Deep sternal wound infection: the role of early debridement surgery

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Abstract

Objective: This retrospective chart review study aimed to evaluate whether a more aggressive staged approach can reduce morbidity and mortality following post-cardiotomy deep sternal wound infection. Methods: Between 1979 and 2000, 14,620 patients underwent open heart surgery: mediastinitis developed in 124 patients (0.85%). Patients were divided in two groups: in 62 patients (Group A) (1979–1994) an initial attempt of conservative antibiotic therapy was the rule followed by surgical approach in case of failure; in 62 patients (Group B) (1995–2000) the treatment was staged in three phases: (1) wound debride-ment, removal of wires and sutures, closed irrigation for 10 days; (2) in case of failure open dressing with sugar and hyperbaric therapy (11 patients, 17%); (3) delayed healing and negative wound cultures mandated plastic reconstruction (three patients, 4%). Categorical values were compared using the Chi-square test, continuous data were compared by unpaired t-test. Results: Incidence of mediastinitis was higher in Group B (62 out of 5535; 1.3%) than in Group A (62 out of 9085; 0.7%) (P<0.007). Mean interval between diagnosis and treatment was shorter in Group B (18 ± 6 days) than in group A (38 ± 7 days) (P = 0.001). Hospital mortality was higher in Group A (19/62; 31%) than in Group B (1 out of 62; 1.6%) (P < 0.001). Hospital stay was shorter in Group B (30.5 ± 3 days) than in group A (44 ± 9 days) (P = 0.001). In Group B complete healing was observed in all the 61 survivors: 47 cases (76%) after Stage 1; 11 (18%) after Stage 2; three (4.8%) after Stage 3. Conclusions: Although partially biased by the fact that the two compared groups draw back to different decades, this study showed that an aggressive therapeutic protocol can significantly reduce morbidity and mortality of deep sternal wound infection. © 2001 Elsevier Science B.V. All rights reserved.

Keywords: Deep sternal wound infection; Closed chest irrigation; Sugar dressing; Pectoralis muscle flap reconstruction

1. Introduction

In spite of protocols of hospital infection control, improved antibiotic therapy and asepsis of perioperative care; the incidence of postoperative deep sternal wound infection has not decreased over the years.

Incidence of postoperative mediastinal infections ranges between 0.15 [1] and 8% [2] and it averages 1–2% in the most recently reported series [3–8].

Many studies [1–11] have already identified risk factors for development of postoperative deep sternal wound infection. Unfortunately only few of these risk factors are modifiable, being related to preoperative chronic conditions [12]. Moreover, with the modern progresses in cardiac surgery, the number of immunodepressed cardiac surgery patients with multiple risk factors for mediastinal infection is increasing.

Prognosis of deep sternal wound infection is severe; despite appropriate antibiotic treatment and wound debridement, infection may propagate in the mediastinum and eventually involve the cardiac sutures leading to septic shock and/or catastrophic hemorrhage [11,13]. Mortality for post-cardiotomy deep sternal wound infection is still high, ranging between 5 and 47% in spite of early diagnosis and appropriate treatment [3,4,8,14,15].

The appropriate treatment of deep sternal wound infection is still a field of controversies: since Shumaker [16] proposed closed chest catheter irrigation, this has been the treatment of choice of deep sternal wound infection; on the other hand recently introduced plastic procedures either with omental or pectoralis muscle flaps have reported high rates of success and short hospital stay [15,17–19].

Despite the breakthrough of new approaches in the treatment of deep sternal wound infection, hospital mortality is still high and hospital stay prolonged, with a waste of finan-
cial resources regardless the methods of treatment. Moreover all available series in the Medical Literature report their results with one type of treatment, but no series have been reported so far describing a staged protocol of treatment including those cases with refractory infection.

We reviewed our 20-year experience in the treatment of deep sternal wound infection. Since 1995 we developed an aggressive coded protocol of treatment. The object of this study was to review the results obtained with such protocol and compare them with our previous experience.

2. Material and methods

Between January 1979 and February 2000, 14 620 patients underwent open heart surgery through a complete median sternotomy at our Institution; perioperative protocol of infection control remained almost the same over the years.

Elective patients were showered and shaved the day of their operation. All patients received intravenous cephalosporins and intramuscular aminoglycosides since the morning of the operation, until central venous line and chest drains were removed.

The operative field was painted with povidone-iodine solution and the skin was covered with an adhesive plastic sheet. The skin was incised with a scalpel and electrocautery was used to open the prexternal layers and the pericardium. Bone wax was used only if sternal bleeding was profuse. Internal thoracic arteries were harvested as pedicled in situ grafts when used for coronary bypass. After weaning from bypass the pericardium was left open and haemostasis was achieved. Mediastinal and pericardial chest tubes were inserted. A chest tube was always placed if the pleural cavity was opened. The sternum was closed with stainless steel wires. The prexternal space was obliterated with subcuticular absorbable suture.

Chest tubes were connected to 15 cm water suction postoperatively. Patients were extubated when they were hemodynamically stable, normothermic, and ventilating spontaneously. All drains were removed on the morning of the 2nd postoperative day or when drainage was lower than 25 ml/h. Wound dressing was removed on the 2nd postoperative day and redressed only once. Further dressing was performed only if wound discharge occurred.

All through the study period our clinical follow-up protocol was the following: patients were seen on outpatient visits at least at 1 week, 1 month, 6 months and 1 year after discharge.

2.1. Management of infection

Deep sternal wound infection was observed in 124 patients in our Institution during the study period (0.85%).

Deep sternal wound infection was defined according to the guidelines of the Center for Disease Control and Preven-

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographic variables and preoperative data.</th>
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<tbody>
<tr>
<td></td>
<td>Group A</td>
</tr>
<tr>
<td>Male</td>
<td>44 (71%)</td>
</tr>
<tr>
<td>Female</td>
<td>18 (29%)</td>
</tr>
<tr>
<td>Mean age</td>
<td>57.5 ± 10.5</td>
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<tr>
<td>CABG</td>
<td>0 (32%)</td>
</tr>
<tr>
<td>Valve surgery</td>
<td>30 (48%)</td>
</tr>
<tr>
<td>Other procedures</td>
<td>12 (19%)</td>
</tr>
<tr>
<td>Blood transfusion</td>
<td>47 (76%)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>8 (13%)</td>
</tr>
<tr>
<td>Chronic renal failure</td>
<td>5 (8.1%)</td>
</tr>
<tr>
<td>Reopening for bleeding</td>
<td>6 (9.7%)</td>
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* CABG, coronary artery bypass grafting.

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<thead>
<tr>
<th>Table 2</th>
<th>Microbiology and clinical findings</th>
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<tr>
<td></td>
<td>Group A</td>
</tr>
<tr>
<td>Interval between symptoms and reoperation (days)</td>
<td>38 ± 7</td>
</tr>
<tr>
<td>Positive blood culture</td>
<td>4 (6.5%)</td>
</tr>
<tr>
<td>Positive wound culture</td>
<td>28 (45%)</td>
</tr>
<tr>
<td>Negative wound culture</td>
<td>16 (26%)</td>
</tr>
<tr>
<td>Staphylococcus species</td>
<td>10 (16%)</td>
</tr>
<tr>
<td>S. aureus</td>
<td>6</td>
</tr>
<tr>
<td>S. epidermidis</td>
<td>4</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>12 (19%)</td>
</tr>
<tr>
<td>Fever</td>
<td>55 (89%)</td>
</tr>
<tr>
<td>Leukocytosis</td>
<td>57 (92%)</td>
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</table>
were completely removed. The sternum was closed with heavy braided sutures and the wound was closed in multi-layer. In case of further recurrence re-debridement with closure or open wound dressing were employed.

Group B includes 62 patients operated on between January 1995 and February 2000; in this group deep sternal wound infection was treated according to a precise flow-chart: all patients with wound discharge and even minimal sternal instability underwent wound debridement and mediastinal irrigation with povidone-iodine solution on emergency basis (Stage 1).

Patients were taken to operating room and wound reopening was performed: all sternal wires and fascial or subcutaneous sutures were removed, samples of mediastinal fluids were taken for culture, the pericardial sac was washed with antibiotic and povidone-iodine solutions. A drain for mediastinal irrigation and two tubes for drainage, one in the pericardium and one in the anterior mediastinum, were placed. If a pleural space was opened an additional drain was inserted just above the diaphragm. Wide sternal and wound debridement was always performed, until fresh bleeding was obtained from the edge of the wound. The sternum was not approximated and only skin and subcutaneous layers were full-thickness closed with non-absorbable interrupted stitches. Mediastinal irrigation at 100 ml/h was performed alternating a 5% povidone-iodine (PVI) solution and a 0.1% vancomycin solution every 6 h. Intravenous antibiotic therapy according to the results of microbiology tests was continued all through mediastinal irrigation time. On the 7th postoperative day the infusion was withdrawn and swabs for culture were taken from the drains. If cultures were sterile, wound healing was satisfactory, fever and leukocytosis disappeared, then drains were removed and the patient was discharged. If wound drainage and/or bacterial growth from cultures were observed, mediastinal irrigation was restarted and continued on for other 7 days, and then drains were removed.

When the infection recurred (11 cases) patients entered in Stage 2 of treatment. The sternotomy wound was reopened; redebridement was performed: the mediastinum and surface of the wound were flushed with PVI and packed with antibiotic soaked mulls. The following day, treatment with granulated sugar was started. The wound was washed once a day with oxygen peroxide and 5% PVI solution and filled with granulated sugar four times a day until the wound was healed or the patient underwent pectoralis muscle flap reconstruction. In three patients, during the sugar treatment, hyperbaric therapy was associated until the wound was healed.

Antibiotics were continued, according to in-vitro susceptibility test results, until the wound was healed.

Samples from the wound were taken every day, blood cultures were performed whenever body temperature raised above 38°C. Full blood count was checked daily and blood glucose four times a day.

When cultures from the wound showed no pathogen germ growth and the white blood count fell within the normal range, the patient and relatives were trained in the self dressing technique with granulated sugar.

Three patients showing a delayed healing of the wound and wanting earlier hospital discharge entered in Stage 3 of the protocol: they were referred to the plastic surgeon and pectoralis muscle flap reconstruction was performed.

2.2. Statistical analysis

Statistical analysis was performed with SPSS Statistical software package (Chicago, IL). Categorical values of the two groups were compared by Chi-square test, whereas continuous data, reported as mean ± SD, were compared by unpaired t-test. A P value less than 0.05 was considered statistically significant.

2.3. Limitations of the study

Although antibiotic therapy protocol, patient preparation and surgical techniques have not changed over the years, this study compares two different populations of patients and some of them has been operated on more than 2 decades from another. Changes in drugs, surgical techniques, policy of prevention of infections may add some bias to the study.

3. Results

Incidence of mediastinitis was higher in Group B (62 out of 5535; 1.1%) than in Group A (62 out of 9085; 0.7%) (P = 0.007). Mean interval between diagnosis and treatment was shorter in Group B (18 ± 6 days) than in group A (38 ± 7 days) (P = 0.001). Among strains isolated from drainage samples or wounds Staphylococcal species predominated (38 cases) (Table 2), followed by Pseudomonas aeruginosa (14 cases) and Serratia marcescens (three cases), Enterobacter cloacae (two cases) and Proteus mirabilis (one case).

Hospital mortality was significantly higher in Group A (19/62 patients; 31%) than in Group B (1/62 patients; 1.6%) (P < 0.001). Causes of death in Group A were: sepsis in eight cases, multiorgan failure in five, hemorrhage from the aortic cannulation site in one and from a right ventricular tear in one, respiratory failure in four. In Group B, one patient died for progressive cardiac failure.

Mean hospital stay was significantly higher in Group A (44 ± 9 days) versus Group B (30.5 ± 3 days) (P = 0.001). Number of surgical procedures was higher in Group A (92; mean number of procedures per patient 2.5 ± 0.8) versus Group B (76; mean per patient 1.2 ± 0.5) (P = 0.005). Among Group B patients undergoing sugar dressing, 11 were healed after a time interval ranging from 45 to 80 days (mean 64.8 ± 8 days). The other three Group B patients reaching Stage 3 of the protocol underwent flap reclosure 1, 1.5 and 2 months after first diagnosis of deep sternal wound infection, respectively.
Table 3

<table>
<thead>
<tr>
<th></th>
<th>Group A</th>
<th>Group B</th>
<th>P</th>
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<tbody>
<tr>
<td>Hospital death</td>
<td>19 (30.6%)</td>
<td>1 (1.6%)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Number of surgical</td>
<td>92</td>
<td>76</td>
<td>0.005</td>
</tr>
<tr>
<td>debridements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Total – mean per patient)</td>
<td>(2.5 ± 0.8)</td>
<td>(1.2 ± 0.5)</td>
<td></td>
</tr>
<tr>
<td>Mean hospital stay (days)</td>
<td>44 ± 9</td>
<td>30.5 ± 3</td>
<td>0.0001</td>
</tr>
<tr>
<td>Absence of fever 7 days</td>
<td>33</td>
<td>46</td>
<td>0.025</td>
</tr>
<tr>
<td>after debridement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal WBC count 7 days</td>
<td>18</td>
<td>40</td>
<td>0.0001</td>
</tr>
<tr>
<td>after debridement*</td>
<td></td>
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</table>

* WBC, white blood cells.

Number of in-hospital recurrences was lower in Group B (14 cases; 23%) versus Group A (30 cases; 48%) ($P < 0.001$).

Complete cure of infection was achieved earlier in Group B than in Group A being significantly higher the number of patients without fever and/or leukocytosis at the 7th day after the surgical debridements, as reported in Table 3.

4. Discussion

Mediastinal infection is a dreaded complication of open heart surgery. Medical treatment with antibiotics alone is ineffective: infection may cause septicemia and/or propagate to the cardiac sutures leading to massive hemorrhage [11,13].

The incidence of postoperative mediastinitis ranges between 0.15 and 8% and even after the improvements in antibiotic therapy, extracorporeal circulation and postoperative management, the incidence has remained stable over the last 2 decades [1–8]. These results can be explained with the higher number of sick patients nowadays treated by cardiac surgery: the mean age of patients and the number of immunocompromised patients due to primary diseases (diabetes, renal failure) or drugs (cardiac transplant) are raising. Many studies [1–12] have been performed to find out risk factors for postoperative mediastinitis in order to lessen the incidence of deep sternal wound infection. Many factors have been found to increase the incidence of postoperative sternal infections, unfortunately only few of these are modifiable [12]. Moreover almost all patients undergoing cardiac surgery in the 1990s have at least two risk factors for developing postoperative deep sternal wound infection.

Reoperation is mandatory, nevertheless infection may continue, leading to local and/or systemic complications. Treatment is distressing for both the patient and the surgeon, since rate of failure is high and dressing may be painful and time consuming. Hospitalization time is considerably prolonged and a large amount of resources are wasted [3,4,6,8].

Although some authors [17] reported no hospital death in small series undergoing either closed chest irrigation and pectoralis muscle flap, mortality for deep sternal wound infection is still high: Duke’s series of patients undergone CABG [19] reports 8.1% mortality rate in patients with deep sternal wound infection. Mortality rate in large series reported in the last decade ranges between 4.8 and 10.8% either in patients with plastic procedures and in those with closed chest irrigation [18,21,22], therefore none of those two different approaches have proved in large series to reduce the mortality rate for deep sternal wound infection to less than 4%.

Our series report a 16.9% mortality rate over 20 years of time including patients undergone cardiac transplant and those operated upon deep hypothermia and circulatory arrest for type A aortic dissection, moreover only patients with deep sternal wound infection were included in our series, and those with sterile sternal instability were not considered in this study.

The appropriate treatment of deep sternal wound infection is still matter of controversies: since Shumaker [16] proposed closed chest catheter irrigation, this has been the treatment of choice of deep sternal wound infection, but in the recent years plastic procedures either with omental or pectoralis muscle flaps have reported high rate of success and short hospital stay [15,17–19]. Two therapeutic options are available whenever the infection shows refractory to a closed irrigation system. Redebridement is anyway mandatory. Some authors claim a higher success rate with open treatment, others support the theory that primary muscle or omental flap may achieve earlier and better results. Conventional dressing with PVI solution soaked gauze are often difficult to apply and require special nursing staff. Even with frequent redressing and careful active debridement of all necrotic tissues, the wound often remains purulent for a long time without granulating.

Granulated sugar in the reports of other authors, so as in our experience, has shown to provide a clean wound in a reasonable time, ready to be treated with plastic procedures. Sugar does not adhere to wounds, and dressing changes are easy and painless. Adverse effects were not observed but in three patients with diabetes, requiring increased doses of insulin during the treatment.

The explanation for the success of sugar treatment is still being debated.

Chirife et al. [23] proposed that sugar reduces water activity in the wound, impairing bacterial growth. Trouillet et al. [24] believe that granulated sugar acts in a less specific way providing a series of osmotic shocks to any bacteria which may be present.

Plastic procedures such as pectoralis or omental or rectus abdominis flaps have a high rate of success and a shorter hospital stay. Nevertheless these plastic procedures need a clean wound, otherwise the infection may spread to other tissues or cavities.

The present study confirm that deep sternal wound infection is still a dreaded complication of cardiac surgery,
nevertheless hospital mortality can be considerably reduced through an aggressive protocol of treatment preventing the infection from spreading in the mediastinal space. No treatment has proved to achieve better results than another, if not timely employed. Excellent results can be obtained only with a coded protocol and with the combination of different techniques.

References


Appendix A. Conference discussion

Dr. K. Jeyasingham (Winterbourne Down, UK): I am ignorant about the usage of sugar in these matters. Would you explain the rationale for sugar?

Dr. Renzulli: The Ancient Egyptians used to make a dressing of the wound with honey and with molasses and they got good results. The rationale hasn’t been found yet. Someone has hypothesized that they can determine osmotic shock to the bacteria getting a sterile wound within 7 days.

Dr. T. Treasure (London, UK): A very low infection rate and very good success rate in treating them, and I would agree with I think all of your protocol, with the exception of sugar, which we have not tried.

The question has to do with muscle flaps as opposed to omentum. My preference is to use omentum. Having irrigated, cleaned things up, then bring up the omentum and close. But anyway, when we had such a problem, we referred the patient to the plastic surgeon. So we discussed with them and they decided to go ahead with muscle flap.

Dr. Renzulli: I agree with you on the omentum, and cardiac surgeons are becoming used to dealing with it, with right gastroepiploic artery harvesting. But anyway, when we had such a problem, we referred the patient to the plastic surgeon. So we discussed with them and they decided to go ahead with muscle flap.

Dr. Treasure: Exactly. In our experience, muscle flaps are what they do. And the trouble is that if you have chronically infected bone with a low grade infection, the omentum will help clear it, whereas the muscle will atrophy. It’s hard to prove. I mean it’s only based on case series because I don’t know of any trial which really compares the two in a sensible way. So your experience is the same as ours; we ask the plastic surgeons and they use muscle.

Dr. T. Dosios (Athens, Greece): I agree with you that during the first days after the operation, the best treatment of the infection in the mediastinum, is just drainage and not direct repair. I disagree with the use of glucose since we know that glucose is a good substance for culture of bacteria. If you are interested in using a hypertonic solution, I would suggest to use hypertonic sodium chloride, 15%. That’s what I am using in these patients. I soak the gauzes with a hypertonic solution of 15% and I change them twice a day.
Dr Renzulli: Hypertonic solution has a good antibacterial activity, but just on the external tissue. What I said is that we are filling the mediastinum with the sugar. That doesn’t mean a glucose solution anymore. It means at least 500 g of sugar with highest osmolarity: with such amount of glucose we get a hyperosmotic environment where bacteria cannot live. Moreover, to avoid a rise in blood glucose in diabetic patients, we check blood glucose, and we were able to show only a slight increase of blood glucose, well controlled with the supplement of the insulin therapy.

Dr E. Ruffini (Torino, Italy): Do you think that the prevalence of sternal infections would be different in general thoracic surgery and in cardiac surgery? At least in our experience we have minimal incidence of sternal infection. Is it possible that the two populations, the cardiac surgery population and the general thoracic population, are different in terms of risk for infection?

Dr Renzulli: I think it came out in many papers on myasthenia patients who underwent a thymectomy through median sternotomy that although immunodepressed, have a very low incidence of mediastinitis. Cardiac surgery is a different topic. We have the systemic inflammatory reaction from extracorporeal circulation and coagulation disorders contributing to retrosternal hematoma. So incidence of mediastinitis is definitely lower in thoracic surgery patients.

Dr I. Poliakov (Krasnodar, Russia): I never use sugar in these circumstances. Do you use any sterilization method for sugar, and, if so, what method have you used in these circumstances, or is it not necessary to use sterilization methods?

Dr Renzulli: We have a low incidence. We just buy one kilo of sugar and put it in the wound four times a day and that’s it. That’s the main technical option to dress the wound. Granulated sugar, the sugar that we put normally in the coffee, creates such a high hypertonic condition that sterilizes all the infected surfaces.

Dr A. Lerut (Leuven, Belgium): I just have a comment on the sugar. First of all, I was born in a city that has a sugar factory, so I’ve always had an interest in sugar. I’ve been using it for more than 20 years. The way that we are doing it is to mix it up with a neutral pasta-like agar so that it stays well in the wound. The speculation on its action is that through the polysaccharides it is probably stimulating the neoangiogenesis and that this is probably the main factor which is resulting in these real spectacular results that you can obtain with sugar. That’s just an additional comment.