Review

Risk factors for surgical site infections after breast surgery: A systematic review and meta-analysis

D.Q. Xue a,c, C. Qian b,c, L. Yang a,c, X.F. Wang a,*

a Department of Breast Surgery, The Third Affiliated Hospital of Suzhou University, 185 Juqian Road, 213003 Changzhou, China
b Department of Breast Surgery, The Affiliated Hospital of Jiangsu University, 438 Jiefang Road, 212001 Zhenjiang, China

Accepted 27 February 2012
Available online 14 March 2012

Abstract

Background: Breast surgical site infections (SSIs) are major sources of postoperative morbidity and mortality, and it’s established that surveillance of risk factors is effective in reducing hospital-acquired infections. However, studies about risk factors for breast SSIs were still under controversy because of limited data, contradictory results and lack of uniformity.

Materials and methods: We searched the electronic database of PubMed for case–control studies about risk factors for breast SSIs, and a meta-analysis was conducted.

Results: Eight studies including 681 cases and 2064 controls were eligible, and data was combined if the risk factor was studied by at least two studies. Of the 20 possible risk factors involved, 14 were proved significant for SSIs as follows: increased age, hypertension, higher body mass index (BMI), diabetes mellitus, American society of anesthesiologists (ASA) 3 or 4, previous breast biopsy or operation, preoperative chemoradiation, conservation therapy versus other surgical approaches, hematoma, seroma, more intraoperative bleeding, postoperative drain, longer drainage time and second drainage tube placed. However, other factors like smoking habit, immediate reconstruction, axillary lymph node dissection, preoperative chemotherapy, corticosteroid usage and prophylactic antibiotic didn’t show statistical significance.

Conclusions: This meta-analysis provided a list of predictable or preventable factors that could be taken measures to reduce the rate of breast SSIs and excluded some negligible factors. This could be useful for developing effective prevention and treatment policies for patients with SSIs and improving the overall quality of life.

Keywords: Breast surgical site infections; Breast surgery; Risk factor; Meta-analysis

Introduction

Surgical site infections (SSIs) are major sources of adverse operation-related events in patients undergoing surgery, including increased morbidity, psychological trauma, additional cost and delay of postoperative adjuvant therapies.1,2 The rate of breast SSIs range from 1% to 30%, depending on definition of SSIs, type of operation, comorbidities of the patients, time of follow up, perioperative therapy and reporting institution. It’s higher than other clean operations in which the infection rate is less than 5%.3–6

Several studies were performed to identify risk factors for SSIs after breast procedure, but quite a few limits existed in these studies: some studies just focused on one or a small list of potential risk factors and the variant criteria of some risk factors made conclusions hard to be drawn from them7–12; there were also some studies which had such a small sample (patients’ number of SSIs < 20) that the results might be biased.13–16 Besides, some results remain conflicting rather than conclusive: smoking and prolonged use of surgical drain were considered as risk factors to SSIs in some studies,7,17 but some other results didn’t show statistically significance between them,13–15,18,19 preoperative chemotherapy, breast reconstruction and the administration of antibiotic

Abbreviations: SSIs, surgical site infections; BMI, body mass index; ASA, American Society of Anesthesiologists; OR, odd ratio; CI, confidence interval.

* Corresponding author. Tel.: +86 0519 68870113.
E-mail address: wangxufen0102@163.com (X.F. Wang).

† These authors contributed equally to this work.
prophylaxis were reported to influence the incidence of SSIs in some studies,8,19,20; however, the opposite results were observed in other studies.13,18,21

There were also 3 cohort studies in research of risk factors for SSIs.7,37,38 However, patients recruited in each study were all pretreated with different influencing factors from each other. Therefore, the data from these 3 studies were not suitable to combine as a meta-analysis.

Therefore, to give surgeons more precise information to tailor their treatment to individual patients, the objective of our study was to systematically review observational case–control data to investigate possible contributing factors for SSIs after breast surgery.

Methods

Search strategy and selection criteria

Meta-analysis was performed as described previously.22,23 Relevant articles were selected by searching PubMed databases (updated on November 2011), using the following terms in the searching algorithm: case–control, breast surgery or breast procedure, surgical site infections or wound infections. Two reviewers (DX and CQ) independently screened titles and abstracts of the identified papers. References in identified articles and previous reviews were also reviewed for possible inclusion. We limited the search to human studies and full text articles published in English language. Studies were included if they met the following criteria: a) SSIs was standardized using the Centers for Disease Control and Prevention definitions for surgical infections, b) breast surgery included breast cancer surgery (biopsy or operation), breast reduction and breast reconstruction, c) a case–control study examining the risk factors for SSIs after breast surgery, and d) sufficient published data for estimating an odds ratio (OR) with 95% confidence interval (CI). For overlapping studies, only the one with the largest sample numbers was selected.

Data extraction

Information was carefully extracted from all the eligible studies independently by two reviewers (DX and CQ). The following variables were extracted from each study if available: first author’s name, publication year, country of origin, study design, numbers of cases and controls in different risk factors for SSIs. After disagreement was resolved by discussion, all the data were reached consensus.

Statistical analysis

Crude ORs with 95% CI were used to assess the association between different variant and subsequent SSIs risk. Heterogeneity between the studies was tested with Q statistics.24 If \( P < 0.10 \), the between-study heterogeneity was considered to be significant. When between-study heterogeneity was absent, the fixed-effects model (the Mantel–Haenszel method) was used to calculate the pooled ORs.25 Otherwise, a random-effects model (the DerSimonian and Laird method) was selected.26 The meta-analysis was summarized graphically using a Forest Plot. Publication bias was investigated by funnel plot, in which the standard error of log (OR) of each study was plotted against its log (OR). Funnel plot asymmetry was assessed by the method of Egger’s linear regression test, a linear regression approach to measure funnel plot asymmetry on the natural logarithm scale of the OR. The significance of the intercept was determined by the \( t \) test as suggested by Egger, and a \( P \) value less than 0.05 was considered significant.27 All analyses were performed using the software Stata version 11.0 (Stata Corporation, College Station, TX, USA).

Results

Eligible studies

Of 513 articles, 145 studies received full text review, of which eight met our inclusion criteria. Of these eight included studies, four were in United States of America; three were in Mexico and one from China. These articles were published between the years 1998–2010, including 681 SSIs cases and 2064 controls.13–16,18–21 The detailed information of the studies was shown in Table 1.

Risk factors for SSIs

Meta-analysis of combinable data was conducted, and main results were shown in Table 2. In this meta-analysis significant risk factors were older age (OR: 1.73), hypertension (OR: 1.69), higher BMI (OR: 1.96), diabetes mellitus (OR: 1.88), American Society of Anesthesiologists (ASA) 3 or 4 (OR: 2.06), previous breast biopsy or operation (OR: 1.84), preoperative chemoradiation (OR: 2.97), breast conservation therapy versus other surgical approaches (OR: 0.25), hematoma (OR: 2.45), seroma (OR: 1.65), more intraoperative bleeding (OR: 1.38), postoperative drain (OR: 2.84), longer drainage time (OR: 2.95) and second drainage tube placed (OR: 3.35). The Forest Plots of the 14 significant results were shown in Figs. 1–4 On the other hand, smoking habit, axillary lymph node dissection, immediate reconstruction, antibiotic prophylaxis, preoperative chemotherapy, corticosteroid usage were proved to be no significant.

Funnel plot and Egger’s test were performed to access the publication bias of literatures. In overall studies, no significant publication bias (\( P > 0.05 \)) existed (data not shown).

Risk factors evaluated in single study

There were also some risk factors only mentioned in single study and proved to be significant including epidermolysis,20 grade III myelosuppression once occurred in
adjuvant chemotherapy, performance of surgery during an evening shift, current or past breast cancer, history of malignancy, local infiltration of anesthetic agent, reduction operation only, hematoma drainage, ecchymosis and lymphedema. Duration of the surgery was also recognized clinically as a risk factor for the development of SSIs but the standard were different among studies. In addition, we summarized some valuable information from 3 cohort studies as a supplement. Apart from the significant risk factors mentioned above, smoking habit, alcohol consumption, surgical experiences, skin flap necrosis, and bacterial colonization of the drain were considered as independent risk factors for breast SSIs. Besides, antibiotic prophylaxis was beneficial for patients at high risk of SSIs.

**Discussion**

This meta-analysis of eight case—control studies gave a more precise estimation of independent risk factors for breast SSIs in patients undergoing breast surgery. Meanwhile, risk factors evaluated in single study also provided some guiding suggestion for further research.
Predictable factors

Our results showed that patients with increased age, obesity, higher ASA score, and basic diseases like hypertension and diabetes mellitus were more vulnerable to suffer from SSIs. Although these host factors were not amenable to intervene, they may remind the surgeons of the possible danger and taking measures in time.

Smoking habit was considered as an independent risk factor for wound infections owing to impeded wound blood supply as well as presence of microvascular disease and alterations in the cellular and inflammatory system in smokers.7,28–30 However, smoking habit didn’t show same trend in our review. The difference may result from the preceding researched focus on major surgeries like mastectomy and free transverse rectus abdominis musculocutaneous flap breast reconstruction which is vulnerable to ischemia, and in our review the coverage of surgical types is wider.

What’s more, we also found that existence of hematoma and seroma after surgery may be warning symptoms for surgeons to pay attention and take some measures. So adequate hemostasis, handling of tissue gently and closing the incision without tension may take effect on reducing the risk of SSIs.

Table 2
Summary of ORs and 95% CI of significant risk factors for breast SSIs.

<table>
<thead>
<tr>
<th>Risk factors</th>
<th>Odds ratio</th>
<th>95% CI</th>
<th>P value for heterogeneity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Significant factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>1.73</td>
<td>1.41–2.12</td>
<td>0.21</td>
</tr>
<tr>
<td>Hypertension</td>
<td>1.69</td>
<td>1.34–2.14</td>
<td>0.27</td>
</tr>
<tr>
<td>BMI</td>
<td>1.96</td>
<td>1.63–2.37</td>
<td>0.20</td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>1.88</td>
<td>1.47–2.39</td>
<td>0.78</td>
</tr>
<tr>
<td>ASA 3 or 4</td>
<td>2.06</td>
<td>1.24–3.40</td>
<td>0.53</td>
</tr>
<tr>
<td>Previous breast biopsy or operation</td>
<td>1.84</td>
<td>1.07–3.16</td>
<td>0.54</td>
</tr>
<tr>
<td>Preoperative chemoradiation</td>
<td>2.97</td>
<td>2.43–3.63</td>
<td>0.27</td>
</tr>
<tr>
<td>Surgical approaches</td>
<td>0.25</td>
<td>0.10–0.61</td>
<td>0.41</td>
</tr>
<tr>
<td>Hematoma</td>
<td>2.45</td>
<td>1.68–3.58</td>
<td>0.78</td>
</tr>
<tr>
<td>Seroma</td>
<td>1.65</td>
<td>1.28–2.12</td>
<td>0.33</td>
</tr>
<tr>
<td>Intraoperative bleeding</td>
<td>1.38</td>
<td>1.11–1.70</td>
<td>0.66</td>
</tr>
<tr>
<td>Postoperative drain</td>
<td>2.84</td>
<td>1.09–7.37</td>
<td>0.41</td>
</tr>
<tr>
<td>Drainage time</td>
<td>2.95</td>
<td>1.17–7.47</td>
<td>0.004&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Second drainage tube placed</td>
<td>3.35</td>
<td>2.11–5.32</td>
<td>0.48</td>
</tr>
<tr>
<td><strong>Insignificant factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoke</td>
<td>1.17</td>
<td>0.90–1.51</td>
<td>0.79</td>
</tr>
<tr>
<td>Axillary lymph node dissection</td>
<td>1.62</td>
<td>0.99–2.66</td>
<td>0.83</td>
</tr>
<tr>
<td>Immediate reconstruction</td>
<td>1.24</td>
<td>0.49–3.17</td>
<td>0.003&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Antibiotic prophylaxis</td>
<td>1.38</td>
<td>0.84–2.28</td>
<td>0.04&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Preoperative chemotherapy</td>
<td>0.71</td>
<td>0.27–1.85</td>
<td>0.008&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Corticosteroid use</td>
<td>1.36</td>
<td>0.31–5.86</td>
<td>0.68</td>
</tr>
</tbody>
</table>

OR, odds ratio; CI, confidence interval.
<sup>a</sup> Estimates for random-effects model.

Figure 1. Forest plots for meta-analysis of breast SSIs risk of age, ASA, BMI and diabetes mellitus. The width of the horizontal line represents the 95% CI of the individual studies, and the square proportional represents the weight of each study. The diamond represents the pooled OR and 95% CI.
Controllable factors

There were also some factors could be intervened to reduce the risk, such as previous breast biopsy or operation, surgical approaches, intraoperative bleeding, postoperative drain, drainage time and second drainage tube placed. So we suggested that selecting suitable surgical approaches, decreasing intraoperative bleeding as far as possible, shortening drainage time, inserting a second drainage tube and applying preoperative surgical operation with caution may reduce the SSIs risk. Besides, immediate reconstruction, axillary lymph node dissection and corticosteroid use didn’t exhibit influence on the occurrence of SSIs, and that could dispel surgeons’ misgivings to some degree.

Several studies already examined the effect of preoperative chemotherapy on wound healing, but the results were in conflict. Our result showed that simply preoperative chemotherapy didn’t increase the risk of breast SSIs. The reason may be that some generally adopted criteria like assuring the safe WBC and platelet count before surgery were helpful to minimize the risk of infections. Besides, our result also showed that surgical infections were higher in patients treated with both chemotherapy and radiation therapy compared to those didn’t receive any treatment before surgery. The reason may be increased fibrosis, decreased vascularity and hypoxia in affected tissues accompanied with radiation therapy can lead to tissue necrosis, fibrosis, and ulceration. What’s more, the pathophysiology of radiation injury was hard to prevent. So, surgeons should pay more attention to patients who received radiation therapy or even put it off for some high-risk patients.

The benefit of antibiotic prophylaxis seemed to be no significant in our article, and it was also reported in a cohort study that the rate of SSIs decreased significantly based on the administration of antibiotic prophylaxis to high-risk patients only. So it was suggested that antibiotic prophylaxis should not be considered as an independent protective factor and systematic administration of antibiotic prophylaxis for breast surgery is not necessary, but it should be taken into consideration if other risk factors were accompanied.

There were also some risk factors only proved significant in single study. Although the dependability should be confirmed by further studies, it could still provide later researchers with some valuable suggestion to make their research more complete.

Some limitation still existed in this meta-analysis. First, there were relatively few studies for some risk factors that may cause bias. Second, of these eight studies,
most subjects were Caucasians, including a bit of Asians, while no African was included. Therefore, the conclusion in African populations was still unclear. Third, the present results were based on unadjusted ORs, and more precise estimation may be adjusted by other potential covariates.

In conclusion, this review gave surgeons more accurate and practical information about the occurrence of breast SSIs. It can also be helpful to set up prospective surveillance program and take strategies to reduce the incidence of breast SSIs. Further studies with larger sample size and more detailed classification are necessary to focus on

Figure 3. Forest plots for meta-analysis of SSIs breast risk of postoperative drain, preoperative chemoradiation, previous breast biopsy or operation and second drainage tube placed. The width of the horizontal line represents the 95% CI of the individual studies, and the square proportional represents the weight of each study. The diamond represents the pooled OR and 95% CI.

Figure 4. Forest plots for meta-analysis of breast SSIs risk of seroma and surgical approach. The width of the horizontal line represents the 95% CI of the individual studies, and the square proportional represents the weight of each study. The diamond represents the pooled OR and 95% CI.
some obscure or uncertain factors and get more precise estimation of SSIs risk after breast surgery.

**Conflict of interest**

There are no conflicts of interest.

**References**


