Institutional report - Cardiac general

A multimodal approach for reducing wound infections after sternotomy

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Abstract

As previous efforts failed to reduce infection rates after cardiac surgery at our institution, we developed a concept based on adjustment of surgical technique. This concept was then evaluated in clinical practice. We modified our surgical technique towards: minimizing contamination, avoidance of devitalizing tissue, and securing a rigid fixation of the caudal part of sternum. After a pilot series sequential series was compared before and after introduction of the modified technique in a case-series design. All surgical site infections were recorded at discharge, after 6 weeks and by the attending cardiologist at 2 and 6 months. In the pilot series 9/136 patients developed sternal wound infections (SWI) compared with 15/89 patients in the control group \( P = 0.015 \). In the larger study population we found a significant drop in the total number of SWIs (72/772 vs 124/772, \( P < 0.001 \)). Although not statistically significant a 32% reduction in deep SWIs was observed. No reduction in infections at harvest sites for graft material was seen. The preliminary results from the pilot study appear reproducible and we were able to reduce the incidence of SWIs significantly, using this simple modified surgical technique.

1. Introduction

Surgical wound infection remains a major problem in cardiac surgery and occurs mainly after full sternotomy [1]. Further risk factor analyses have revealed diabetes, hyperglycemia, obesity, and use of double IMA to be associated with deep sternal wound infection (DSWI). On the other hand it is generally accepted that different surgeons have different rates of operative complications such as postoperative infection [2]. Differences between surgeons are commonly attributed to varying degree of difficulty in the surgical procedures performed, risk factors for complications or to the level of surgical training. However it may be assumed that differences in infection rates also may be credited to differences in surgical techniques. Infection rates would thus be possible to influence by adopting an improved technique. Steps in this direction has been taken in describing different methods for wound closure, management of obese patients and methods to achieve a secure fixation of the sternotomy [3,4] Furthermore, it has been reported that bacteria may be cultured from a majority of surgical wounds during heart surgery [5]; hence we developed a concept of maintaining wound resistance to infection in a setting were bacterial contamination must be anticipated. The basis of wound protection in this study was based on bedside observation of the course of an evolving infection. This concept of wound protection by surgical technique was evaluated in a pilot study that supported the idea that an altered surgical technique may reduce infection rates. The aim of this study was to evaluate whether wound infection rates would decrease if this concept is to be implemented generally at our department.

2. Patients and design

With a case-series design infection rate in sequential cohorts of patients was studied. Beginning in March 1998 until the end of 1999 a study group (A) of 136 patients undergoing heart surgery was operated with a surgical technique described in Section 3. For comparison a group (B) of patients \((n = 89)\) operated by the same surgical team during 1997 until the end of February 1998 were chosen. After implementing changes in surgical technique, SWIs were then compared in 772 of 845 patients (C) operated during...
2000 with 772 of 825 patients predominantly operated with conventional technique in 1999 (D). A flow chart is provided in Table 1. All patients undergoing heart surgery from a region of 970 000 inhabitants were included. The only exclusion criterion was incomplete data on follow-up (Table 2).

3. Methods

3.1. Clinical management

All patients had preoperative skin disinfections with chlorhexidine detergent wash the evening before, in the morning before surgery and on the operating table after anesthesia. Chlorhexidine in ethanol was then used for skin preparation. Cloxacillin–sodium 2 g (Ekvacillin®) was administered for antibiotic prophylaxis with four doses during the first 24 h.

3.2. Surgical technique

The operative technique developed for the pilot study was based on reduced tissue trauma, avoidance of both contamination and strangulation of prestenal tissues. The surgeon used double gloves. Study patients also had an extra incision drape which was found to have a more sticky adhesion (Ioban®, 3M, Brookings, SD). The extra incision drape was placed onto the skin before the drape (Clinidrape® Mölnlycke) was applied. The leg used for vein graft harvesting was covered with Ioban® and the contralateral leg covered with sheets. Skin incision was carried out with a scalpel. Prestenal tissues were divided preferably with scalpel or with cutting diathermy. Bleeding vessels were subjected to ‘pin-point’ electrocautery. After sternal split, bleeding vessels in the peristome were ‘pin-pointed’ and wound edges were covered. Electrocautery was not used at the stab wounds for the chest-tubes. After hemostasis with discriminatory use of electrocautery, the sternum was firmly closed with 7–8 single steel wires with special endeavor to stabilize the caudal part of corpus. No effort was made to close the fascia covering the sternum. Whenever opened, linea alba was closed with a continuous 2–0 monofilament Monocryl® (Ethicon), the suture interlocked and then used for loose adaptation of the deep subcutaneous layer. The skin was closed with continuous intradermal 3–0 Monocryl®, with the incision drape left in situ. Whenever possible a self-locking knot [6] was used to minimize the bulk of the knot.

The conventional technique used in Group D encouraged liberal use of coagulative diathermy to divide prestenal tissues and for hemostasis. Extra incision drape was not used on the chest and no incision drape at all on the harvest site. Most surgeons used single gloves. Sternum was closed with 6–7 single steel wires with no extra wire in the caudal part. Fascia and prestenal tissue was firmly closed in two layers to avoid dead space and the incision drape was routinely removed before skin closure.

3.3. Follow-up

All patient data were obtained from the clinical database at our institution. Clinical evaluation of infection was made according to a pre-established routine without involvement of the authors. Beside assessment at discharge and registration of any readmissions due to postoperative infection, a questionnaire was sent to the patient 6 weeks after surgery and a phone call was conducted via telephone. The patients’ cardiologists
were contacted by mail and asked to report any wound infections after 2 and 6 months. Infections involving only soft tissues above the fascia were defined as superficial (SSWI). A deep infection (DSWI) denotes both deep presternal infections (reaching but not involving the sternum), and mediastinitis.

3.4. Validation

After evaluation of the results in this pilot study a recommendation was given to all staff surgeons and an approval was made by the majority to comply with the new technique. Adherence to the protocol was evaluated by a questionnaire filled up by the surgeons after the procedures during a 6-months period.

3.5. Statistical analyses

Statistical analyses were performed using a computerized statistical package (Statistica 5.1, StatSoft, Inc and Staview 4.57, Abacus Concepts, Inc). The $\chi^2$-test was used for evaluation of categorical data. Continues data are presented as mean ± SD and groups are compared with Mann–Whitney $U$-test. Significance was defined as $P < 0.05$. The number of observations is denoted by $n$.

4. Results

In the pilot series (A) 9/136 patients developed SWI compared with 15/89 in the period prior to change in technique (B) ($P = 0.015$). One patient had a deep presternal infection without involvement of sternum or mediastinum and was not subjected to revision in the pilot series. Among the controls (B) three patients had deep infections, one of whom was subjected to revision due to mediastinitis.

During the first year of implementation of the new multi-modal concept regarding surgical technique a significant drop in the overall SWI rate was noted, but no statistically significant reduction either in DSWI or in the number of infections at harvest sites was observed (Table 3). There was no difference in the need for erythrocyte transfusion between groups C and D (38.9 vs 39.0%). Figures for adherence to the protocol are given in Table 4.

5. Discussion

Our previous efforts in trying to reduce the incidence of postoperative infections included a post-discharge surveillance program, multiple preoperative whole-body disinfections with chlorhexidine-detergent, shortened preoperative hospital stay, new surgical dressings, review of state of the art regarding antibiotic prophylaxis, and efforts to identify risk factors among our patients. But not even a transfer to newly constructed operation theatres with laminar flow of ultra-clean air reduced infection rates.

We realized that the 60% reduction in infections in the pilot study might be due to chance with respect to the relatively small number of patients included and the use of sequential series. On the other hand no overall reduction of our wound infection rate occurred at the time of the pilot series. The risk of selecting more resistant strains of bacteria by instituting a prophylactic antibiotic with a more extended antimicrobial spectrum or a prolonged prophylaxis made us try the described concept for preventing surgical site infections.

From a practical point of view most of the risk factors for wound infections are not possible to alter, whereas surgical techniques are highly modifiable. The measures suggested in this study are designed: first to minimize contamination from skin flora, secondly to avoid unnecessary devitalization of tissues, which may serve as a favorable substrate for bacterial growth especially in obese patients and, thirdly, to secure a rigid fixation of the caudal part of sternum, which usually is the first to fail [4].

This multi-modal concept applied, is a pragmatic approach to a problem with a multi-factorial etiology [1]. Evaluation of each measure would require a material not possible to recruit at a single institution.

The surgical technique previously used was highly focused on meticulous hemostasis also in the subcutis and the sternum often leading to an excessive use of diathermy.
The firm adaptation of presternal tissues commonly attained with two running sutures in fascia and subcutis, performed with the aim of avoiding a dead space, may have caused decreased circulation in the tissues overlying the sternum. This may leave a favorable substrate for bacterial growth, particularly in the caudal part of the wound, which is known to have an inherent paucity of nutrient supply [7].

One major issue in developing a technique with the aim of reducing the wound’s resistance against infection as little as possible is: where does the infection start? Judging from observations of subcutaneous necrosis and the fact that obesity is a risk factor for wound infection we favor the opinion that the origin in many cases is situated in the subcutis. Accordingly great attention must be paid to a delicate handling of this tissue, which is subjected to bacterial contamination due to the proximity to the skin, where recolonization of bacteria progresses during surgery [8]. Thus we find it important to maintain a nutrient flow also in the suture line in the subcutis. Therefore avoidance of thermal necroses and strangulating sutures appear to be important.

The importance of a stable sternal osteosynthesis is well-documented and our simple modification was to reinforce the caudal part with an extra wire. The use of an incision film and leaving it in situ during skin closure and the use of double gloves may reduce bacterial contamination from skin flora.

An ideal surgical knife divides presternal tissues without increasing the wound’s vulnerability to infection and it has been shown that a scalpel is superior both to electroklysis and to laser in that respect [9]. Nishida demonstrated that pinpoint hemostasis with diathermy significantly reduces the severity and frequency of penetrating mediastinitis in a dog model. Excellent clinical results were achieved also in a clinical setting [10].

Total infection rates are higher in this study than what is usually reported [11,12], but we find them in accordance with recently published studies with active surveillance [3]. This active follow-up is not commonly stated in articles when incidences of infectious complications are given [13]. It must be kept in mind that the majority of postoperative infections appear after discharge [14] and that follow up is 6-months in the present study. Active surveillance is the basis of registration of our institution and four times higher rates of infectious complications during heightened (active) surveillance than during routine surveillance has been shown [15]. Furthermore deep sternal infections appear to be more common than superficial in several studies [10,13] conflicting with our findings of an inverse proportion. This discrepancy may be due to differences in follow up. Hence, comparison with other materials must be prudent and limited to materials with active surveillance of post-operative infections after discharge and similar criteria for diagnosis.

The major limitations in this study are the lack of randomization and the time effect between study group and control group and therefore the results must be regarded as a generator of a hypothesis that infectious complications may be reduced by adaptation of a surgical technique, and not as evidence. However, 40% reduction in SWIs following the change in surgical technique cannot be accounted for by any other known systematic alteration in clinical practice. The unchanged rate of wound infections at harvest sites indicates that the explanation to the reduction in SWIs is due to the modified surgical technique. Furthermore several risk factors for wound infection have been taken into account and no difference between groups has been observed.
regarding diabetes, BMI > 30, revisions due to bleeding or operation time, etc. This supports our assumption that the change in surgical technique contributed to the decrease in infection rates.

In a total of 7.5% both the patient and his cardiologist failed to report and in these cases we can only affirm that no infection was detected during hospital stay, and that the patients were not readmitted because of infection.

Another limitation is lack of adherence to protocol. Table 4 indicates significant benefit from using double gloves and avoidance of coagulative diathermy for division of pre sternal tissues but also that individual surgeons often deviated from the protocol. In only 60% of the operations did surgeons actually use double gloves but these patients had a significantly lower infection rate. Adherence to protocol was better regarding leaving incision drape in situ during skin closure (94%) and avoidance of using coagulative diathermy for division of pre sternal tissues (90%).

In year 2000 the first significant reduction of infection rates occurred at our institution. In a material of this size, a reduction in deep pre sternal and mediastinitis of 32% is not statistically significant but still, we find it encouraging in the clinical practice. Although this study is not randomized, the presented figures of compliance indicate that deviation from the suggested measures enhance the risk of developing wound infection.

References