Institutional report - Cardiac general

Decrease of deep sternal surgical site infection rates after cardiac surgery by a comprehensive infection control program

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Abstract

When we noticed an increasing incidence of deep sternal surgical site infections (DSSI), a bundle of interdisciplinary infection control measures was initiated in order to prevent further cases of DSSI. Adherence to infection control measures was re-inforced, which included (1) methicillin-resistant Staphylococcus aureus (MRSA) screening, (2) bacterial decolonisation measures, (3) hair clipping instead of shaving, (4) education, (5) good stewardship for antibiotic prophylaxis, (6) change of surgical gloves after sternotomy and after sternal wiring, (7) new bandage techniques, (8) leaving the wound primarily covered for at least 48 h. We checked for potential risk factors in a case–control study (120 patients each) by multivariate analysis. A significant decrease of DSSI from 3.61% (CI 95: 2.98–4.35) down to 1.83% (CI 95: 1.08–2.90) occurred. Independent significant risk factors for DSSI were age > 68 years (OR = 2.47; CI 95: 1.33–4.60), diabetes mellitus (OR = 4.84; CI 95: 2.25–10.4), and intra-operative blood glucose level > 8 mmol/l (OR = 2.27; CI 95: 1.17–4.42). Protective factors were preoperative antibiotic prophylaxis (OR = 0.31; CI 95: 0.13–0.70) and extubation on the day of surgery (OR = 0.25; CI 95: 0.11–0.55). Close co-operation between clinical physicians and the infection control team significantly reduced the rate of DSSI. Thus, cardiac surgeons should know the local baseline DSSI rate, e.g. by surveillance, and should be aware of the risk factors for DSSI cases.

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Keywords: Deep sternal wound infections; Cardiac surgery; Risk factor analysis; Prevention measures

1. Introduction

Deep sternal surgical site infections (DSSI) are a devastating complication after cardiac surgery. In Germany, the DSSI incidence is currently estimated ranging from 1 to 4% while DSSI-associated mortality is assumed to be 15–40% [1, 2]. Previous studies have recognized a number of patient-related risk factors [1, 2].

However, other factors may also have a significant impact on the overall outcome. For example, such ‘external’ factors may include surgical technique and the type of causative pathogen.

The infection control department got notified about a rising incidence of DSSI in the thoracic surgical department of our tertiary care university hospital. Immediately, prospective surveillance was performed and a bundle of infection control measures was introduced. We also carried out a case–control study to characterize patients who are especially at risk of acquiring DSSI.

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2. Materials and methods

2.1. Setting

This single institution study was conducted at the department of cardiac, thoracic, transplantation and vascular surgery of Hannover Medical School. Approximately 2300 patients per year undergo median sternotomy in this department for various reasons.

2.2. Timeline

The investigation period included 27 months (from January 2006 to March 2008). When informed about an increase in the local DSSI rate, retrospective surveillance was performed for 21 months to (1) confirm this impression and (2) to perform a case–control study for risk factor determination. All procedures were investigated. During the second time frame of six months an appropriate bundle of infection control measures was discussed, strengthened, or newly introduced. Prospective surveillance of DSSI including timely feed-back of results to surgeons was performed to (1) confirm success of the measures applied and (2) to promote alertness of new DSSI cases in the second time frame.
2.3. Staff

Staff from various kinds of medical departments were involved in the infection control team including cardiac surgeons and nurses in the operating theatre, anaesthesiologists, technicians, physicians and nurses on the ward, and people from the infection control department.

2.4. Preoperative infection control measures

(1) Nasal and oral screening for methicillin-resistant Staphylococcus aureus (MRSA), (2) use of intranasal mupirocin ointment, (3) use of a chlorhexidine throat rinse, (4) use of antiseptic body scrub, (5) use of single-use towels, (6) using hair clippers only instead of shaving on the operation day, (7) implementation of a standard operation protocol for all infection control measures, (8) documentation of their successful application using a rubber stamp in the patient’s file, and (9) information of the patients themselves about appropriate infection control measures before cardiac surgery by a newly created information sheet of paper.

2.5. Intra-operative infection control measures

(10) Application, timing and documentation of the antibiotic prophylaxis was improved, (11) surgical gloves got changed after sternotomy and before closure of the wound by the surgeon, (12) a new cover for the incision site was introduced, and (13) frequent education of surgeons and medical students in the operating theatre was performed.

2.6. Postoperative infection control measures

(14) Use of new bandage techniques (allowing removal of thoracic drainages without the need to remove a clean and dry sternal dressing), (15) keeping first dressing of the wound in place for at least 48 h, and (16) continuous feed-back of DSSI surveillance results.

2.7. Cases for the case–control study

A critical review of the current medical literature was performed to check for known risk factors for DSSI development. DSSI cases were defined according to the definitions of Centers of Disease Control and Prevention (CDC) [3]. We excluded patients when younger than 18 years of age, organ transplant patients, emergencies, and patients presenting with an obvious infection at any other site before and during the study period.

2.8. Controls for the case–control study

Controls needed to undergo the same surgical procedure following after a case, but lacking the diagnosis of DSSI during or after hospital stay.

2.9. Risk factor analysis

We checked for potential risk factors in a case–control study (120 patients each) by multivariate analysis: (1) diabetes mellitus, (2) body mass index (BMI) >25, (3) COPD, (4) renal insufficiency, (5) nicotine abuse, (6) immunosuppression, (7) length of hospital (LOS) stay before surgery, (8) ASA-score, (9) wound contamination class, (10) duration of extracorporeal circulation (ECC), (11) correct timing of antibiotic prophylaxis, (12) blood glucose levels, (13) duration of mechanical ventilation, (14) LOS on an intensive care unit (ICU), and (15) total hospital LOS. The following demographic data and risk factors were recorded for each patient: (1) age, (2) gender, (3) BMI, (4) type of surgical procedure, (5) diabetes mellitus, (6) chronic obstructive lung disease (COLD), (7) renal insufficiency, (8) nicotine abuse, (9) immune suppression of any kind, (10) hospital LOS before surgery, (11) ASA-score, (12) wound contamination class, (13) date of operation, (14) duration of the procedure, (15) ECC time, (16) appropriate application of an antibiotic prophylaxis using a 3rd generation cephalosporin, (17) preoperative, intra-operative and postoperative blood glucose levels, (18) extubation time, (19) LOS on an ICU, and (20) overall hospital LOS until discharge.

3. Results

3.1. Infection rates over time

During the observational 27-month period (January 2006 until March 2008) a total of 4130 cardiac surgical procedures were performed. After the changes of infection control, we recognized a reduction in the incidence of DSSI in the second six-month time period from October 2007 to March 2008. The incidence rate significantly ($P<0.001$) decreased from 3.61% (CI 95: 2.98–4.35) to 1.83 (CI 95: 1.08–2.90) as shown in Table 1.

3.2. DSSI cases

One hundred and twenty DSSI cases got included in the risk factor analysis. Patient characteristics are shown in Table 2. The median ASA-score was 3.

One-hundred (83%) of the 120 cases were diagnosed during their hospital stay in our facility already or during stay in a rehabilitation clinic. The remaining 20 (17%) cases were diagnosed when re-admitted to the hospital. Overall, 27 (22.5%) events of DSSI occurred after first discharge of the patient. In 112 (93.3%) cases, up to four different microorganisms were cultured in the microbiological laboratory. Most frequently cultured isolates were coagulase negative staphylococci (39%), S. aureus (23%; with a proportion of 52% MRSA), and enterococci (10%). The mean time after

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Incidence of deep sternal surgical site infection before and after intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of DSSI</td>
<td>114</td>
</tr>
<tr>
<td>Number of cardiac surgical procedures</td>
<td>3150</td>
</tr>
<tr>
<td>Incidence (DSSI/100 cardiac surgical procedures)</td>
<td>3.61%</td>
</tr>
<tr>
<td>95% Confidence Interval</td>
<td>2.98–4.35</td>
</tr>
</tbody>
</table>

DSSI, deep sternal surgical site infection.
surgery until the diagnosis of DSSI was 13.4 (median: 19) days.

3.3. Risk factor analysis

The results of the risk factor analysis are shown in Table 3. We identified age older than median age of 68 years (OR 2.47, 95% CI: 1.33–4.60), diabetes mellitus (OR 4.84; 95% CI: 2.25–10.40), and an intra-operative blood glucose concentration > 8 mmol/l (OR 2.27; 95% CI: 1.17–4.42) as significant risk factors for DSSI development. In contrast, antibiotic prophylaxis (OR 0.31; 95% CI: 0.13–0.70) and extubation within 24 h postoperative (OR 0.25; 95% CI: 0.11–0.55) were associated with lower DSSI rates.

3.4. Outcomes

As shown in Table 4, the mean hospital LOS of cases and controls was 56 days and 14 days, respectively (median: 41 vs. 13 days). LOS on an ICU was also significantly longer for DSSI case patients (median: 2 vs. 0 days).

4. Discussion

We noted significant reductions of 51% in DSSI and low infection after the implementation of prevention measures.

Table 2

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>Cases* (n = 120)</th>
<th>Controls* (n = 120)</th>
<th>P-value**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>69</td>
<td>67</td>
<td>0.138</td>
</tr>
<tr>
<td>LOS before surgery (h)</td>
<td>70</td>
<td>68</td>
<td>0.296</td>
</tr>
<tr>
<td>Duration of OP (min)</td>
<td>195.5</td>
<td>189</td>
<td>0.038</td>
</tr>
<tr>
<td>Bypass time (min)</td>
<td>90.5</td>
<td>83.5</td>
<td>0.009</td>
</tr>
<tr>
<td>Preoperative blood glucose level (mmol/l)</td>
<td>6.8</td>
<td>6.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Intra-operative blood glucose level (mmol/l)</td>
<td>8.3</td>
<td>8.0</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Table 4

<table>
<thead>
<tr>
<th>Assessment of outcomes associated with deep sternal surgical site infections</th>
<th>Cases* (n = 120)</th>
<th>Controls* (n = 120)</th>
<th>P-value**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital LOS (d)</td>
<td>41</td>
<td>13</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LOS in ICU (d)</td>
<td>7</td>
<td>0</td>
<td>0.003</td>
</tr>
<tr>
<td>Time frame (d) until DSSI</td>
<td>19</td>
<td>9</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

DSSI, deep sternal surgical site infection; LOS, length of stay; ICU, intensive care unit.

The acceptance in all departments was high which can be seen in the fast decreasing levels. The success of our study is based on a multimodal concept.

Most of the cases (83%) were diagnosed during hospital stay or rehabilitation in a rehabilitation clinic. Seventeen percent were diagnosed by re-admission. Patients are discharged at the tenth day after operation if there is no other serious problem that requires extra hospitalisation. All re-admitted patients (17%) showed DSSI, so it seems to be necessary to give patients information and to train staff at rehabilitation clinics in first signs of sternal wound infections to react immediately and to avoid further DSSI.

The mean duration of stay in the hospital (56.2 days vs. 14 days, median 41 vs. 13 days) was longer for patients with DSSI. We could not get significance, because we cannot show clearly if a longer stay is due to an infection or if the infection causes a longer stay. It is undeniable that a stay which is more than four times longer causes much more costs, the stay at ICU and costs which result from several revision operations can be added. Both case and control group show remarkable extension of LOS than the average which can be caused by higher morbidity (mean ASA-score = 3) of both groups.

4.1. Infection control measures

Although microbiologic findings were diverse, gram-positive organisms were most frequently implicated in the patients, which is postulated by the change of the peri-

DSSI, deep sternal surgical site infection; n.d., not determined.

*Data presented as medians; **McNemar’s test was used; ***OR, odds ratio; conditional logistic regression was used.
operative antibiotic prophylaxis to cephalosporins [4, 5]. Endogenous and exogenous pathways play a role in DSSI, the route of transmission may be permeable gloves of the staff, but also patients own skin [6, 7]. This fact shows the need for a multimodal concept of prevention measures. Coagulase-negative Staphylococci were isolated most frequently, which represents the common development and we had not only to improve the preoperative antibiotic prophylaxis, but also double-gloving, change of gloves after critical procedures and the improved cover technique.

S. aureus was also isolated very often and the proportion of MRSA was really high, which is typical for this kind of infection [8]. This is an argument for our decolonisation measures. It is well described that nasal carriage of S. aureus and MRSA increases the risk of surgical site infection in cardiac surgery [9]. Nasal carriers of S. aureus have a significant higher incidence of surgical site infection than non-carriers. Multiple studies have demonstrated that nasal colonisation and infection is due to the same strain [10, 11].

Although we have limitations in this study such as incomplete post discharge surveillance, study of surface wound infections and small sample size, we could find important results in this study, even some of the risk factors are influenceable.

Observing, recording and feedback were integral parts of the intervention program. Continuous surveillance will be necessary to control the DSSI rates and interdisciplinary work will help to keep them on a low level. Implementation of prospective surveillance and the confidential reporting of infection rates have been associated with 20–50% reductions in SSI rates [4, 5]. Other components of the intervention (e.g. decolonisation, elimination of hair shaving through use of hair clippers, change of gloves and improved coverage technique) probably contributed through independent mechanisms, as well as through positive influences on operating room discipline, but these components have not been evaluated individually.

4.2. Risk factor analysis

Our data mainly confirm the results of previous risk factor analyses. Unfortunately, we cannot eliminate the risk factors, but these findings should assist clinicians in identifying patients who are at increased risk of DSSI, as well as in developing strategies to minimize modifiable risks [12, 13].

High age, D. mellitus and high intraoperative blood glucose have been recognized as factors with an increased risk of DSWI. D. mellitus and high intra-operative blood glucose levels are known to be risk factors for the development of DSSI [14].

Those factors can be detected preoperatively and fortunately influenced by the physicians.

Perioperative antibiotic prophylaxis and extubation during 24 h after operation were associated with low DSSI levels. Especially, the perioperative antibiotic prophylaxis as a protective factor is in the hands of clinicians and should get attention.

It was recommended to apply the perioperative antibiotic prophylaxis after the first venous puncture during operation preparation to achieve the infusion time between two hours and thirty minutes before operation. Due to this new standard we could not only improve the number of infusions, but also the right infusion time.

We had the opportunity to educate the participating departments altogether, so we were able to discuss important points such as practicability of prevention measures altogether and to develop strategies to optimize the working process.

The idea was not to set new regulations by the department of hygiene but to develop and improve the new measures altogether.

We demonstrated significant reductions in DSSI rates following implementation of a comprehensive infection control program. Similar programs at other institutions would be an effective strategy for control and prevention of DSSI. Further studies will be needed to evaluate program efficacy in different types of institutions. Long-term surveillance of infection rates and follow-up of compliance will be required.

References


