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# High-Pressure Suction Drainage via a Polyurethane Foam in the Management of Poststernotomy Mediastinitis

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**Background.** This study was performed to evaluate the effectiveness of suction drainage in the management of early poststernotomy mediastinitis.

**Methods.** From September 1998 to August 1999, we encountered nine cases of poststernotomy mediastinitis out of 1,209 adult median sternotomies performed in this time period. All these cases were treated with suction drainage, which was recently introduced to our management protocol. From September 1997 to August 1998, we encountered 11 cases of poststernotomy mediastinitis of 1,343 adult median sternotomies. All these cases were initially treated by closed drainage and irrigation, which was our previous first-line management. We used the latter group as historical controls for the evaluation of

suction drainage. Lengths of hospitalization were compared using the Mann-Whitney *U* test, and success versus failure of the primary treatment was compared using the  $\chi^2$  test.

**Results.** Treatment with the suction dressing resulted in a decreased length of hospitalization after treatment starts ( $p = 0.02$ ) and a lower rate of treatment failure ( $p = 0.03$ ).

**Conclusions.** The use of high-pressure suction drainage is a valuable adjunct in the early management of poststernotomy mediastinitis.

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Poststernotomy mediastinitis (PSM) remains a major cause of morbidity after median sternotomy and is independently associated with increased early and late mortality [1-3]. The prolonged hospital stay, the need for repeated surgical procedures, and the secondary complications contribute to ongoing misery for patients and surgeons alike, and increase the cost of hospitalization substantially [3, 4].

Median sternotomy wound complications vary from sterile dehiscence to suppurative mediastinitis. A diagnosis of PSM implies deep sternal wound infection with infected retrosternal space or sternal osteomyelitis [5]. Early diagnosis and management is essential. In the early stages, osteomyelitis is confined to the sternal wound edges and debridement reveals underlying healthy bone. The mediastinum is lined with a loose fibrinous exudate. Prompt and efficacious treatment of this condition is vital to avoid the development of a chronic mediastinitis in which the exudate forms a thick fibrous cortex and loculated collections develop sinus tracts extending to the sternum. This situation then requires a more radical approach. Despite this, there is no general consensus on the optimal treatment at the early stage and there remain wide variations in approach [5].

We have found that the majority of PSM in our patients occurred in cases with significant risk factors for poor healing. Encouraged by the success of high-pressure suction to treat wounds in plastic surgery in situations of poor healing [6, 7], we applied a similar system to our infected sternotomy wounds. High-pressure suction applied through a polyurethane foam dressing has been shown to improve wound granulation and reduce wound bacterial counts in experimental situations. The technique not only enhances the environment for wound healing but also fulfils the principles of surgical therapy for deep-seated infection, ie, thorough debridement and open drainage.

Initially, we used the technique in 2 patients who had failed treatment with our first-line therapy at the time, which was closed drainage and irrigation (CDI). After the good results in these cases, we used the technique as a first-line treatment in the next seven cases of PSM in our unit. We report here our experience with the treatment of early PSM in a group of patients with multiple risk factors for poor healing. We compared their outcome with consecutive patients who developed PSM in the preceding year and were treated initially by CDI. We should emphasize that all the patients in this paper had sternal dehiscence and an infected mediastinum, and required removal of the sternal wires and open drainage of the mediastinum. Superficial sternal wound infections, suture and wire abscesses, chronic sternal osteomyelitis, and sterile sternal dehiscences were not included.

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## Patients and Methods

### Patients

One thousand two hundred and nine adult median sternotomies were performed from September 1998 to August 1999 inclusive, and 1,343 from September 1997 to August 1998 inclusive. Routine antibiotic prophylaxis comprised perioperative flucloxacillin and gentamycin, substituting cefuroxime for these in cases of allergy to penicillin or renal impairment.

The case records of all patients with sternal wound complications at our institution were reviewed. Poststernotomy mediastinitis occurred in 9 patients (0.7%) from September 1998 to August 1999 (group A) and in 11 patients (0.8%) from September 1997 to August 1998 (group B). One patient in group B died 14 days postoperatively of a cause largely unrelated to PSM and was excluded from the study.

Patient demographics, procedure, and selected risk factors for poor postoperative healing were recorded. Four risk factors were selected from those published in major series of PSM [2, 3, 8] that were considered to be particularly relevant to poor wound healing [9]. These were bilateral internal mammary artery use, body mass index (BMI) greater than or equal to 30, diabetes on medication, and systemic steroid use.

A clinical diagnosis of mediastinal infection was made on the basis of sternal instability, spreading wound erythema, or purulent discharge, with or without systemic features of infection such as pyrexia or leukocytosis. All these patients were reexplored formally in theater and microbiologic samples obtained. All the patients in this study had positive bacteriologic cultures from mediastinal tissue samples. There were four cases of sterile sternal dehiscence during the period of the study, which were not included.

### Methods

**GROUP A.** Patients in group A all received treatment with high-pressure suction drainage. The first patient in group A was initially treated by debridement and CDI on day 11, and then by further debridement and pectoralis advancement flaps on day 26. Failure of these interventions led to our first use of the suction dressing on day 44 after this patient's initial operation. The second patient in group A was initially treated by debridement and CDI on day 10, before use of the suction dressing on day 24. The subsequent 7 patients were all treated by debridement and placement of a high-pressure suction dressing within 48 hours of diagnosis of infection.

**SUCTION DRESSING PROCEDURE.** The dressing materials used were supplied by KCI Medical Ltd (Witney, Oxfordshire, UK). These comprised a large medical-grade reticulated polyurethane ether foam dressing with a 400- to 600- $\mu$ m pore size, a noncollapsible suction tube draining into a reservoir canister, a large transparent adhesive dressing, and a vacuum pump capable of producing a continuous negative pressure of 125 mm Hg.

At exploration, the sternal wounds were completely

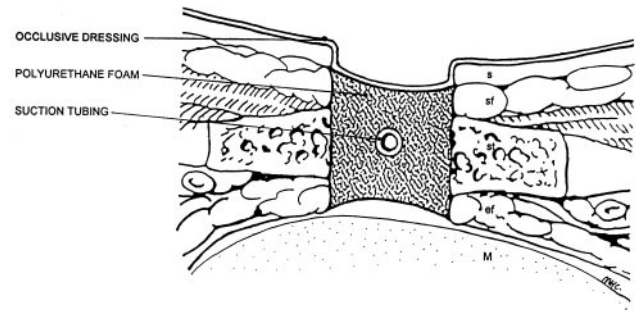


Fig 1. Cross-sectional view of the sternum with the suction dressing in situ. (s = skin; sf = superficial fascia; st = sternum; ef = extrapleural fascia; M = mediastinum.)

reopened and all sternal wires removed. Thorough debridement was performed. Samples were sent for microbiological investigation. The mediastinum was then washed out with warm normal saline. The polyurethane foam was shaped to fit the resulting sternal defect. The foam was placed within the cavity just below the skin edge (Fig 1). The suction tube was then inserted inside the foam to exit the wound from the inferior margin. The wound edges were dried, and the transparent occlusive dressing was applied over the foam. This was fashioned to incorporate the suction tube in a "mesentery" to form an airtight seal over the wound. The suction tube was inserted into the vacuum pump via the reservoir canister, which collected any exudate. A continuous negative pressure of 125 mm Hg was applied beneath the adhesive dressing within the sponge. The vacuum caused the foam to reduce in volume by around three-quarters, which pulled the sternum together splinting it, and also brought the wound edges closer together (Fig 2).

Drainage fluid varied according to the patient and was collected in the reservoir canister in the vacuum pump. Every 48 to 72 hours, the polyurethane foam dressing was changed on the ward. Most patients tolerated this with oral analgesia and topical local anesthetic applied to the



Fig 2. Suction dressing, showing the polyurethane foam filling the defect between the split sternum, with the tubing to the vacuum pump exiting. A transparent occlusive dressing forms a mesentery around the tubing and seals the space containing the foam.

wound cavity, but some required intravenous midazolam or opiates. This allowed inspection, further debridement, and microbiological sampling. A new polyurethane foam and drainage tube were then inserted and covered with a fresh adhesive dressing and the vacuum reapplied.

After 1 to 4 weeks, when the wounds were considered to be clean with evident granulation tissue and negative microbiological cultures, delayed primary closure was performed in theater. Interrupted steel wires were used to close the sternum and deep interrupted nylon sutures to close the superficial fascia and skin in one layer. The nylon sutures were removed between 14 and 16 days postclosure.

**GROUP B.** Patients in group B were all initially treated by debridement and CDI.

**CDI PROCEDURE.** The sternal wounds were completely reopened and all sternal wires removed. Thorough debridement was performed. Samples were sent for microbiological investigation. The mediastinum was then washed out with warm normal saline. Two 16 Charrière catheters for irrigation and two 28 Charrière Argyle drains were placed in the mediastinum. The sternum was closed with interrupted steel wires. Deep interrupted nylon sutures were used to close the superficial fascia and skin in one layer. These were removed 14 to 16 days later if treatment was successful.

Irrigation with normal saline was continued at a rate of 1 L every 6 hours until the effluent was microbiologically clear. The irrigating catheters were then removed, and 12 hours later, the drains were removed.

#### *Subsequent Management*

In both groups, broad-spectrum intravenous antibiotics were used initially and then modified according to culture results, continuing for 6 weeks. Patients were discharged once their wounds were closed if their clinical condition was otherwise satisfactory. Where required, intravenous antibiotics were administered at home by a district nurse via a tunnelled subclavian venous line.

#### *Follow-up*

Patients from both groups were reviewed as outpatients 6 months after discharge.

#### *Statistical Analyses*

In comparisons between groups A and B, interval variables were analyzed using the Mann-Whitney *U* test and nominal variables were analyzed by the  $\chi^2$  test, with Fisher's exact test correction for small samples. Significance was accepted for *p* value less than 0.05.

## **Results**

### *Group A Patients*

The patients in group A were aged 64 to 74 years (median 68 years). There were 7 males and 2 females. All patients underwent cardiopulmonary bypass. Seven underwent isolated coronary artery bypass grafting, 1 underwent

aortic valve replacement, and 1 underwent aortic and mitral valve replacements and coronary artery bypass grafting. The presentation varied from postoperative day 7 to 17 (median 11 days). All patients had bacterial growth from their mediastinal tissue samples. In 6 patients, *Staphylococcus aureus* was the significant pathogen; but in several patients, there were multiple pathogens, including *S epidermidis* (1), *Escherichia coli* (2), group A Streptococci (1), *Streptococcus milleri* (1), *Enterobacter cloacae* (1), and *Acinetobacter* (1). Methicillin resistance is uncommon in our unit, and only 1 patient cultured methicillin-resistant *S aureus* (MRSA).

Only 1 patient did not have a selected risk factor for poor wound healing. Three patients had one risk factor, 3 patients had two risk factors, and 2 had three identified risk factors. Of note, 7 of the 9 patients were diabetics and 6 had a high BMI.

### *Group B Patients*

The patients in group B were aged 46 to 75 years (median 66 years). There were 7 males and 3 females. All underwent isolated coronary artery bypass grafting under cardiopulmonary bypass. Presentation varied from postoperative day 5 to 13 (median 9.5 days). All had positive microbiology from their mediastinal samples including *S aureus* (6), *S epidermidis* (2), *E coli* (1), Enterococci (2), *Klebsiella* (1), and group A Streptococci (1).

One patient had no risk factors, 7 had one risk factor, 1 had two, and 1 had three identified risk factors. Five of these patients were diabetic and 5 had a high BMI.

Comparisons between the patient and wound variables were made using the Mann-Whitney *U* test for lengths of hospitalization, and the  $\chi^2$  test for nominal variables. There were no significant differences in the presentation day, the presence of multiple pathogens, or the presence of *S aureus* or MRSA between groups A and B. Furthermore, there were no significant differences in the risk factor profiles.

Outcome measures are presented in Table 1.

### *Group A Outcome*

The suction dressing was used as a third- and second-line treatment in the first two cases, respectively, at days 44 and 13 after first clinical diagnosis of PSM. Once the suction dressing became our first-line treatment, it was inserted within 48 hours of clinical diagnosis of PSM. After the initial insertion of the dressing in theater, extubation was achieved immediately or within a few hours of surgery.

The suction dressing remained in place for 6 to 26 days (median 11 days). The length of hospitalization after its deployment was 12 to 34 days (median 15 days). The first 2 patients spent 44 and 13 days, respectively, pursuing alternative treatments before use of the suction dressing. Two patients had prolonged hospitalizations despite satisfactory wound healing, because of treatment for concomitant congestive cardiac failure and lower respiratory tract infection. Total hospitalization for the 7 patients treated primarily by the suction dressing was 22 to 49 days (median 27 days).

Table 1. Outcome Measures

	Duration of Primary Treatment (Days)	Length of Hospitalization After Start of Treatment (Days)	Total Length of Hospitalization (Days)	Treatment Failure
Group A (n = 9)	6-26, median 11	12-34, median 15	22-88, median 35 (22-49, median 27) <sup>b</sup>	None
Group B (n = 10)	8-20, median 13	14-89, median 40.5	27-98, median 50	5
<i>p</i> <sup>a</sup>	NS	0.02	NS (0.04) <sup>b</sup>	0.03

<sup>a</sup> Mann-Whitney *U* test was used to assess significance for interval variables. The  $\chi^2$  test, with Fisher's exact test correction, was used for nominal variables. Significance was accepted for  $p < 0.05$ . <sup>b</sup> Data with first two group A patients eliminated, leaving only patients primarily treated with suction dressing.

There were no treatment failures in group A and thus no patients required plastic surgical intervention. All patients achieved excellent functional and cosmetic results and were discharged with closed stable sternums. All were well at 6-months of follow-up except for 1 patient who died after 5 months from pneumonia. There was no evidence of a wound complication at this time, although no postmortem was performed. In the remaining patients, there were no recurrent wound complications and no reinterventions.

#### Group B Outcome

Closed drainage and irrigation was used for 8 to 20 days (median 13 days). The length of hospitalization after treatment start was 14 to 89 days (median 40.5 days). Total hospitalization was 27 to 98 days (median 50 days). Five of 10 patients (50%) in group B failed primary treatment, and this figure rises to 7 of 12 (58%) if the primary treatment of the first 2 patients from group A are considered. Two patients subsequently underwent pectoralis advancement flaps, 2 underwent pectoralis major rotational flaps, and 1 underwent transposition of the rectus abdominis muscle. All had a satisfactory functional and cosmetic outcome and were well at follow-up after 6 months.

#### Comparisons

Treatment failure was significantly greater for group B patients ( $p = 0.03$ ). There was no significant difference between the duration of suction dressing treatment and the duration of closed drainage and irrigation. Total length of hospitalization was also not significantly different between groups A and B. However, eliminating the 2 patients who underwent initial failed treatment with CDI revealed a significantly reduced length of hospitalization for those patients who had primary suction dressing treatment ( $p = 0.04$ ). Furthermore, comparison of the length of hospitalization after undertaking the chosen treatment showed a significant reduction for patients treated by the suction dressing ( $p = 0.02$ ).

#### Comment

There remains a small but consistent rate of mediastinitis resistant to prophylactic measures. Most large recent studies quote an incidence of around 1% [1-3]. Although this is

a low rate, the consequences for the individual patient remain substantial. The morbidity is considerable and the associated mortality ranges from 10% to 50% [3, 10].

There is a lack of consensus regarding the optimal management of poststernotomy mediastinitis [5, 11, 12]. Reexploration at least is universally accepted, and usually determines subsequent treatment, which may vary from simple drainage to extensive myocutaneous plastic procedures. Surgical dogma in respect of deep-seated infection stresses the importance of early diagnosis, wound debridement, and open drainage. However, open treatment of sternotomy wound infections has a number of problems, in particular, the disadvantage to thoracic mechanics [12] and heavy nursing load. In an effort to achieve primary closure, closed irrigation systems have been used [13, 14]. These have a number of pitfalls, including blockage, systemic absorption of irrigating fluid, difficulty in measuring and culturing exudate, and no access for repeated debridement. Some authors advocate aggressive early debridement and muscle flap closure [15, 16]. This has the advantage of increasing wound vascularity, both directly and indirectly (by stimulating angiogenesis) [17]. However, these procedures are often radical and may be difficult for the patient to accept immediately after diagnosis of PSM. Patients are often acutely ill and may not tolerate the more extensive surgery, and a number of long-term functional deficits are described [15].

The use of suction has been described in closed wounds, both in conjunction with continuous irrigation and as a simple series of retrosternal drainage tubes attached to vacuum bottles [18]. We describe here our experience with a form of open wound treatment employing a period of suction drainage followed by delayed primary closure. The use of suction in our series is distinguished by its application via a polyurethane foam, a technique employed in the field of plastic surgery [6, 7]. The firm open cell structure of the foam with 400- to 600- $\mu$ m pores serves to maintain a high contact area with the wound and to distribute the negative pressure uniformly. This encourages drainage of exudate. The foam is changed at the bedside every 48 hours, allowing reexamination of the wound, further debridement, and serial microbiological sampling. This ensures the benefits of an open wound without allowing desiccation, or presenting a heavy nursing load of frequent repeated dressing

changes. The high-pressure suction splints the sternum, reducing pain and avoiding disruption of thoracic wall mechanics. This is evidenced by the early extubation possible for our patients, many of whom had additional risk factors for respiratory dysfunction. Early mobilization with a battery-powered vacuum pump was also promoted.

Studies from the field of plastic surgery have shown that the negative pressure delivered by foam pores to the edge of the wound encourages the formation of granulation tissue [6]. Reduced tissue edema and bacterial colonization have also been documented. In animals, increases in local blood flow, angiogenesis, and increased mitotic rates have been measured [19]. High-pressure suction has been used in plastic surgery largely to promote healing by secondary intention. This approach has been taken up by some cardiothoracic units to treat PSM [20], resulting in a long duration of use of the suction dressing, long hospitalization times, and fibrous union of the sternum. In our experience, the most important effect of the suction dressing is the dramatic improvement in wound vascularity. It is this that allows us, in patients with poor healing, to shorten the treatment duration and rewire the sternum to achieve delayed primary closure. This produces a stable, cosmetically acceptable sternal wound.

A potential problem with our open treatment is the increased risk of bacterial colonization, particularly in the presence of the foam, which acts as a temporary foreign body. The evidence from studies of other open wounds is that bacterial counts are less than  $10^2$  to  $10^3$  per gram of tissue with the foam in place [6], and this appears to allow successful wound healing. In the poststernotomy patient, this needs to be weighed against the alternative of a closed "cleaner" wound (which is not usually an option in the wounds examined in these other studies [6, 19]). Our experience would favor the value of the increased vascularity achieved by the suction dressing, over the risk of bacterial colonization.

The limitation of studies of treatment for PSM is the difficulty in controlling for patient variables and severity of infection [5]. No statistically significant difference was seen between patient or infection variables between groups A and B, but the numbers are small. However, the tendency was for group A to be worse than group B (more diabetics, more high BMI, more MRSA, and more multiple pathogens). It would be necessary to balance the different patient and wound variables in any attempt at a randomized trial, which would consequently need a long recruitment period.

In nine cases, with numerous risk factors for poor healing, we have found high-pressure suction drainage with a vacuum dressing to be an excellent adjunct in the management of early sternotomy wound infection. No patient required further intervention, plastic surgery was avoided, and hospitalization times were significantly reduced compared with our previous experience. It is well tolerated by patients and can be used early after diagnosis. The additional cost of the dressing material and hire of the vacuum pump is compensated for by the reduced nursing time for dressings and reduced length of hospitalization.

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