Surgical Site Infection Following Bowel Surgery

A Retrospective Analysis of 1446 Patients

J. Matthias Walz, MD; Craig A. Paterson, MD; Jeanne M. Seligowski, RN; Stephen O. Heard, MD

Hypothesis: We sought to determine whether the administration of preoperative antibiotics, intraoperative transfusion of blood products, and intraoperative hypothermia has any impact on the incidence of postoperative surgical site infections (SSIs) in a heterogeneous patient population undergoing bowel surgery.

Design: Retrospective analysis.

Setting: From September through December 2002, data on 1472 patients undergoing bowel surgery at 31 academic medical centers in the United States were collected.

Patients: Patients were included in the analysis if they were older than 17 years of age and underwent any surgery involving the small bowel, colon, or rectum.

Main Outcome Measure: Postoperative SSI. Variables that might affect the risk for developing SSIs were analyzed using multivariate logistic regression analysis.

Results: Perioperative transfusion (P = .04; odds ratio, 1.64), and the presence of any infection at the time of surgery (P = .05; odds ratio, 2.46) were independent risk factors for SSI. Patients with a lower intraoperative temperature nadir had a lower risk for SSI (P = .05; odds ratio, 1.33), although this difference is not clinically significant (35.8°C±0.8°C vs 36.0°C±0.9°C, P<.05). There was a trend toward statistical significance for wound class when added to the multivariate model (P = .09; odds ratio, 1.41). The administration of antibiotics within 120 minutes prior to incision or within 120 minutes prior to and 120 minutes after incision had no effect on SSIs in this patient population.

Conclusions: This study validates perioperative transfusion as an independent risk factor for SSI. The lack of effectiveness of perioperative antibiotic prophylaxis is surprising because it is discordant with the previous literature, and this finding needs further evaluation.

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Surgical Site Infections (SSIs) represent the second most common type of nosocomial infection (20%) and are a major source of morbidity. The associated increase in treatment cost is estimated to be around $2000 to $4500 per case, and the postoperative length of stay is extended by 7 to 10 days. Kirkland et al showed that the development of SSI results in a 225% increase in total direct costs per patient after laparotomy and a 77% increase after colon surgery. According to the National Nosocomial Infections Surveillance System Report, the incidence of SSI following bowel surgery ranged from 1% to 13.5% (median) for the period from January 1992 through June 2003. Most studies investigating the incidence and risk factors for SSI in bowel surgery have focused on a certain anatomic region within the gastrointestinal tract, (eg, gastroduodenal or colorectal surgery) while other studies have analyzed mixed patient populations with respect to their wound class, ie, clean and clean-contaminated wounds. Other interventions that have been associated with a decreased risk for SSI include the avoidance of intraoperative hypothermia and the appropriate timing of antimicrobial prophylaxis prior to incision.

See Invited Critique at end of article

Although the efficacy of preoperative mechanical bowel preparation to reduce the incidence of SSI has recently been questioned, perioperative transfusion has frequently been shown to increase the risk for SSI. We sought to investigate the relative contribution of these variables in combination to SSI following bowel surgery (small bowel, colon, and rectum) in a cohort of 1472 patients.

METHODS

From September through December 2002, data on patients (24-50 patients per site) undergoing surgical procedures for which there is currently no controversy over the need for antimicrobial prophylaxis to reduce SSIs include cardiac and noncardiac surgery like vascular surgery, general abdominal colorectal surgery, abdominal and vaginal hysterectomy, and surgery for trauma patients who sustained penetrating abdominal wounds. Other interventions that have been associated with a decreased risk for SSI include the avoidance of intraoperative hypothermia and the appropriate timing of antimicrobial prophylaxis prior to incision.
Surgical site infections were divided into superficial infection, from a surgical site that was closed primarily, the surgeon’s diagnosis of SSI in the univariate model are presented in Table 1. The rate of SSI for all wound categories combined was 8.7%. For patients with clean-contaminated wounds, the rate of SSI was 7.9%; for those with contaminated or dirty/infected wounds, the rates were 12.0% and 20.4%, respectively.

Comorbidities and risk factors that were identified in this patient cohort are listed in Table 2. Variables that were potentially associated with SSI and analyzed in the univariate model are presented in Table 3. Some of the factors that did not reach statistical significance in the univariate analysis were the use of supplemental oxygen in the postanesthesia care unit, American Society of Anesthesiologists physical status score, classification of surgery (elective vs emergent), the type of anesthesia (regional, general, or combined regional and general), and the administration of a preoperative bowel preparation. The remaining variables excluded from further analysis were as follows: age; sex; obesity; immunosuppression; and a history of cirrhosis, smoking, alcoholism, diabetes mellitus, or renal failure. Logistic regression with SSI as the dependent variable incorporated perioperative transfusion, the intraoperative temperature nadir, presence of any infection at the time of surgery, wound class, surgical time, and perioperative administration of antibiotics as independent variables. Factors that were independently associated with an increased risk for SSI in the multivariate analysis were perioperative transfusion of packed red blood cells and presence of any infection at the time of surgery (Table 4).

At the end of the study period, 1472 cases were included in the database. Of those, 26 cases with lengths of stay ranging from 38 to 93 days were excluded from the database by the University HealthSystem steering committee to achieve a more homogenous patient population. Wound categories were not documented in 42 of 1446 patients included in the analysis. The median patient age was 57 years with a range of 18 to 96 years. Demographics and patient characteristics are presented in Table 1. The rate of SSI for all wound categories combined was 8.7%. For patients with clean-contaminated wounds, the rate of SSI was 7.9%; for those with contaminated or dirty/infected wounds, the rates were 12.0% and 20.4%, respectively.

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Table 3. Univariate Logistic Regression Analysis for Risk Factors Associated With SSI

<table>
<thead>
<tr>
<th>Variable</th>
<th>P Value</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound class</td>
<td>.001</td>
<td>1.68 (1.21-2.32)</td>
</tr>
<tr>
<td>Perioperative PRBC</td>
<td>.004</td>
<td>1.75 (1.20-2.63)</td>
</tr>
<tr>
<td>Intraoperative temperature nadir</td>
<td>.007</td>
<td>1.37 (1.09-1.73)</td>
</tr>
<tr>
<td>Presence of any current infection</td>
<td>.02</td>
<td>2.52 (1.19-5.33)</td>
</tr>
<tr>
<td>Surgical time (≤4 h or &gt;4 h)</td>
<td>.06</td>
<td>1.51 (0.97-2.33)</td>
</tr>
<tr>
<td>Administration of perioperative antibiotics</td>
<td>.05</td>
<td>0.64 (0.40-1.01)</td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; PRBC, packed red blood cells; SSI, surgical site infection.

Table 4. Multivariate Logistic Regression Analysis

<table>
<thead>
<tr>
<th>Variable</th>
<th>P Value</th>
<th>Odds Ratio (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perioperative transfusion</td>
<td>.04</td>
<td>1.64 (1.03-2.63)</td>
</tr>
<tr>
<td>Intraoperative temperature nadir</td>
<td>.05</td>
<td>1.33 (1.002-1.76)</td>
</tr>
<tr>
<td>Presence of any current infection</td>
<td>.05</td>
<td>2.46 (1.00-6.04)</td>
</tr>
<tr>
<td>Wound class</td>
<td>.09</td>
<td>1.41 (0.95-2.10)</td>
</tr>
<tr>
<td>Surgical time (≤4 h or &gt;4 h)</td>
<td>.24</td>
<td>1.36 (0.80-2.31)</td>
</tr>
<tr>
<td>Administration of perioperative antibiotics</td>
<td>.38</td>
<td>0.83 (0.53-1.3)</td>
</tr>
</tbody>
</table>

Abbreviation: CI, confidence interval.

The duration of surgery (≤4 h vs >4 h) had no impact on the rate of SSI. Furthermore, the perioperative administration of antibiotics (within 120 minutes prior and 120 minutes after the incision) was not independently associated with a decreased risk for SSI (Table 4). This was true even when the statistical analysis was limited to administration of perioperative antibiotics either 120 or 30 minutes prior to incision (data not shown). There was a trend toward statistical significance in the multivariate analysis when wound class (clean-contaminated vs contaminated or infected) was factored in to the model (P = .09).

To determine whether the anatomic site of surgery has an influence on the risk for postoperative SSI, patients were separated into those who underwent large bowel procedures and those who had small bowel procedures. The multivariate analysis as described earlier was then repeated and was not statistically significant for small bowel procedures. For large bowel surgery, factors that significantly increased the risk for SSI were wound class (odds ratio, 1.61; confidence interval, 1.01-2.58), and perioperative blood transfusion (odds ratio, 1.82; confidence interval, 1.04-3.13).

The major findings of this study are that perioperative blood transfusion, a higher intraoperative temperature nadir, and presence of any infection at the time of surgery were associated with a risk for postoperative SSI. The fact that a higher intraoperative temperature nadir was associated with higher incidence of postoperative SSI is surprising considering that a number of recent trials have demonstrated that avoidance of intraoperative hypothermia reduces the incidence of postoperative wound infection. Although the difference between the lowest temperatures in the patients with and without wound infections is statistically significant, the clinical difference is negligible. A major difference between this analysis and previous studies is that patients with the use of immunosuppressive drugs; a recent history of fever; or evidence of infection, malnutrition, and bowel obstruction were not excluded from the database. In addition, previous studies that have examined this issue have used surgical wound infection as the outcome variable rather than SSI (which includes organ/space infection and wound disruption). Approximately 25% of the hospitals in this study routinely used convection warmers; however, specific data regarding the use of these devices were not collected. Because the difference in temperatures between the groups is so narrow and several prospective studies have shown the use of such devices is not associated with an increased risk for wound contamination, it is unlikely that the use of these warmers caused an increase in SSI.

The use of allogeneic blood has been implicated with an increased risk for infection in patients following surgery and for critically ill patients in the intensive care unit. The blood that was used in the majority of these studies was not leukocyte depleted. Because leukocytes are thought to be the cause (at least in part) of transfusion-associated immunosuppression, the use of leukocyte-depleted blood should reduce the risk for infection. Indeed, several studies have shown that the use of high-efficiency leukocyte-depleting filters will reduce the risk for perioperative infections following gastrointestinal surgery. No data regarding the use of leukocyte-depleted blood were gathered in this study; consequently, we are unable to determine the extent to which blood without leukocyte depletion is implicated in SSI. Some authors suggest that the timing of perioperative transfusion and certain confounding factors have an impact on the incidence of SSI. Vamvakas and Carver were able to demonstrate that when severity of illness, diffi-
culty of operation, and risk for wound infection were included in the statistical analysis, postoperative transfusion had only a marginal effect on the incidence of SSI and intraoperative transfusion had no effect on SSI.

The use of prophylactic antibiotics did not reduce the incidence of SSI in the present study. We chose to examine the effect of administration of antibiotics both 120 minutes before and 120 minutes after the incision because an analysis of antibiotic dosing just 120 minutes before incision resulted in a worse multivariate model than when the time interval of 120 minutes after incision was included. This finding is unexpected given that the evidence in support of perioperative antibiotic prophylaxis in colorectal surgery is unequivocal. In a recent publication from the Cochrane Database of Systematic Reviews, Song and Glenny prospectively studied the occurrence of surgical wound infections in 2847 patients undergoing elective clean or clean-contaminated surgical procedures at a large community hospital. They concluded that the administration of antibiotics 120 minutes prior to skin incision reduces the incidence of wound infection. However, their study differs from ours in several important aspects. Patients with clean wounds were included in the analysis and patients undergoing emergency surgery or with any preexisting infection were excluded from the study. The latter variable was independently associated with a higher risk for SSI in this investigation. Furthermore, previous trials on risk factors for SSI in bowel surgery were more restrictive with respect to the anatomic site of surgery criteria (e.g., gastroduodenal or colorectal surgery). This study was designed to look at best practices of individual institutions in a retrospective fashion. Therefore, no recommendations were made a priori on the timing and type of antibiotic administration prior to surgery as well as guidelines on redosing of antibiotics if the duration of surgery exceeded 120 minutes. Data on repeat antibiotic dosing were collected, but the number of patients who received a repeat dose was too small to analyze (data not shown). Taken together, these factors may explain in part the discrepancy of our findings compared with the current literature.

Several recent studies have shown that supplemental oxygen administration in the perioperative period reduces the incidence of SSI. Indeed, Greif and coworkers concluded that the rate of SSI in patients undergoing colorectal surgery may be reduced by as much as 50%. However, patients with a history of fever, infection, malnutrition, and bowel obstruction were excluded from the study. A more recent prospective randomized trial did not show a decreased incidence of SSI but did reveal potentially deleterious effects related to administration of a high fraction of inspired oxygen during the perioperative period. These findings confirm the result of our analysis, which did not show an association between oxygen administration in the postanesthesia care unit and the incidence of SSI.

Limitations of our study include the retrospective design and the fact that the determination of the patient's core temperature across the participating medical centers was not standardized. Coding of the wound class for a small number of patients (n=46) was incomplete, which may have had a small effect on our calculation of the rate of SSI in this cohort. The fact that patients with extensive lengths of stay were excluded from the analysis should have minimal if any impact on the incidence of SSI in this patient population. It is uncommon for SSIs to occur beyond 3 to 7 days after surgery, and most infections will appear within several days to a week. After this point, the wound has most likely epithelialized and the subsequent risk for infection would be very low. Because of the retrospective design of this study, no data could be abstracted as to how the participating surgeons treated the operative wounds with respect to irrigation and wound dressings.

We demonstrate in a heterogeneous population of patients undergoing bowel surgery that perioperative blood transfusion, a higher intraoperative temperature nadir, and any preoperative infection are associated with an increased risk for SSI. Further investigations are warranted to determine optimal timing of perioperative antibiotic prophylaxis in this patient population.

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Author Contributions: Study concept and design: Walz, Paterson, and Heard. Acquisition of data: Paterson, Seligowski, and Heard. Analysis and interpretation of data: Walz, Paterson, and Heard. Drafting of the manuscript: Paterson, Seligowski, and Heard. Critical revision of the manuscript for important intellectual content: Walz, Paterson, and Heard. Statistical analysis: Walz, Paterson, and Heard. Administrative, technical, and material support: Walz, Seligowski, and Heard. Study supervision: Paterson and Heard.

Previous Presentation: This study was presented in part at the CHEST World Congress of the American College of Chest Physicians; October 27, 2004; Seattle, Wash.

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Invited Critique

This study is a retrospective analysis of 1,472 adult patients undergoing bowel surgery in 31 US academic medical centers who were treated over a 4-month period. The purpose was to identify clinical factors possibly associated with the development of SSIs. The events of interest included not only superficial infections but also intra-abdominal infections and wound disruption. Some clinical criteria for diagnosis of SSI were objective (positive culture for organisms), but they were mostly subjective (wound exudates, surgeon's diagnosis, site reopened). Using subjective inclusion criteria among multiple institutions without prior standardization could be problematic. Similarly, there was no standardization in the choice of antibiotic used, use of heating devices, and technique of intraoperative temperature monitoring. The majority of operations were performed in open fashion, and two thirds were elective procedures. Only 12% of the wounds were classified as either contaminated or dirty. In terms of comorbidities, only 8% of patients were American Society of Anesthesiologists class 4 or higher, and those patients with conditions identified in previous studies to be associated with postoperative infection, such as obesity, renal failure, and diabetes mellitus, represented a very small fraction of the overall group.

Although I admire the authors for this undertaking, I have concerns that the overall number of patients and the characteristics of the study group have influenced the results, ie, failing to demonstrate an effect. First, epidemiological studies of wound infections in clean and clean-contaminated cases indicate a rate of perhaps 1% and less than 10%, respectively. It may be that the number of patients in this study are insufficient to statistically demonstrate a true effect of the variables analyzed because the expected wound infection rate is so low. Second, the small number of patients with risk factors known to be associated with postoperative infection may also have led to a failure to demonstrate a true clinical impact of these other variables, such as obesity. Third, the finding regarding the intraoperative temperature nadir probably is a statistical aberration because there is significant overlap regarding the variance between the 2 groups. Finally, the possible influence of perioperative transfusion is interesting and does deserve further investigation in the future. Again, I commend the authors for their efforts and encourage them to continue their work.

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