Wound complications after median sternotomy: a single-centre study

Claudia Heilmann*, Rahel Stahl†, Christian Schneider‡, Tetyana Sukhodolya*, Matthias Siepe*, Manfred Olschewski‡ and Friedhelm Beyersdorf

* Department of Cardiovascular Surgery, Heart Center Freiburg University, Freiburg, Germany
† Institute of Medical Microbiology and Hygiene, Medical Center Freiburg University, Freiburg, Germany
‡ Department of Microbiology and Hygiene, Medical Center Freiburg University, Freiburg, Germany

* Corresponding author. Department of Cardiovascular Surgery, Heart Center Freiburg University, Hugstetter Str. 55, 79106 Freiburg, Germany. Tel: +49-761-72200; fax: +49-761-72201; e-mail: claudia.heilmann@universitaets-herzzentrum (C Heilmann).

Received 14 September 2012; accepted 7 December 2012

Abstract

OBJECTIVES: Sternal wound complications following median sternotomy remain a challenge in cardiac surgery. Changes in both patient profile and type of operations have been observed in recent years. Therefore, we analysed current wound healing complications after median sternotomy at our centre.

METHODS: All adult patients undergoing a median sternotomy between January 2009 and April 2011 were included in this retrospective analysis. Transplants and assist devices implantations were omitted. We assessed outcome, prognostic factors and microbiological results of standardized wound swabs.

RESULTS: In total, 1297 patients with an average age of 67.0 ± 12.7 years were analysed. Operation types included 598 solitary coronary artery bypass grafts (CABGs), 213 solitary valve procedures, 105 CABGs with aortic valve replacement and 116 solitary aortic operations or conduit implantations. Furthermore, 255 of the remaining 265 were combined or otherwise complex procedures. Superficial healing disorders occurred in 43 patients (3.3%), while 33 (2.5%) developed deep wound complications. Six patients with sternal wound complications (7.9%) died in-hospital. In 7 patients, no pathogen was identified and the wound appeared uninfected (21% of all deep complications or 0.05% of all patients). These healing disorders were considered deep dehiscences. Patients with insulin-dependent diabetes mellitus, BMI of >40 kg/m² and who underwent reoperation were prone to superficial infections. Risk factors for all deep sternal wound complications were insulin-dependent diabetes mellitus, COPD and reoperation. Moreover, multivariate analysis revealed 'emergency' as an independent prognostic factor for all sternal wound complications. Microbial swabs of the sternal wound were taken in 82 of the 1297 patients (6.6%). Pathogens of the normal skin flora represented the majority of pathogens in both superficial and deep wound complications. Eight patients with deep, but only 2 patients with superficial complications suffered from polymicrobial infections. All deep polymicrobial infections involved coagulase-negative Staphylococci.

CONCLUSIONS: Wound complications following median sternotomy remain a challenge to cardiac surgery. Redo and emergency operations are the most important risk factors in this contemporary series. More efforts seem mandatory to decrease this arduous morbidity and the costs of prolonged treatment.

Keywords: Median sternotomy • Surgical wound infection • Risk factors

OBJECTIVES

Sternal wound complications following median sternotomy remain a challenge in cardiac surgery with a severe burden for the patient and high costs for health care providers [1, 2]. According to previous studies, superficial problems occurred in 1.1–6.7% whereas the incidence of deep sternal wound complications ranged from 0.1 to 3.7% [3–5].

© The Author 2013. Published by Oxford University Press on behalf of the European Association for Cardio-Thoracic Surgery. All rights reserved.
at our centre. Outcome, prognostic factors, and microbiological results of standardized wound swabs were analysed retrospectively.

METHODS

All adult patients undergoing a median sternotomy between January 2009 and April 2011 were included in this retrospective analysis, with the omission of transplants and assist devices implantations.

We aimed to answer the following questions:

(i) What were the clinical characteristics of the study population?
(ii) What were the incidences of sternal wound complications and in-hospital mortality?
(iii) Which pre- and perioperative risk factors were predictive of sternal wound complications?
(iv) What microbial pathogens could be identified?

Data were retrieved from the database of the microbiological laboratory and electronic records of the patients. The diagnosis of deep or superficial wound complication was made according to the Guideline for Prevention of Surgical Site Infection [8]. Superficial wound complications refer to the definition of Superficial Incisional Surgical Site Infection (SSI). Deep infections comprise the definitions Deep Incisional SSI and Organ/Space SSI. In addition, a deep dehiscence was diagnosed if the sternum was unstable, but swabs were negative and there were no clinical signs of an infection.

Emergency was defined as an operation performed before the next working day.

The software SPSS 19.0 was used for statistical analysis. Mortality was compared by the χ² test. For risk factor analysis, two subsets were analysed, which included patient-dependent preoperative and intraoperative parameters, respectively. Univariate analyses of the effect of suspected variables were performed first. Factors with a P-value of ≤0.05 were then included in a multivariate logistic regression analysis. Binary logistic regression analysis was done using the Wald forward method.

Obesity was used as a categorical variable with the categories BMI of <30 kg/m² (reference), ≥30–<40 kg/m², ≥40 kg/m².

RESULTS

Patients

In total, 1297 patients were included. Of these 903 were males (69.6%) and 394 females (30.4%). The average age was 67.0 ± 12.7 years (range 18–91 years, median 70.0 years) with 182 oct- or nonagenerians (14.0%). Clinical characteristics are presented in Table 1.

Operation types included 598 solitary coronary artery bypass grafts (CABGs), 213 solitary valve procedures, 105 CABGs with aortic valve replacement and 116 solitary aortic operations or conduit implantations. Further that 255 of the remaining 265 were combined or otherwise complex procedures.

Table 1: Clinical characteristics of included patients (n = 1297)

<table>
<thead>
<tr>
<th>Preoperative factors</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt; 70 years</td>
<td>622/1297 (48.0)</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>320/1297 (24.7)</td>
</tr>
<tr>
<td>Insulin-dependent</td>
<td>22/1297 (1.7)</td>
</tr>
<tr>
<td>Chronic obstructive pulmonary disease</td>
<td>115/1297 (8.9)</td>
</tr>
<tr>
<td>BMI &gt; 30–40 kg/m²</td>
<td>310/1297 (23.9)</td>
</tr>
<tr>
<td>BMI &gt; 40 kg/m²</td>
<td>14/1297 (1.1)</td>
</tr>
<tr>
<td>Peripheral arterial disease</td>
<td>120/1297 (9.3)</td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td>183/1297 (14.1)</td>
</tr>
<tr>
<td>Cardiogenic shock</td>
<td>81/1297 (6.2)</td>
</tr>
<tr>
<td>Creatinine &gt; 2 mg/dl</td>
<td>78/1273 (6.1)</td>
</tr>
<tr>
<td>Terminal renal insufficiency</td>
<td>18/1297 (1.4)</td>
</tr>
<tr>
<td>Emergency</td>
<td>151/1297 (11.6)</td>
</tr>
<tr>
<td>Intra- and postoperative factors</td>
<td>n (%) mean ± SD</td>
</tr>
<tr>
<td>Operation time</td>
<td>266 ± 89 min</td>
</tr>
<tr>
<td>CPB duration</td>
<td>1294/1297 (99.8), 117 ± 56 min</td>
</tr>
<tr>
<td>CPB &gt; 200 min</td>
<td>79/1297 (6.1)</td>
</tr>
<tr>
<td>Aortic clamping duration</td>
<td>1273/1297 (98.1), 89 ± 37 min</td>
</tr>
<tr>
<td>Reoperation</td>
<td>101/1297 (7.8)</td>
</tr>
<tr>
<td>Bilateral internal mammary artery</td>
<td>63/1297 (4.9)</td>
</tr>
<tr>
<td>Intra-aortic balloon pump</td>
<td>61/1297 (4.7)</td>
</tr>
<tr>
<td>Revision</td>
<td>69/1297 (5.3)</td>
</tr>
</tbody>
</table>

Complications and mortality

Seventy-six of the 1297 patients developed sternal wound complications: superficial healing disorders were observed in 3.3% of patients (n = 43). Six additional patients had positive superficial swabs with skin colonizers, but no signs of wound healing problems were observed. They were excluded from risk factor analysis.

Deep complications occurred in 2.5% of patients (n = 33). In 7 patients (21 or 0.05% of all patients) of this group, the wound appeared uninfected and was considered a deep dehiscence.

Antibiotic treatment was given according to the standard operating protocol. Vacuum-assisted closure (VAC) therapy was applied to 28% (n = 12) and 58% (n = 19) of patients with superficial and deep wound problems, respectively. Sternal revision was required in 45% of patients with deep infections (n = 15 of 24) and 44% with deep dehiscence (n = 4 of 9).

7.9% of the patients with sternal wound complications died in-hospital (n = 6/76). These were 4.6% of patients (n = 2) with superficial and 12.1% of patients with deep complications (n = 4). In comparison, 5.0% patients without healing disorders died (n = 61/1221). Mortality was not increased in the groups with sternal complications (P = 0.19 between superficial, deep and no complication; P = 0.068 deep vs superficial or no complication). However, patients with wound healing disorders stayed longer in-hospital (P < 0.001).

Risk factors

Patients with a BMI of >40 kg/m² or who underwent reoperation were prone to superficial complications (Table 2). Predetermined risk factors for deep sternal wound complications were insulin-dependent diabetes mellitus, chronic obstructive pulmonary disease (COPD) and reoperation (Table 3). The same
risk factors were found when only deep infections, but not sterile dehiscences, were considered (Table 4).

In addition, multivariate analysis revealed emergency as an independent prognostic factor for all sternal wound complications (Table 5). Prognostic effects of the preoperative patient-dependent factors age, gender, non-insulin-dependent diabetes mellitus, BMI of 30–40 kg/m², shock, previous myocardial infarction, peripheral artery disease (PAD) and any renal insufficiency were not significant in the univariate analysis. Further, the intraoperative variables duration of operation, cardiopulmonary bypass, and aortic clamping, use of bilateral internal mammary artery (BIMA), lowest intraoperative temperature <35.3°C, implantation of an intra-aortic balloon pump, and repeated sternotomy for revision did not independently increase the risk of either superficial or deep sternal wound complications.

Probable clinical causes for non-infectious deep dehiscences were COPD, substernal seroma or haematoma in 2 patients each and postoperative delirium in 1.

**Microbial results**

Microbial swabs of the sternal wound were taken in 82 of the 1297 patients (6.6%). The majority of pathogens found in both deep and superficial sternal wound complications belonged to the normal skin flora. However, a number of more aggressive agents was also identified (Table 6).

Infections with more than one type of pathogen were found in 8 patients with deep, but only in 2 patients with superficial, complications. Coagulase-negative *Staphylococci* were involved in all deep, but not in both superficial polymicrobial infections.

No pathogen was found in only 3 of the 43 patients with superficial complications (7.0%). Another 6 patients had positive swabs with skin colonizers, but no signs at all of wound healing problems.

Further, no pathogen was identified in 9 patients with deep wound healing problems. Two of them presented clinical signs of infection. Seven patients suffered from a deep dehiscence.

**DISCUSSION**

We analysed sternal wound complications in 1297 consecutive patients who underwent a median sternotomy for cardiac surgery. Superficial wound problems occurred in 3.5% of all patients, 2.5% suffered deep complications and a non-infectious deep healing disorder was observed in 0.05%. Approximately 8% of all patients with sternal wound complications died in-hospital. Emergency was identified as an independent risk factor for both complication types. The most frequent pathogens were colonizers of skin folds.
Table 4: Risk factors for deep infections only (multivariate)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>OR</th>
<th>95% CI limits</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM (insulin)</td>
<td>15.7</td>
<td>4.7–51.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>COPD</td>
<td>6.7</td>
<td>2.7–16.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Resternotomy</td>
<td>5.1</td>
<td>1.9–13.7</td>
<td>0.001</td>
</tr>
<tr>
<td>Emergency</td>
<td>3.0</td>
<td>1.2–7.8</td>
<td>0.024</td>
</tr>
</tbody>
</table>

OR: odds ratio; CI: confidence interval; DM: diabetes mellitus; BMI: body mass index; COPD: chronic obstructive pulmonary disease.

Table 5: Risk factors for all sternal wound complications in multivariate analysis (n = 76/1297)

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>OR</th>
<th>95% CI limits</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI &gt;40 kg/m²</td>
<td>11.5</td>
<td>3.5–38.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>DM (insulin)</td>
<td>5.4</td>
<td>1.8–16.1</td>
<td>0.003</td>
</tr>
<tr>
<td>Resternotomy</td>
<td>4.1</td>
<td>2.2–7.6</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Emergency</td>
<td>3.5</td>
<td>2.0–6.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>COPD</td>
<td>2.2</td>
<td>1.1–4.4</td>
<td>0.021</td>
</tr>
</tbody>
</table>

OR: odds ratio; CI: confidence interval; DM: diabetes mellitus; BMI: body mass index; COPD: chronic obstructive pulmonary disease.

Sternal wound complications and mortality

Superficial and deep sternal wound complications were classified according to the Guideline for Prevention of Surgical Site Infection [8]. In general, the reliability of microbial swabs, especially of superficial ones, is subject to discussion in many cases and it seems impossible to differentiate between the actual infectious agent and contamination. However, this distinction may be considered irrelevant, since wound complications are caused by skin colonizers in the majority of patients [9]. Wound infections and non-infected dehiscences are almost never discriminated in superficial complications, and therefore we also refrained from this distinction. In contrast, swabs taken from the depth of the wound during an operation can be assumed to reflect the true situation. Microbial pathogens can escape detection due to previous antibiotic therapy, effective immunological elimination, low number of pathogens and preanalytic errors. However, in cases of a sterile aspect of the wound, e.g. occurrence of a seroma, and lacking the detection of pathogens, the diagnosis of a non-infectious wound dehiscence can be made. The incidence is reported to range from 0.4 to 3.7% [4, 10].

In our data set, the mortality in patients with sternal wound complications was not increased. However, this could be a statistical effect, since we observed a tendency to higher mortality in patients with deep healing disorders. Of note, no patient with a non-infectious deep complication died.

It is probable that not only the risk profile of patients, but also the capabilities of cardiac intensive care have increased in the last few years. In addition, the determined use of VAC could have contributed to our positive results. This procedure has gained wide acceptance in the last few years and has shown superior results in comparison with conventional therapy [11–13].

Risk factors

The analysis of risk factors corresponds by and large with previous studies. These analyses were single or multicentre studies that comprised 815 [4], approx. 3000 [3] and approx. 23 500 patients [5], respectively or referred to a national database and included over 330 000 patients [14]. Insulin-dependent diabetes mellitus was the most serious predisposing factor for deep infections with an odds ratio (OR) of 15.7 in our study. In contrast, it had no independent influence on superficial complications. This indicates that severe immunological impairment could play an important role in the development of deep sternal wound infections. In addition, mechanical strain on the sternum due to COPD seems to be a frequent reason for sternal instability but not for superficial complications in our study. Preoperative New York Heart Association class IV status was identified as another risk factor for non-infectious deep complication in a study by Olbrecht et al. [10] on 12 380 patients of whom 0.4% experienced a noninfectious deep healing disorder. In contrast, Schimmer et al. [4] analysed 815 patients with sterile dehiscences in 3.2% of them and found impaired renal function, PAD and immunosuppression (4.5% of patients) to be predictive, but not COPD or BMI of >30. We found no increased risk associated with renal insufficiency or PAD. New York Heart Association status and immunosuppression were not included in our analysis. Very high BMI and resternotomy of the healed bone increased the risk of superficial problems.

Use of BIMA was not a risk factor for deep sternal wound complications in our population in contrast to previously published data [3–5]. Our result is, however, in accordance with a recent publication that found the use of BIMA to be as safe as that of unilateral IMA even in diabetic patients [15]. In addition, age did not increase risk, unlike in observations from studies on procedures done in the late 1990s and early 2000s, either for superficial [3] or for deep wound healing complications [5, 14]. Interestingly, a surveillance of 23 500 patients by Baillot et al. [5] identified age as a risk factor during the time period from 1992–2001, but this was no longer the case between 2002 and 2007.
Of note, emergency was a significant independent risk factor for all types of complications with an OR of 3.1–8.0. High urgent surgery implies conditions that cannot be altered: there is not enough time for several recommended procedures [8, 16], such as optimizing blood glucose levels, implementing antiseptic measures, screening for methicillin-resistant *Staphylococcus aureus* (MRSA) or the timely application of prophylactic antibiotics. Patients are likely to be in poor general condition and immunologically compromised. For the surgeon, emergency cases present an important stressor [17]. Interestingly, techniques that hereby help to reduce complication rates [19]. A specific guideline for cardiac surgery has been published recently [20]. Its effectiveness in reducing mortality and complication rates including wound healing complications after median sternotomy will be subject to future analysis.

**Microbial pathogens**

Elements of the normal skin flora, specifically, coagulase-negative *Staphylococci* were identified most often in our population. Together with a spectrum of other pathogens, this is in accordance with previous studies [5, 21]. Infections with MRSA have decreased in recent years due to massive efforts for screening, decolonization and antibiotic prophylaxis [21, 22].

**Limitations of the study**

We present a retrospective study. Classification of complications was made according to the patients’ charts. We also omitted some risk factors that were not recorded in a standardized fashion. The analysis of diabetes mellitus as a risk factor would have been even more reliable with the use of HbA1C instead of the ICD10 diagnosis only.

**Conclusion**

Wound complications following median sternotomy are still a challenge to cardiac surgery. Redo and emergency surgery were identified as the most important risk factors in this contemporary series. Increased efforts are necessary to reduce the incidence of this morbidity and avoid expensive treatment.

**ACKNOWLEDGEMENT**

The technical support by Carola Glotz and Josef Schiefele is highly appreciated.

**Conflict of interest**: none declared.

**REFERENCES**


APPENDIX. CONFERENCE AND DISCUSSION

Dr T. Langanay (Rennes, France): You are brave, as I told you yesterday, to communicate on such a subject. We always prefer to emphasize our successes rather than our problems, despite the fact that we probably learn more from our complications than from our victories.

I would like to ask you two questions, the first one from a technical viewpoint. If I understood correctly, you state in your manuscript that only half of your patients with deep sternal wound infection have been reopened and that vacuum therapy was your first choice. Do you mean that half of the patients have not been reopened, and what is your experience with Redivac?

And the second question is also a comment. When you tell us that mortality is not increased in cases of deep infection, don't you think that it is maybe related to the small number of patients involved in the group with deep sternal infection, because with 12% mortality versus 5%, at least there is a trend. And I would prefer, as I think everybody here would, to be in the group of 5% mortality rather than 12%.

Dr Heilmann: The policy with regard to resternotomy or reopening the sternum is that if the sternum is not stable and the infection is clearly above the sternum, then the wires are refastened and vacuum therapy is placed above it. And if the infection comes from the sternum level or below, then the sternum is indeed reopened, and the vacuum therapy is applied between the sternal halves.

As to the second question, you are completely right in the matter of statistics. We had about 5% mortality in the group without complications and in the group with superficial infections, and we had a mortality of 12% in patients with deep infections. But the statistical effect is probably due to the low numbers of patients and of mortality. And you can clearly recognize the trend towards a higher mortality with this P value of 0.068.

Dr Langanay: Do you have any experience in your group with Redivac therapy in deep infection? Because, if I understood well once again, you left the sternum open and then you placed the VAC. Is that correct?

Dr Heilmann: Yes.

Dr Langanay: So for the patient and for all the team it is a rather time-consuming process, the daily business of checking and dealing with the patient. If you use a Redivac, you place the Redivac, then you close the chest, and it is less onerous for the patient and the team. Do you have this experience or not? In France, it is quite common to use Redivac.

Dr Heilmann: Well, we prefer to have the sternum open in those cases.

Dr B. Aberg (Karlskrona, Sweden): I did not get whether you told us what kind of protocol you have for antibiotic prophylaxis? I know some centres in the United States have been very aggressive over recent years with vancomycin and the combination of two antibiotics.

Dr Heilmann: We have a standard protocol for all median sternotomy that is cefuroxime during the operation and for three days afterwards. And in the case of infection, we rely on the antibiogram.

Dr M. Bitner (Lodz, Poland): When do you consider that the wound should be closed after VAC therapy?

Dr Heilmann: Right now we need the clinical aspect of clean healing, and we still need three consecutive negative antibiograms. But we are thinking about changing this policy because it involves a long period of time for the patient and for us too.

Dr R. Deac (Targu-Mures, Romania): In the case of an unstable sternum without sign of infection, would you consider early rewiring if the patient has some other risk factor such as being overweight, redo, and so on?

Dr Heilmann: Well, if the sternum is unstable and the patient is at risk for more complications, we do it fast.

Dr Deac: As soon as possible?

Dr Heilmann: Yes, of course.

eComment. Poststernotomy infections without flaps

Author: Jan J. van Wingerden

Department of Plastic and Reconstructive Surgery, University of Amsterdam, Amsterdam, Netherlands
doi:10.1093/icvts/ivt137
© The Author 2013. Published by Oxford University Press on behalf of the European Association for Cardio-Thoracic Surgery. All rights reserved.

This well written and referenced study by Heilmann and colleagues [1] describes the experience of a single-centre over a period of two years, and includes 1297 patients. Of these, 2% (n = 24), developed deep incisional surgical site infection (SSI) and organ/space SSI according to a 1991, Centers for Disease Control (CDC) Guideline. A few salient points warrant highlighting.

If we accept that microbial swabs (n = 82) were taken of all suspected and confirmed superficial and deep wound complications (n = 76), the analysis of the infective agent is representative. Two points are then of interest: firstly, the finding that coagulase-negative Staphylococci (CoNS) were involved in all deep, but none of the superficial poststernotomy wound infections supports an earlier observation that CoNS is becoming more of a threat and more specific preventative measures should be developed to counter this threat [2]. Secondly, the microbial swabs and cultures were negative in two (8.3%) of the 24 patients who presented with clinical deep sternal wound infections. This figure is high enough to emphasize that alertness to the possibility of a deep sternal wound infection is more important than reliance on the outcome of microbial swabs alone.

Finally, 62.5% (15 of 24, not 45%, as the authors suggested) of patients with deep sternal wound infections required sternal “revision” and a slightly lower percentage (58%) were additionally managed with vacuum assisted closure (VAC) therapy. It would be of interest to know how the rest of the group of patients was managed, if not by VAC-therapy: was continuous drainage or an alternative method of open management used? Of particular interest, no mention of revascularization by means of flap surgery (muscle or omentum) was made. Unless the authors routinely advance the pectoral muscles medially, following sternal revision and wound closure, the lack of need for flap surgery could indicate that the diagnosis was made very early, when no or minimal sternal destruction had occurred and for this, the authors should be commended.

Conflict of interest: none declared.

References