Post-sternotomy chronic osteomyelitis: is sternal resection always necessary?

Maria Pia Toccoa,*, Milva Ballardinib, Marcello Masalac and Antonio Perozzid

a Thoracic Surgery Unit, San Filippo Neri Hospital, Rome, Italy
b Microbiology Unit, San Filippo Neri Hospital, Rome, Italy
c Infectious Disease Unit, San Filippo Neri Hospital, Rome, Italy
d Department of Radiology, San Filippo Neri Hospital, Rome, Italy

* Corresponding author. Thoracic Surgery Unit, San Filippo Neri Hospital, via Martinotti n. 20, Rome, Italy. Tel: +39-06-33062413; fax: +39-06-33062393; e-mail: mptocco@yahoo.it (M.P. Tocco).

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Abstract

OBJECTIVES: The goal of this study was to investigate alternative strategies to the sternal resection in the treatment of post-sternotomy osteomyelitis. We report our experience in the treatment of chronic infection of median sternotomy following open heart surgery without sternal resection.

METHODS: A 4-year retrospective study was performed, consisting of 70 patients affected by post-sternotomy sternocutaneous fistulas due to chronic osteomyelitis: 45 patients underwent only medical treatment and 25 underwent steel wire removal and surgical debridement (conservative surgery). Of the 25, 7 patients underwent an additional vacuum assisted closure (VAC) therapy due to widespread infected subcutaneous tissue. The diagnosis of osteomyelitis was supported via 3D CT scan images.

RESULTS: Complete wound healing was achieved in 67 patients including a patient who achieved healing after being affected by a fistula for over 24 years before coming under our observation, another, affected by mycobacteria other than tuberculosis osteomyelitis, who needed antimicrobial treatment for a period of 30 months and 2 who were affected by Aspergillus infection and needed radical cartilage removal. Fistula relapses were observed in 6 patients of the total 70, possibly due to the too short-term antibiotic therapy used in the presence of coagulase-negative Staphylococcus (CoNS) with multiple resistances and in the presence of Corynebacterium species.

CONCLUSIONS: Post-sternotomy chronic osteomyelitis can be successfully treated mainly by systemic antimicrobial therapy alone, without mandatory surgical treatments, provided that accurate microbiological and radiological studies are performed. The presence of CoNS and Corynebacterium species seemed to be associated with a need for a prolonged combined antimicrobial therapy with a minimum of 6 months up to a maximum of 18 months. The CT scan and the 3D reconstruction of the sternum proved to be a good method to evaluate the status of the sternum and support the treatments. The VAC therapy was not useful in treating osteomyelitis, although, if used appropriately in the postoperative deep sternal wound infection with the sponge fitted between the sternal edges, it seems to be an effective method to eradicate the infection in the sternum and to prevent chronic osteomyelitis.

Keywords: Post-sternotomy sternocutaneous fistula • Post-sternotomy chronic osteomyelitis • Post-sternotomy chronic dehiscence • Chronic sternal wound infection

INTRODUCTION

Sternal chronic osteomyelitis following median sternotomy is a serious complication of open heart surgery, presenting as purulent draining sinus tracts in patients with a closed sternal wound [1]. It is presented as a chronic, low virulence infection, without systemic symptoms, associated with increased healthcare costs and an impaired quality of patient life.

The fistulas occur after the patient is discharge, usually after some weeks, months or even years following the median sternotomy [1–4]. This is the reason why it is very difficult to determine their real incidence. It is thought that the occurrence of sternocutaneous fistulas may be much greater than the international reported values. Furthermore, in the presence of a chronically infected wound dehiscence, it is difficult to understand whether it is a wound infection alone or actually an emergence of an underlying sternal osteomyelitis.

There are very few studies about the incidence and the treatment of sternal chronic osteomyelitis. The eradication of the infection usually requires partial or total sternectomy and often a further excision of all infected costal cartilage, should this also be compromised with the infection, followed by a chest reconstruction by using muscle flaps to fill the chest gap [2, 4]. The surgical treatments are associated with a high rate of morbidity and
postoperative infections, were not always possible to obtain. Bilateral mammary artery in grafting as well as any eventual data regarding the primary surgery and, in particular, the use of This study did not include postoperative chronic infected sequent loss of identity of the pathology.

myelitis usually requires a multidisciplinary approach with a consequent loss of identity of the pathology.

MATERIALS AND METHODS

We conducted a retrospective study of 4 years, starting from 2007, which involved 70 patients, affected by fistula due to post-sternotomy chronic osteomyelitis and treated without sternal resection. All patients underwent open heart surgery through a midline sternotomy: 45 patients had coronary artery bypass grafting (CABG), 10 had CABG plus aortic valve replacement (AVR), 8 had AVR, 4 had ascending aorta replacement, 2 had a mitral valve repair and 1 had an atrial septal defect closure. Fifty-two patients were male and 18 were female with a mean age of 66 years (age range 29–84 years).

A patient was defined as any patient presenting with a sterno-cutaneous fistula or a chronic breakdown in the healed wound involving the soft tissue and the bone, including wound dehiscences existing for a period of over 2 months following surgery. The involvement of the bone in the infection was always corroborated by a 3D reconstruction of the CT scan images (Fig. 1). This study did not include postoperative chronic infected dehiscences.

All patients came from other institutions and because of this, data regarding the primary surgery and, in particular, the use of bilateral mammary artery in grafting as well as any eventual postoperative infections, were not always possible to obtain.

Seven patients developed fistulas after 2–12 months (two patients after 12 months, two after 6 months, one after 4 months and two after 2 months) without history of previous infections. Sixty-three patients had a history of infected wound dehiscences developing after the cardiac surgery. Some of these patients developed the dehiscences in the postoperative period while others, after the discharge or in the cardiological rehabilitation centre. These patients reported a history of proven sternal wound infection in the postoperative period and only 27 of whom had fistulas from the same germs as initially reported, while the remaining 36 patients had developed different germs.

All patients had one or more failed treatments before coming under to our observation. Sixty-seven patients (95%) presented one or more infection risk factors that included diabetes, obesity, chronic obstructive pulmonary disease, the use of bilateral internal mammary arteries for grafting, age, preoperative renal failure, peripheral arterial disease and hypertension. Perioperative risk factors were not included due to the lack of data as the patients came from other institutions. Three patients (4%) did not present any risk factors: a young woman, 30 years of age, who underwent heart surgery (atrial septal defect closure) at the age of 6 and since then, for 24 years, was suffering from a sternocutaneous fistula and 2 male patients, aged 29 and 35, who underwent AVR.

Technique

All patients underwent clinical examination in our outpatient department. They were subjected to laboratory investigations, including C reactive protein and erythrocyte sedimentation rate to assess inflammatory status, as well as chest CT scan and a 3D bone reconstruction to rule out any possible infection in the mediastinum and to assesses the status of the sternum, respectively. After halting any eventual previous antibiotic therapy, a microbiological investigation was carried out to assess the microorganism responsible for the infection. Deep tissue samples were always preferred rather than culture swabs. All patients were treated and monitored by a single surgeon.

The patient pool was divided into two groups: the first group included 25 patients, 23 of whom underwent steel wire removal and surgical debridement (conservative surgery) followed by antimicrobial therapy. In these patients, the decision to perform surgery was based upon the presence of easy-bleeding inflammatory tissue through the fistulas (three patients), or because of a very slow response to the antibiotic therapy (two patients) or due to the presence of multiple fistulas (18 patients). Of these 18 patients, 7 underwent a further vacuum assisted closure (VAC) therapy because of the widespread infected subcutaneous tissue. The foam was positioned above the sternum as the edge of each hemisternum was already calcified together. The remaining 2 patients of the 25 needed an additional radical removal of two cartilages due to the presence of an Aspergillus spp. in the cartilage.

The second group included 45 patients who underwent only medical treatment without the need for surgery. However, all the patients had a previous failure of treatments before coming under our observation: 20 patients (44%) had previous chronic sinus removal, including steel wires at the base of the sinus and 8 (18%) had unknown surgical treatments (probably curettage). Seventeen patients (40%) had repeated medical treatments.
Bacteriological findings

The most common pathogens causing chronic osteomyelitis were Gram-positive bacteria in 67% of the cases. *Staphylococcus* species were observed in 46 patients (65% of the patient pool) with predominance of coagulase-negative *Staphylococci* (CoNS) observed in 28 (60% of the total *Staphylococcus* species).

The CoNS presented methicillin resistance in 89% of the 28 patients and were observed to be in polymicrobial infection in 13 (18%).

*Staphylococcus aureus* was isolated in 18 patients (25% of the patients pool), combination with other germs were found in 3 patients (17% of total *S. aureus*). Methicillin resistance was observed in 13 patients (72%).

*Corynebacterium* species were isolated in 6 patients (10% of the cases) and were always in addition to CoNS. Gram negative were found in 15 patients (21%), of which, 5 were in association with other germs. No growth of bacteria was observed in 10 patients (14%). Fungi were present in four patients (6%). Furthermore, one patient had a mycobacteria other than tuberculosis (MOTT) infection (*Mycobacterium abscessus*) (Table 1).

**Table 1: Isolated organisms**

<table>
<thead>
<tr>
<th>Pathogens</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>CoNS</td>
<td>15</td>
</tr>
<tr>
<td>CoNS-MSSA</td>
<td>2</td>
</tr>
<tr>
<td>CoNS-MRSA</td>
<td>2</td>
</tr>
<tr>
<td>CoNS-Corynebacterium</td>
<td>6</td>
</tr>
<tr>
<td>CoNS-Candida albicans</td>
<td>1</td>
</tr>
<tr>
<td>CoNS-Pseudomonas aeruginosa</td>
<td>1</td>
</tr>
<tr>
<td>CoNS-kpc-producing Klebsiella pneumonia</td>
<td>1</td>
</tr>
<tr>
<td>MRSA</td>
<td>12</td>
</tr>
<tr>
<td>MRSA-Proteus mirabilis</td>
<td>1</td>
</tr>
<tr>
<td>MSSA-Aspergillus spp</td>
<td>1</td>
</tr>
<tr>
<td>MSSA-Morganella morganii</td>
<td>1</td>
</tr>
<tr>
<td>MSSA</td>
<td>3</td>
</tr>
<tr>
<td>Pseudomonas aeruginosa</td>
<td>7</td>
</tr>
<tr>
<td>Aspergillus spp</td>
<td>1</td>
</tr>
<tr>
<td>Enterococcus faecalis-Escherichia coli-Candida albicans</td>
<td>1</td>
</tr>
<tr>
<td>Kpc-producing Klebsiella pneumonia</td>
<td>2</td>
</tr>
<tr>
<td>No growth</td>
<td>10</td>
</tr>
</tbody>
</table>


Radiological findings

In the majority of the patients (56 patients), the CT scan with 3D reconstruction of the bone showed the presence of multiple zones of osteolysis in the midline (exactly in the line of the sternotomy), very often with characteristics of complete erosions (Fig 2a and b). The feature of a single erosion was observed in the patients presenting a single sternocutaneous fistula (14 patients; Fig 3a and b). These radiological images were very important because their localizations suggested that the sternal osteomyelitis could have been a relapse of a previous low virulence and long-standing wound infection caused probably by a nidus of bacteria within the spongy bone (in the substantia spongiosa) and not a primary infection of the steel wires. In fact, the steel wires are most probably involved in the infection only at a second time rather than being the direct cause of the primary infection itself.

**Antimicrobial therapy**

Antimicrobial therapy was always directed against an identified microorganism except in the patients with no growth in the cultures. In these patients, an empirical combined therapy against *Staphylococcus* species was established. In the majority of the patients, the oral regimen was preferred with the combination of two antibiotics; rifampicin was mainly preferred as a second agent, also when resistant, to increase antistaphylococcal activity [7]. When it was necessary, the interaction with oral anticoagulant agents was resolved using enoxaparin instead of warfarin. The drugs and the dosage in patients with normal renal function are listed in Table 2.

The treatments aimed to target CoNS and *Corynebacterium* species also when found in association with other germs. They were always considered agents of infection rather than contaminants (provided deep cultural samples were collected).

The antimicrobial therapy was prolonged from a minimum of 3 months up to a maximum of 30 months, with a mean ± SD of 7 ± 4 months. The full dosages, in the patients with normal renal function, were always used to achieve therapeutic concentrations for the entire duration of the treatment. The relapses reported in five patients affected by CoNS infection and treated using linezolid alone, seemed to be attributable to the short-term therapy, in the presence of pathogens presenting multiple antibiotic resistances. In this matter, linezolid seemed to work very well on the osteomyelitis due to CoNS and *Corynebacterium* species, but its limitation was the 28-day therapy. These patients needed prolonged therapy with other drugs after the relapses.

Very good results were achieved via the use of oral long-term fusidic acid plus rifampicin, but their limitations were the side effects particularly affecting the gastrointestinal tract and causing discomfort such as vomiting. Good results were achieved by using trimethoprim/sulphamethoxazole (TMP-SMX) plus minocyclin, although particular caution was necessary in using TMP-SMX in the presence of reduced renal function.

For the treatment of MRSA, teicoplanin was the only glycopeptide used due to the intramuscular administration. It was used only when the MIC was 0.5 mg/l, in fact, values greater than this excluded its use. Teicoplanin was used in association with rifampicin or minocyclin. Glycopeptides were never considered for the treatment of CoNS infections.

**RESULTS**

In the first group of 25 patients, who underwent conservative surgery, complete wound healing was achieved in 22, supported by the features of the CT scan and a 1-year follow-up. Fistula relapses were observed in six patients and hence, a prolonged antibiotic therapy was needed: in five of the six patients, the therapy lasted 12 months and 18 months in the remaining patient. Two patients needed an additional glucocorticoid therapy due to the presence of inflammatory tissue in the
fistulas. Five patients with fistula relapses had a CoNS infection (in two patients also in combination with Corynebacterium species), in the last patient no growth of germs was observed. Furthermore, one patient was affected by lung cancer and underwent lobectomy at the time of the treatment for the multiple fistulas and another was affected by a diabetic foot.

Two patients of the first group had a fistula in the lower third of the sternum with the presence of *Aspergillus flavus*, in one of whom it was in association with methicillin-susceptible *S. aureus* (MSSA). Surgical debridement was performed and involvement of cartilage in the infection was found. Hence, a radical removal of the seventh cartilage was needed (in one patient bilaterally) followed by a 2-month treatment using oral voriconazole.

The patients in the second group had an antibiotic therapy of 6–18 months, without relapse in a 1-year follow-up; only a patient, who was affected by *M. abscessus* post-sternotomy osteomyelitis, needed 30 months of therapy with cefoxitin 1 g twice a day i.m. plus minocyclin. Another female patient, aged 30, who underwent heart surgery at the age of 6, had been suffering from sternocutaneous fistula by *Pseudomonas aeruginosa* for a period of 24 years before coming under our observation. During the last 24 years she had repeated failed treatments of surgical debridement. The culture sample (biopsy) of the bone showed the persistence of the same germ. A chest CT scan with 3D reconstruction showed an erosion of a few millimeters in the sternum. Cefepim 1 g i.m. twice a day plus oral ciprofloxacin
infected tissue in the entire wound (the presence of multiple
no or low response to the therapy, in patients with evidence of
and performing conservative surgery only in the patients with
combined use of antibiotics for all patients presenting a
nevertheless observed.

500 mg twice a day was started. The response was prompt so the
therapy continued for 12 months. So far, there has not been any
relapse after 12 months of antibiotics suspension. The CT scan
showed a reduction of the erosion following 8 months of therapy.

DISCUSSION

Several publications report the importance of removing the
infected bone for the successful treatment of chronic osteomye-
litis and the need to remove the steel wires because of the pres-
ence of biofilms in the foreign materials [1, 2, 4, 8].

At the beginning of our experience, many patients coming under
our observation presented very serious side pathologies such as reduced renal function, renal insufficiency that needed
haemodialysis treatments, severe cardiomyopathies, etc. (six
patients had severe renal insufficiency, two of them needed
haemodialysis treatments, three had cardiomyopathies and two
had chronic obstructive airway disease needing oxygen therapy). Hence, it would have been very difficult to plan a surgical oper-
ation due to the very high risk of mortality and morbidity.
Furthermore, the high hospital costs due to long hospital stays,
and of the use of expensive parenteral new drugs, forced the need
for less expensive therapeutic alternatives [8, 9]. Due to these
reasons, in these patients, we tried to administer mainly oral anti-
biotic therapies to treat the fistulas with antistaphylococcal activity
evaluating the bone as it is relatively expensive and, in some
patients using mainly oral antibiotic therapy as sternocutaneous
integration and the duration of the therapy, as the medical therapy of
chronic osteomyelitis, reported in many papers, is generally
based on non-randomized studies and on experimental models.
The correct antibiotic duration to ensure an effective ef-
efficacy of
further glucocorticoid therapy was needed). As well as using an
antibiotic therapy, the systemic study of the mediastinum with
CT scan was performed in all patients to rule out the possibility of
deep infections, highlighted by bone erosions in correspond-
ence with the fistulas. These radiological findings supported the
possibility that the sternocutaneous fistulas could have always
been an expression of chronic osteomyelitis. The images of 3D
CT scan showing the presence of osteomyelitis between the
edges of the sternum seemed to be the result of a previous, often
underestimated, infection at the time of sternotomy (Fig. 4). Pre-
vious wound infection and sternal ischaemia, due to the use of mammary artery grafting (in 78% of cases), seemed to
be the major source of osteomyelitis.

In our study, magnetic resonance imaging was not used for
evaluating the bone as it is relatively expensive and, in some
patients, contraindicated (presence of a device, claustrophobia,
obesity, etc.). The leucocyte scintigraphy was also not used in
our study due to the cost and the difficulty in using it routinely.

Regarding the antibiotic choice, we decided to treat these
patients using mainly oral antibiotic therapy as sternocutaneous
fistulas are usually due to a compartmental infection without a
systemic involvement (in fact, only the patients who underwent
steel wire removal needed hospital stay). Overall, the decision to
use oral therapy was supported by the consideration that one of
the major source of fistulas was attributed to CoNS infections
(40% in our study), usually presented without signs of any sys-
temic infection [10].

Another point of discussion is the choice of the antibiotics
and the duration of the therapy, as the medical therapy of
chronic osteomyelitis, reported in many papers, is generally
based on non-randomized studies and on experimental models.
The correct antibiotic duration to ensure an effective efficacy of
the treatment, avoiding the feared relapses, remains a challenge.
In our experience, the relapses observed in the patients who
underwent steel wire removal seemed to be due to the short-

Table 2: Antibiotics used in the treatment of outpatients

<table>
<thead>
<tr>
<th>Pathogens</th>
<th>Antibiotic therapy (oral/intramuscular regimens)</th>
<th>Antibiotics in association</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staphylococcus species</td>
<td>Moxifloxacin 400 mg/day</td>
<td>Rifampicin 600 mg/day</td>
</tr>
<tr>
<td></td>
<td>Levofoxacin 500 mg twice/day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Levofloxacain 500 mg twice/day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minocyclin 100 mg twice/day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TMP/SMX 160/800 twice/day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ceftriaxon 1 g/day (i.m.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cefepim 1 g three or two times/day (i.m.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Teicoplanin 6 mg/kg/day (i.m.) after loading dose</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minocyclin 100 mg twice/day</td>
<td></td>
</tr>
<tr>
<td>Enterococcus faecalis</td>
<td>Linezolid 600 mg twice a day for 28 days followed by</td>
<td></td>
</tr>
<tr>
<td>Enterobacteriaceae</td>
<td>two antibiotics with antistaphylococcal activity</td>
<td>Ceftriaxon 1 g/day (i.m)</td>
</tr>
<tr>
<td></td>
<td>Cefepim 1 g three or two times/day (i.m.)</td>
<td>Ciprofloxacin 500 mg twice a day</td>
</tr>
<tr>
<td></td>
<td>Ciprofloxacin 500 mg twice a day</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colistin 1 m three times/day (i.m.)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Colistin 1 m three times/day (i.m.)</td>
<td></td>
</tr>
<tr>
<td>Kpc-producing Klebsiella pneumoniae</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Doses in normal renal function.
complete resolution of the infection due to the maximum therapy duration which is limited to 28 days [9]. In fact, in all patients, a further prolonged therapy using other antibiotics was necessary to eradicate the infection.

In our experience, the compliance of the patients was very important to achieve a good result. In fact, the failures reported in some patients were often due to voluntary therapy suspension by the patient.

The limitations of our study were the lack of data regarding the cardiac surgery (performed in other institutions) and the microbiological features of previous sternal wound infections: in some patients, it was impossible to know if the fistulas were due to the same bacteria of a previous infection, as in many patients cultures were never collected before coming to our observation. Generally, there was a correlation between postoperative MRSA and gram-negative infections and fistulas sustained by the same germs, but it was not true in patients with fistulas due to CoNS or Corynebacterium species, where the correlation between the previous proven infection and the germs found in the osteomyelitis was never demonstrated. These findings suggest that the CoNS and Corynebacterium species infections should be considered a major and rising cause of infections in open heart surgery [10–12] and that also the superficial sternal wound infection should be observed as a potential source of osteomyelitis. In fact, a superficial sternal wound infection with CoNS is considered, wrongly, benign and self-contained. We believe that a scrupulous observation of all postoperative wound secretions, in the presence of pain, redness, heat or localized swelling, and their culture investigations followed by susceptibility guided antimicrobial therapy can help to prevent the fistulas due to chronic osteomyelitis.

CONCLUSIONS

The findings reported in this study suggest that the aetiology of sternocutaneous fistula was a previous sternal wound infection sometimes proven but not radically treated, sometimes unrecognized or underestimated. The fistulas due to CoNS or to Corynebacterium species were particularly difficult to treat, and associated with a very slow response to the antibiotic therapy due to the high antibiotic resistance, common among these pathogens. In our experience, the debridement and the steel wire removal did not seem to have an important effect on the healing of the fistulas, although they can be useful in selected patients. The essential point in the success of the treatment seemed to be the healing of the therapy: it should not last <6 months, in selected patients, but usually good results in treating the infection are achieved in 1 year, sometimes longer, but always avoiding certain antibiologic monotherapies. What was found to be very effective was the use of rifampicin as a second agent; its anti-staphylococcal activity and bioavailability seemed to be excellent for the treatment of osteomyelitis [7].

In the presence of a reactive, inflammatory tissue, a glucocorticoid therapy was found to facilitate healing [13].

In our opinion, having considered all types of bacteria found in the deep cultural samples as pathogens, including corynebacteria and CoNS, also when found in association with other bacteria, has been the key to the good results obtained in this study.

The VAC therapy was not found to be useful in the treatment of the fistula although it did help to clean the infected wound.

Some patients had history of VAC therapy at the time of the heart surgery, but as reported, they all had the sponge above the sternum rather than between the sternal edges and fitted deep within the mediastinum.

The patients affected by deep sternal wound infection treated in our hospital with the VAC therapy, having the sponge positioned between the edge of each hemisternum and another layer of sponge in the subcutaneous tissue had no infection relapses or osteomyelitis [14]. These findings, in addition to considering any CoNS-positive cultures in the wound secretion after sternotomy as a potential source of osteomyelitis, in our opinion, are the most important points in the prevention of this devastating open heart surgery complication.

Conflict of interest: none declared.

REFERENCES


Figure 4: Sternal osteomyelitis in the midline.