Intraoperative Factors Associated with Development of Surgical Site Infection after Colorectal Surgery

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Citation

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Abstract

Background: We sought to identify perioperative factors that were associated with development of surgical site infection (SSI) following colorectal surgery.Methods: Administrative data from colorectal surgeries in 2004-2005 were used to screen cases for SSI and manual chart review was used to confirm presence of SSI. Perioperative parameters were extracted and those with significant univariate associations with SSI were analyzed for independent associations with SSI.Results: A resulting dataset of 545 cases - 22 with and 523 without SSI - was analyzed. Multiple regression analysis identified younger age, larger volume of crystalloid administration, greater weight, and inpatient status to be independently associated with the incidence of SSI. Subanalysis of crystalloid administration revealed a significant association with development of SSI, independent of both procedure duration and EBL.Conclusions: Greater volume crystalloid administration (independent of procedure duration and EBL), greater weight, younger age, and inpatient status were independently associated with an increased risk of SSI after colorectal surgery.

BACKGROUND

Surgical site infection (SSI) is the second leading cause of nosocomial infection and increases length-of-stay, mortality, and cost of care. [1] The median incidence of SSI after colorectal surgery has been reported to range from 3% (range 0-6%) in low risk patients to 13% (range 2-21%) in high risk patient categories. [2] Given this high incidence of infection in patients undergoing colorectal surgery, many attempts have been made to identify and modify risk factors associated with SSI. Since SSI appears to become established within the first few hours of bacterial contamination, the risk of SSI may be influenced by the actions of anesthesiologists if intraoperative factors controllable by anesthesia care teams are modifiable. [3] We hypothesized that we could identify intraoperative factors that were associated with postoperative development of SSI.

METHODS

After obtaining Institutional Review Board approval for a retrospective investigation and waiver of informed consent, we queried our hospital's CPT coding records to identify all patients who had undergone colorectal surgery during the time period 2004-2005. Administrative coding was reviewed to determine which of the cases had documentation suggesting development of an SSI during the post-operative hospitalization. This coding for SSI at our center had been previously studied and was found to have positive and negative predictive values of 24% and 99%, respectively. [4] Because of the low positive predictive value, a comprehensive chart review of those coded as having a SSI was conducted to identify true SSI based on Centers for Disease Control criteria. [5] Cases with charts that were unavailable for review were excluded.

For all cases, we queried our anesthesia information management system (AIMS) (CompuRecord, Philips Medical System, Andover, MA) to extract values for intraoperative parameters that could potentially influence the development of SSI. Patient characteristics and intraoperative variables were screened, one at a time, for an apparent association with SSI, using chi-square tests or tests for trend. Data were grouped based on clinically appropriate cutoffs and distributions of values in the dataset. Variables with $p<0.2$ were included in a stepwise multiple logistic regression procedure to identify factors having significant ($p<0.05$) independent associations with SSI.

RESULTS

We identified 575 patients who had undergone colorectal surgery during the study period, 77 of whose charts had been coded as having developed SSI. Of those, 71 charts were

available and manually reviewed and SSI was confirmed in 26 of them (4.6% of all cases). In the remainder, there was either no documentation of SSI or infection appeared to be pre-existing (e.g., colonic perforation and peritonitis) at the time of the procedure, or occurred due to anastomotic leakage. AIMS case data were available for 545 cases - 22 with and 523 without SSI. (Records were not retrievable from our AIMS research database for 30 of the identified cases.)

Table 1 shows the results of the univariate analyses. Factors that were retained for inclusion in the multiple regression model to test for independent association with SSI were: patient age, weight, preoperative admission status, procedure duration, estimated blood loss (EBL), and total volume of crystalloid administered (both in absolute amount and relative to patient body weight).

Multiple logisitic regression analysis of the aforementioned factors identified only younger age, inpatient status, greater weight, and larger volume of crystalloid administration to be independently associated with the incidence of SSI. The goodness-of-fit statistic was c=0.80. Table 2 shows the odds ratios for these factors.

Because of the finding that larger volumes of crystalloid administration and greater patient weight were independently associated with greater incidence of SSI, we attempted to better characterize these associations. To this end, we determined the body mass index (BMI) of 437 cases (including 18 SSI) with necessary height data available. For this subset of cases, a significant univariate association was found between BMI and SSI, but multiple regression analysis did not reveal a significant independent association of BMI with SSI beyond that provided by total crystalloids, even when weight was removed from the model.

In order to further explore the influence of crystalloid administration, we examined the association between volume of crystalloids administered and SSI, controlling for procedure duration and EBL, both of which are typically determinants of crystalloid administration but were not retained as independent predictors of SSI in the multiple regression procedure. Table 3a shows the association of total crystalloid administration with SSI, stratified by combinations of high and low EBL and long and short procedure duration. Table 3b is similar, but with crystalloids expressed per kg of body weight. Although dividing the data in this way reduces the numbers of SSI in each grouping considerably, the increasing risk of SSI with increasing crystalloid administration is evident, particularly when EBL and duration are either both low or both high. A Mantel-Haenszel test of trend over the entire sample, with strata as shown in the tables, revealed a significant association of both crystalloid and crystalloid/kg with development of SSI, independent of procedure duration and EBL.

DISCUSSION

Our analysis revealed an independent association between four perioperative factors (younger age, greater weight, inpatient status prior to surgery, and greater volume of crystalloid administration) and development of SSI during a 2 year period at our large academic urban medical center.

The finding that intraoperative fluid administration was associated with the development of SSI is potentially important because anesthesia care providers are typically responsible for intraoperative fluid management and could, therefore, influence development of SSI. Since greater volume of fluid administration is typically associated with longer surgery and greater blood loss, the finding that fluid administration was an independent risk factor is particularly interesting. Several previous prospective studies have addressed the issue of fluid administration and its effect on outcomes, since excess fluid gain may result in impaired tissue oxygenation, gastrointestinal function, wound healing, and cardiopulmonary function. [6] A prospective study comparing a relatively restrictive vs. standard perioperative fluid regimen during colorectal surgery concluded that a relatively restrictive strategy significantly decreased infections, bleeding, and cardiopulmonary complications. [7] A similar study during major abdominal surgery of various types also showed a decrease in complications when the volume of fluids administered was relatively reduced. [8] Other studies, however, failed to show a decrease in complications attributable to perioperative fluid restriction for colorectal surgery. [9] The inconsistent study designs make it difficult to compare the results among the studies or to our results. Our data further support the concept that fluid management strategies may influence the development of SSI.

The finding that younger patients (ranging from 7 to 17 years in our dataset) seem to have a greater risk of infection than older patients seems to go against the conventional belief that older patients tend to have more complications due to comorbid conditions and age-related changes. Younger patients presenting for colorectal surgery may be a special group of patients with greater disease burden

(typically inflammatory bowel disease) compared with older patients (most of whom undergo resections for cancer or diverticular disease) that may place them at greater risk of SSI. [10] Similarly, patients who are scheduled for day-of-surgery admission rather than inpatients probably represent a group of healthier patients that might be expected to have fewer complications. Our dataset did not contain measures of disease burden other than ASA physical status classification with which to further characterize this association.

Previous studies have identified predictors of SSI that were not replicated in our investigation. These include timely antibiotic administration [3] , inspired oxygen concentration, [11] temperature management, [12] blood transfusion, [13] hyperglycemia, [14] BMI, [15] and blood pressure. [16] Differences in our methods, sample sizes, and analyses limit our ability to compare our results with those reports.

Our study is limited by its retrospective design and use of data from a single center with a relatively low SSI rate for colonic surgery. Our observed SSI rate likely underestimates the true incidence since some SSIs develop after discharge but would not have been included in our dataset. Our small number of SSI limited our power to detect all possible significant associations. We were also unable to include all factors that may be of significance because our dataset did not contain all such factors (e.g., preoperative comorbidities, bowel preparation, laparoscopic vs. open technique, creation of ostomy, post-discharge SSI). Use of administrative data for identification of SSI has been reported to be unreliable [17] but, as described earlier, our internal review of our administrative coding showed a strong negative predictive value, and we performed manual chart review to address a low positive predictive value.

In summary, we found greater volume of crystalloid administration, greater weight, younger age, and inpatient status to be independently associated with an increased risk of developing SSI after colorectal surgery. Since fluid administration is a potentially modifiable factor, additional studies are warranted to determine the optimal fluid management strategy for patients undergoing colorectal procedures.

Figure 1

Table 1: Univariate Association of Potential Risk Factors for Surgical Site Infection after Colorectal Surgery

Factor	Range	Total N	N (%) with SSI	p
Age Group	<18	13	2 (15%)	<0.01
	18-59	368	18 (5%)	
	≥60	164	2 (1%)	
Gender	Male	270	11 (4%)	0.97
	Female	275	11 (4%)	
Weight	≤ 70kg	280	7 (3%)	0.05
	>70 kg	260	15 (6%)	
Admission Status	Inpatient	200	13 (7%)	0.03
	Day of Surgery	345	9 (3%)	
ASA Physical Status	1	22	0 (0%)	0.90
	2	352	15 (4%)	
	3	155	7 (5%)	
	4	16	0 (0%)	
Emergency Status	Yes	31	0 (0%)	0.63
	No	514	22 (4%)	
Pre-Incision Antibiotics*	Yes	404	17 (4%)	0.73
	No	141	5 (4%)	
Procedure Duration	<2 hrs	70	0 (0%)	0.02
	2-3.9	364	14 (4%)	
	4-5.9	93	7 (8%)	
	≥6	15	1 (7%)	
Inspired Oxygen Concentration (Mean)	<50%	274	9 (3%)	0.57
	50-75%	249	13 (5%)	
	> 75%	17	0 (0%)	
Mean Arterial Pressure (Mean)	< 70	16	1 (6%)	0.19
	70-89	334	16 (5%)	
	90-100	141	4 (3%)	
	> 100	51	1 (2%)	
Core Temperature (Mean)	< 35.5	95	5 (5%)	0.57
	35.5-35.9	147	7 (5%)	
	36-36.5	142	4 (3%)	
	> 36.5	141	6 (4%)	
Hyperglycemia (Glucose>200mg/dL)	Yes	17	0 (0%)	0.60
	No	135	8 (6%)	
Estimated Blood Loss	< 100mL	73	1 (1%)	0.03
	100-199	141	4 (3%)	
	200-349	155	7 (5%)	
	≥ 350	130	9 (7%)	
Blood Administration	Yes	104	7 (7%)	0.16
	No	441	15 (3%)	
Total Crystalloid Administration	≤ 2500 mL	156	0 (0%)	<0.01
	2501-3000	126	4 (3%)	
	3001-4000	142	6 (4%)	
	≥ 4000	118	12 (10%)	
Total Crystalloid Administration / Actual Body Weight	≤ 35 mL/kg	133	0 (0%)	<0.01
	35-45	116	4 (3%)	
	45-60	142	9 (6%)	
	> 60	128	9 (7%)	
Body Mass Index	≤ 20	77	1 (1%)	0.02
	20-25	164	5 (3)	
	25-30	124	6 (5%)	
	>=30	72	6 (8%)	

* within 1 hour before skin incision (vs. shortly after incision, typically)

Figure 2

Table 2: Independent Predictors of Surgical Site Infection after Colorectal Surgery: Multiple Regression Analysis

Predictors	Odds Ratio	95% Confidence Interval
Age <18 vs. ≥60 yrs	20.24	2.26-181.34*
Age 18-59 vs. ≥60 yrs	3.62	0.82-16.08
Weight >70 kg	5.19	1.74-15.42*
Day-of-Admission Surgery vs. Inpatients	0.38	0.15-0.94*
Crystalloid (per ml per kg body weight)	1.02	1.01-1.04*

*p<0.05

Table 3: Crystalloid Admininstration and Surgical Site Infections (SSI) after Colorectal Surgery Stratified by Estimated Blood Loss (EBL) and Procedure Duration

Figure 3

Table 3a: Total Crystalloids Administered

EBL	<200 mL				≥ 200 mL			
Procedure Duration	<3 hrs		≥3 hrs		< 3 hrs		≥ 3 hrs	
Crystalloid (mL).	N	% SSI	N	% SSI	N	% SSI	N	% SSI
≤2500	80	0	19	0	27	0	9	0
2501-3000	38	5	20	5	37	3	23	0
3001-4000	24	4	18	0	38	5	52	4
>4000	1	0	13	8	11	0	86	13
Total	143	2	70	3	113	3	170	8
p*	0.11		0.39		0.49		0.01	

*Chi-square tests for trend

Mantel-Haenszel test of trend over 4 strata: p<0.01

Figure 4

Table 3b: Crystalloids per kg of Body Weight

EBL	< 200 mL				≥ 200 mL			
Procedure Duration	< 3 hrs		≥ 3 hrs		< 3 hrs		≥ 3 hrs	
Crystalloid (mL/kg)	N	% SSI	N	% SSI	N	% SSI	N	% SSI
≤35	57	0	16	0	31	0	15	0
35-45	39	0	18	6	24	8	18	0
45-60	34	6	22	5	37	3	54	9
>60	10	10	14	0	20	0	82	10
Total	140	2	70	3	112	3	170	8
p*	0.01		0.98		0.90		0.10	

*Chi-square tests for trend

Mantel-Haenszel test of trend over 4 strata: p=0.04

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