten years ago we used the closed irrigation technique for deep sternal wound infections.[12] This technique was often complicated by a life-threatening hemorrhage from a partial

Table 3. UNIVARIATE LOGISTIC REGRESSION ANALYSIS OF VARIABLES ASSOCIATED WITH IN-HOSPITAL DEATH

Variable	p Value	Odds Ratio	95% Confidence Interval
Age	0.1181	1.1309	0.96923–1.3190
Diabetes mellitus	0.2279	3.2999	0.47393–22.9770
Preoperative shock	0.0792	6.9999	0.79727–61.4590
Prolonged CPB	0.5016	1.7500	0.34215–8.9500
Pericardial closure	0.4020	0.4706	0.08075–2.7420
Hemodialysis	0.0023	48.0000	3.98833–577.6850
Ventilatory support	0.0075	21.7497	2.27655–207.7930
MRSA	0.1238	5.6843	0.62168–51.9740
Onset of infection	0.9826	0.9992	0.92929–1.0740
Duration	0.2930	0.9611	0.89245–1.0350
Operative procedure	0.8408	1.2000	0.20266–7.1050
Single stage	0.1021	0.1579	0.01727–1.4440

CPB = cardiopulmonary bypass; MRSA = methicillin-resistant *Staphylococcus aureus;* Duration = duration from onset to omental flap transposition; Operative procedure = coronary bypass surgery or vascular graft implant.

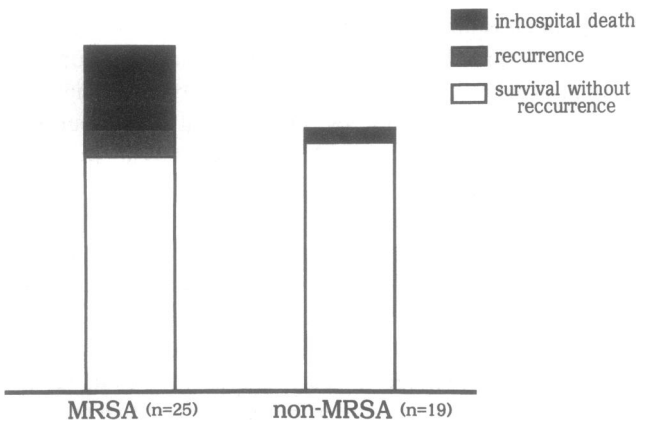

Figure 1. The follow-up period was 44 ± 36 months in the methicillin-resistant *Staphylococcus aureus* group (MRSA), and 48 ± 20 months in the nonMRSA group respectively. The differences between the groups with respect to follow-up period is not significant. Long-term outcome including recurrence and survival were significantly poor in the MRSA group ($p < 0.05$).

disruption of the suture line or formation of a pseudoaneurysm. Advances in the management of sternal wound infections over the past 2 decades have significantly reduced the morbidity and mortality rates associated with this complication. Early diagnosis of sternal wound infections and muscle or omental flap coverage are cornerstones in the treatment of this disease. Furthermore, a single-stage procedure may reduce the length of hospitalization.[10] In fact, compared with closed-catheter irrigation, flap closure has been shown to result in a marked decrease in the mortality rate and a diminished length of hospitalization after treatment. However, despite the application of the transposition of muscle or omentum, the mortality rate of deep sternal wound infection has remained relatively high. This fact may be based on the increase in the number of patients with high-risk categories.

We have used omental flap transposition in the treatment of deep sternal wound infections for the last 10 years. Since the omentum contains a rich vascular and lymphatic supply and induces neovascularity, its efficacy is expected to be superior to the muscle flap.[6,9,13] Omental flaps are often used to protect the vascular prosthesis in retrosternal infections after aortic surgery and to manage the bleeding from right ventricular rupture because of severe mediastinitis.[14–16] However, in the treatment of deep sternal wound infections, the efficacy of omental flap transposition and the influence of perioperative risk factors associated with both the initial cardiovascular surgery and with the transposition on the prognosis have not been reported for a large series of patients.

In this study, excellent results occurred with respect to both in-hospital and long-term outcomes. Our results are superior to those obtained with muscle flaps.[17] However, hemodialysis and ventilatory support at the time of omental flap transposition were predictors of in-hospital death. As previously indicated, these factors are in themselves risk factors for mortality in cardiac surgery.[18,19]

Poor nutritional reserves, hypoproteinemia, anemia, and the overall condition in the immediate postoperative period after cardiac surgery all effect wound healing. Ivert et al.[20] have reported that the severe mediastinitis, combined with cardiac and renal failure, was implicated in 30% of in-hospital mortality. Grossi[21] also reported that poor results in the treatment of sternal wound infections were associated with elevated serum blood urea nitrogen concentrations. The complex problems of postoperative sepsis, massive transfusion, prolonged cardiopulmonary bypass, hemodynamic instability, and suppressed muscular capacity for respiration associated with the initial surgery, may interfere with weaning from the ventilator. Although transposition of an omental flap is a reliable option in the treatment of deep sternal wound infections, patients with renal failure and ventilator dependence may have an unfavorable outcome. This suggests that these patients should undergo debridement alone to minimize the surgical stress as soon as the diagnosis of deep sternal wound infection is confirmed. All exposed foreign bodies, including wire, felt pledgets, and sutures, if possible, must be removed. Inadequate and limited debridement is a major cause of recurrent infection and hemorrhagic complications. Mediastinal irrigation with saline or antibiotic solutions should then be continued under strict sterile techniques. Reconstruction of the open mediastinum must be postponed until the exudate is reduced markedly and the infection is brought under control. In critically ill patients, a single-stage procedure may result in a poor outcome.

Appropriate timing of the surgical intervention for deep sternal wound infections remains a difficult decision. Ideally, patients should be treated with antibiotics and be free of infection at the time of the second surgery. However, this must be weighed against the average interval from the onset of the infection to the catastrophic events caused by the infection such as a rupture of a bypass graft or an anastomotic site, systemic sepsis, or prosthetic endocarditis. From our study, immediate debridement and chest closure with an omental flap may result in an uneventful clinical course if the patient is not dependent on ventilatory support or hemodialysis.

Although the initial surgical procedure and complete pericardial closure were not related to the outcome of the treatment of sternal wound infections, the number of patients undergoing aortic surgery was so small in this series that this should be interpreted cautiously. If the mediastinitis extends to underlying structures, particularly to an implanted aortic prosthesis, the risks may increase.[3]

Methicillin-resistant *Staphylococcus aureus* was not a statistically significant independent risk factor, but a follow-up demonstrated that it was difficult to eradicate. *Staphylococcus aureus* bacteria contain biochemical machinery, which enables the bacteria to infect rapidly and invade through minor breaks in the skin and mucous membranes. Recently, strains of

MRSA have become increasingly prevalent as nosocomial pathogens, which often result in a significant increase in morbidity and mortality rates in patients who have surgery.[22] Our experience is consistent with these reports.

In conclusion, the transposition of omentum can have good long-term results in patients with deep sternal wound infections. However, in patients who require hemodialysis or ventilatory support, immediate and radical debridement followed by mediastinal irrigation should be optioned, and closure with omental flap transposition should postponed until the wound appears relatively clean.

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