Successful treatment of deep sternal infections following open heart surgery by bilateral pectoralis major flaps

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Abstract

Objective: Severe sternum necrosis requiring extended resection necessitates plastic reconstruction of the resulting defect and stabilization of the chest. We analyzed the outcome of patients undergoing bilateral pectoralis major flap repair on functional and cosmetic results, chest stabilization and pulmonary function. Methods: Twelve patients undergoing cardiac surgery between 1997 and 2001 suffered from a deep mediastinal wound infection and sternum necrosis. After a mean of two attempts of extensive wound debridement, all 12 patients underwent complete sternal resection with plastic reconstruction by bilateral pectoralis major flaps. Risk factors were obesity (n = 10) and diabetes (n = 11). Six months postoperatively patients underwent physical examination, pulmonary function testing and functional CT scan. Results: Three patients died in hospital (two septic multorgan failure, one heart failure) and nine were discharged with complete wound closure. One patient suffered a lethal stroke during follow-up. At 6-month follow-up no recurrent sternum infection had occurred. Chest stability was satisfactory without impairment of pulmonary function (VC 77.5 ± 12.1% at follow-up vs 77.8 ± 12.5% preoperatively). Mobility and force of arms and shoulder were adequate; at CT scan the maximum distance change between the former sternoclavicular joint in inspiration versus expiration was minimal. Quality of life questionnaires showed no significant limitations except a disturbed sleep and mild restriction of executing hobbies and social activities. Conclusions: Bilateral pectoralis major flap repair is a safe technique to cure severe mediastinitis necessitating complete sternal resection. Wounds close without extensive reconstructive surgery. Cosmetic results as well as stabilization of the chest were good. Patients reported an almost uncompromised quality of life without respiratory impairment.

Keywords: Open heart surgery; Sternum infection; Wound treatment; Pectoralis flaps

1. Introduction

Wound infection following median sternotomy represents a serious problem in open heart surgery. It occurs in approximately 0.8–8% of all operations [1–3] and contributes significantly to morbidity and mortality [4,5].

Various risk factors for development of wound complications have been reported including diabetes [6], bilateral harvesting of the internal mammary artery [7], obesity [8], corticosteroid treatment [9] and prolonged procedural times [10]. Also prolonged postoperative mechanical ventilation and pulmonary infection increase the risk of a mediastinal infection [11].

Mortality after deep sternal wound infection has been reported up to 70% [13], although more recent reports showed significant improvement of the prognosis with a mortality between 5 and 10% [5]. Standard treatment of deep wound infections has not changed during the recent 25 years.

The key demands for an optimal treatment of this serious and necrotizing infection are control of infection by debridement, antibiotics and open packing or irrigation, chest stabilization to allow early spontaneous breathing, wound closure in reasonable time and with acceptable cosmetic and functional result.

Not surprisingly for such a complex situation, many therapeutic options and combinations exist spanning from open wound treatment to early closure with irrigation and reconstruction with flaps. In more extensive infection,
additional plastic surgery \cite{14}, omental transfer \cite{15} and vacuum sealing \cite{12} have been used. Various techniques to mobilize vascularized flaps from pectoralis major, latissimus dorsi and rectus abdominis muscles have been described \cite{14,16–18}. We adopted the bilateral pectoralis flap repair from our plastic surgeons, who used it for reconstruction after sternal resections for malignancies and more recently for sternal infections. This technique can be easily adopted as it does not raise pedicled flaps, provides a sufficient early chest stability and reduces the remaining wound size enabling further treatment with vacuum sealing.

The following study investigates the outcome of patients suffering from deep wound infection with sternum necrosis, in which complete sternum resection and plastic reconstruction of the resulting defect with bilateral pectoralis major flaps had to be performed. We were particularly interested in late functional results to evaluate the impact on pulmonary function, chest stability, shoulder and arm force, mobility and cosmetic result.

2. Methods

Out of 6000 patients, 174 (2.9\%) undergoing cardiovascular surgery through a median sternotomy at our department from 1997 to 2001 suffered from sternal wound complications being superficial \((n = 112, 1.9\%)\) or deep infections \((n = 62, 1.0\%)\). Twelve patients \((0.2\%)\) experienced a severe sternal wound infection with consecutive sternum necrosis requiring complete sternum resection and plastic reconstruction. Seven patients were female and five male; mean age was 70.4 ± 6.9 years. Mean height was 168.8 ± 7.5 cm and body weight 79.4 ± 14.6 kg.

As risk factors for deep wound infection, diabetes was present in all cases but one (nine patients were insulin-dependent, two patients were treated with oral antidiabetics), bilateral IMA harvesting had been performed in two patients (16\%). Body mass index (BMI) was 28 ± 5.8. BMI graduation revealed that two patients had normal weight, six were overweight, three had obesity and one patient had severe obesity.

Ten patients underwent coronary artery bypass grafting, one patient had an aortic valve replacement, and one patient was operated for acute type A dissection. All patients were operated on-pump and developed deep wound infection including sternum osteitis. The isolated bacteria are summarized in Table 1. Antibiotic treatment consisted of resistance-adapted treatment with a mean of 2.2 ± 0.4 different antibiotics including cephalosporines, meropenem, gentamicin, vancomycin and teicoplanine. A mean of two attempts of local wound debridement and sternal stabilization in the patients were performed prior to complete resection of the necrotic sternum and reconstruction of the resulting defect by bilateral pectoralis major flaps. The first operation had been local irrigation with saline solution in all patients, the second deep wound debridement \((n = 8)\) and resection of partial sternum \((n = 2)\). In two patients wound debridement and open packing was performed first to control ongoing and expanding soft tissue necrosis.

3. Technique

All infected and necrotic tissue, bone and cartilage were resected. In most patients a strong layer of tissue has developed in the anterior mediastinum and posterior to the sternum. Frequently costal cartilage was found to be necrotic especially after attempts of sternal refixation with Robiczek type of longitudinal wiring. Wounds were then cleaned and rinsed with hydrogen peroxide. The reconstruction started by mobilizing the left pectoral muscle from the chest wall and subcutaneous tissue to a distance of about 10 cm from the median line (Fig. 1). Then the humeral attachment of the left pectoral muscle was cut through an incision in the deltoideopectoral groove. After dissection of the muscle from its caudal edge and from the boundary to the rectus abdominis muscle, the flap could be mobilized to reach the right edge of the sternal defect. The right pectoral muscle was then mobilized without cutting the humeral attachment to guarantee sufficient mobility of the arm.

![Fig. 1. Isolation of the left pectoral muscle from the osseous thorax and the subcutaneous tissue to a distance of approximately 10 cm from the median line.](https://academic.oup.com/ejcts/article-abstract/25/2/218/365224)
After complete mobilization of both pectoral muscles, the left flap was fixed to the resection line of the right sternum and cartilage using single stitches with resorbable suture (Fig. 2). The right pectoral muscle was then pulled to the left side to overlap the left pectoral muscle and sewn to the fascia of the left flap. Overlapping of the muscles in the median line required bilateral mobilization, but guaranteed additional stability in comparison to adaptation of the muscles. After insertion of mediastinal and subcutaneous drains subcutis and skin were closed by single stitches. If complete wound closure could not be achieved, vacuum sealing of the remaining defect was performed.

Time between open heart surgery and pectoralis flap plastic was 28 ± 11 days. Surviving patients had a median demand of ventilation of 10 ± 18 days. Mean stay on ICU following plastic surgery was 12 ± 22 days. Wound healing was achieved after a mean of 12 ± 7 days. A follow-up evaluation of all patients was performed 6 months postoperatively. The patients were physically examined with respect to wound healing and cosmetics, shoulder and arm mobility as well as muscular strength assessed by physical examination. Ventricular function was controlled by transthoracic echocardiography; blood gas analysis and respiratory function tests were performed. The results were compared to the preoperative values. For evaluation of chest stability additional to the physical examination a chest CT scan was done in maximum inspiration with the arms lifted above the head compared to a scan in maximum expiration and with the arms close to the body. The distance of the former sternoclavicular joint was measured in both situations and considered as a marker for chest stability following complete sternal resection.

Quality of life was assessed using the Nottingham Health Score profile [19]. The patients were asked to describe and graduate their energy level, discomfort and pain, emotion, quality and amount of sleep, social contacts and mobility. Evaluation of the answers led to a quality of life score ranging from 0 to 100 (0, no limitation; 100, maximum limitation).

4. Results

In all patients bilateral pectoral muscle flaps could be mobilized sufficiently to cover and stabilize the defect created by wound debridement. Hospital mortality was 25% (3 of 12 patients) due to septic multiorgan failure related to a severe pneumonia rather than wound infection ($n = 2$) and heart failure ($n = 1$), nine patients could be discharged and were treated in rehabilitation units.

One patient died from stroke during follow-up. All the remaining eight patients were examined at follow-up 6 months later. The results of echocardiography, blood gas analysis and respiratory function tests are listed in Table 2 demonstrating an improved cardiac function compared to preoperative values and no impairment in pulmonary function.

Examination of arm and shoulder mobility did not reveal any significant impairment. Muscular strength was unchanged except adduction of the left arm.

The CT scan examination of the former sternoclavicular joint demonstrated sufficient stability with mean differences of $1.76 \pm 1.3$ cm between maximum inspiration with the arms being elevated and maximum expiration with the arms close to the body (Fig. 3).

Regarding cosmetics we found satisfactory results with complete wound closure in all eight patients (Fig. 4).

Quality of life evaluated by Nottingham Health Score questionnaires demonstrated no significant discomfort in daily life and no consecutive impairments except a moderately disturbed sleep (Table 3). However, a detailed analysis of the Nottingham Health Score profile questionnaire showed that the study patients perceived an impairment of executing their hobbies and social activities.

Table 2

<table>
<thead>
<tr>
<th></th>
<th>$n = 8$</th>
<th>Preoperative values</th>
<th>6 months post-OP</th>
<th>$P$</th>
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<tbody>
<tr>
<td>EF (%)</td>
<td></td>
<td>45.7 (± 6.7)</td>
<td>53.2 (± 8.1)</td>
<td>0.018</td>
</tr>
<tr>
<td>VC (% of normal)</td>
<td></td>
<td>77.5 (± 12.1)</td>
<td>77.8 (± 12.5)</td>
<td>0.437</td>
</tr>
<tr>
<td>FEV1 (% of normal)</td>
<td></td>
<td>68.6 (± 13.4)</td>
<td>70.0 (± 15.4)</td>
<td>0.333</td>
</tr>
<tr>
<td>PO2 (mmHg)</td>
<td></td>
<td>74.1 (± 6.7)</td>
<td>74.8 (± 6.6)</td>
<td>0.368</td>
</tr>
<tr>
<td>PCO2 (mmHg)</td>
<td></td>
<td>44.2 (± 20.1)</td>
<td>44.6 (± 20.2)</td>
<td>0.206</td>
</tr>
</tbody>
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EF, ejection fraction measured by echocardiography; VC, vital capacity; FEV1, one second forced expiration capacity; PO2, oxygen partial pressure; PCO2, carbon dioxide partial pressure.
5. Conclusions

Severe postoperative sternal wound infection following median sternotomy represents a rare but serious complication in open heart surgery requiring prolonged hospitalization. The incidence of a severe sternum osteitis requiring sternum resection and additional plastic surgery was 0.2% in our patient population, which was comparable to the experience reported in other centers [1–3].

Commonly accepted risk factors for development of sternal wound complications are diabetes, obesity, use of corticosteroids or immuno-suppressive medication. In our patients diabetes was present in all patients and obesity in 10 out of the 12.

Operative debridement followed by sternum closure over irrigation catheters has become the standard procedure for mediastinitis following open heart surgery. However, need for reoperation due to persistent infection ranged from 13 to 66% [9,13] especially if sternum osteitis is present. Numerous approaches have been described to treat sternal necrosis including extensive debridement of necrotic tissue combined with open wound treatment and delayed closure. Wound healing times of up to 16 months have been reported with these methods [2] and mortality rates were as high as 46% [9].

Sternal resection combined with plastic surgery using mobilized flaps and vacuum sealing led to further improvement in patient outcome [12]. The greater omentum as well-vascularized tissue was transplanted into the sternal defect [14,17], its immunological properties further accelerated wound healing. This procedure, however, requires laparotomy, which can lead to additional complications especially in septic and critically ill patients. On the other hand it does not improve sternal stability and frequently necessitates skin transfer. Another option is the transfer of the rectus abdominis muscle, but this technique requires extensive dissection and may result in postoperative abdominal hernia formation [20]. The previous use of mammary arteries may compromise blood supply, and substernal chest tube placement at the primary operation commonly affects the rectus abdominis muscles and may impair the results of the muscle transfer. The use of latissimus dorsi muscle flaps for coverage of the wound defect and chest stabilization is limited by the required large incisions and the resulting

Table 3
Results of the Nottingham Hill score assessing quality of life

<table>
<thead>
<tr>
<th></th>
<th>Result</th>
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<tbody>
<tr>
<td>Energy</td>
<td>Mean 38.6 (±36.4)</td>
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<tr>
<td></td>
<td>Median 12</td>
</tr>
<tr>
<td>Pain</td>
<td>Mean 10.2 (±8.32)</td>
</tr>
<tr>
<td></td>
<td>Median 9.47</td>
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<tr>
<td>Emotion</td>
<td>Mean 15.79 (±19.1)</td>
</tr>
<tr>
<td></td>
<td>Median 10.47</td>
</tr>
<tr>
<td>Sleep</td>
<td>Mean 48.43 (±19.38)</td>
</tr>
<tr>
<td></td>
<td>Median 50.37</td>
</tr>
<tr>
<td>Social contact</td>
<td>Mean 7.56 (±15.95)</td>
</tr>
<tr>
<td></td>
<td>Median 0</td>
</tr>
<tr>
<td>Mobility</td>
<td>Mean 25.56 (±11.1)</td>
</tr>
<tr>
<td></td>
<td>Median 27.12</td>
</tr>
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0, no limitation compared to normal; 100, maximum limitation compared to normal.
functional impairment [20]. Therefore, the pectoralis major flap has gained increasing acceptance in plastic surgery, if stabilization of the chest and coverage of a severely infected sternal wound defect is required [21].

Many different techniques of dissecting, mobilizing and transferring the pectoral muscle have been suggested [22,23]. Our technique of roofing tile like overlapping bilateral muscle flaps allowed a sufficient stabilization of the chest even after complete sternal resection. The dense retrosternal reactive tissue layer contributes to the stability of the repair. Only one small additional incision for mobilization of the left pectoral muscle at the humeral attachment is necessary, which limits the surgical trauma compared with other methods suggested for the coverage of large wound defects of the chest.

Following bilateral pectoralis major mobilization long-term respiratory function remained unaltered compared to preoperative values. Sufficient chest stability could be confirmed by the functional chest CT scan, revealing only minor mobility between the former sternoclavicular joints. Shoulder and arm mobility were comparable to the results seen in patients, who had undergone uncomplicated median sternotomy. Furthermore there was just a mild reduction of muscular strength in the left arm.

There was no impairment of quality of life by chronic pain. Also mobility and social contacts were not limited after the procedure and the reduced quality of sleep could not be directly related to the plastic surgery procedure, but more to the long hospital stay and complicated recovery phase. The impairment of executing the hobbies and social activities can be explained by a functional limitation of chest stability and reduced muscle strength during long-lasting exercise, which was not measured by our tests. Furthermore it is known, that there is a general impairment of activity after long hospital stay, combined with a longer period of complete recovery. For this reason it is reasonable to reinvestigate patients after a longer follow-up.

We considered pectoralis major mobilization only in patients with severe sternum infection, which could not be cured by wound debridement, sternal rewiring and local irrigation. Due to the good functional results pectoralis major flap may be used earlier in the course of surgical attempts to cure deep sternal infection. Particularly due to our bad results with Robicsek type or rewiring in diabetic patients we will use this technique as an alternative for this subgroup.

Bilateral pectoralis major flap reconstruction after sternal resection for postoperative sternal necrosis is a safe and technically straightforward technique. It does not necessitate further reconstructive surgery for wound closure. The advantages of this procedure are early wound closure, sufficient chest stability, almost no impairment of respiratory function and good long-term functional and cosmetic results. Complete sternal resection and repair thus can be considered early in severe sternal wound infections.

References

