Incisional Surgical Site Infection in Colorectal Surgery Patients

Sahaphol Anannamcharoen MD*,
Sitthichai Vachirasrisirikul MD*, Chinakrit Boonya-assadorn MD*

** Department of Surgery, Phramongkutklao Hospital, Bangkok, Thailand*

Background: *Knowledge of specific risk factors for incisional Surgical Site Infection (SSI) is essential to create a specific SSI risk stratification index for colorectal surgery patients.*
Objective: *Identify factors increasing the risk of incisional SSI that lead to the development of a more efficient tool for predicting and comparing surgical site infection rates among surgeons and institutions performing the same type of procedure for colorectal surgery patients.*
Material and Method: *The authors conducted a prospective incisional SSI surveillance in 229 consecutive patients who underwent open colon and rectal resections performed in Phramongkutklao Hospital between October 1, 2008 and September 30, 2010. Independent risk factors for SSIs were identified by multivariate analysis.*
Results: *The present study identified six independent risk factors significantly associated with a higher risk of incisional SSI that included Body mass index (BMI) ≥ 30 (Odd ratio (OD) = 4.4; 95% confidence interval (CI) = 1.235-15.502; p = 0.022), hypoalbuminemia (< 3.5 g/dl) (Odd ratio (OR) = 2.8; 95% confidence interval (CI) = 1.003-7.587; p = 0.049), Hartmann's procedure (Odd ratio (OR) = 2.6; 95% confidence interval (CI) = 1.037-6.729; p = 0.042), postoperative hypotension, (Odd ratio (OR) = 2.3; 95% confidence interval (CI) = 1.043-5.268; p = 0.039) and postoperative hypothermia (Odd ratio (OR) = 5.6; 95% confidence interval (CI) = 1.112-28.482; p = 0.037).*
Conclusion: *Risk factors identified in the present study can be considered for creating a specific incisional SSI risk stratification index for colorectal surgery patients. This specific risk stratification index will be a more efficient tool for predicting and comparing SSI rates among surgeons and institutions.*

Keywords: *Surgical site infection, Risk factor, Colorectal surgery, Risk stratification index*

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Surgical site infection (SSI) is the leading cause of postoperative morbidity. SSI is frequently found following colorectal operations since the potential for bacterial contamination during the procedure is inevitable. Prevention of SSI has become an important goal to reduce patient suffering and associated health care costs. Since the 1970s, the US National Nosocomial Infection Surveillance (NNIS) proposed a basic index to stratify the risk of infection among surgical patients known as the risk index category (RIC) originally designed as a scoring system based on three variables: the American Society of Anesthesiologists' (ASA) score, length of operation, and surgical wound classification[1]. Because of the wide variability in the factors for predicting risk between different types of operative procedures, some believe that the NNIS risk index should be used to indicate risk after different types of operations[2]. RIC has been validated as a reliable predictor for the development of surgical site infection in colorectal surgery patients[3]. In Thailand, RIC has not been widely used and the overall rate of incisional surgical site infection following colorectal cancer surgery in a university hospital was 14.5%[4]. Knowledge of specific risk factors for SSI is essential to create a specific SSI risk stratification index for colorectal surgery to improve quality of care by prevention of postoperative SSI. The present study aimed to identify the incidence and factors increasing the risk of incisional SSI in colorectal surgery patients that may allow a reduction in the rate of postoperative incisional SSI.

Correspondence to:
Anannamcharoen S, Department of Surgery, Phramongkutklao Hospital, Bangkok 10400, Thailand.
Phone: 0-2215-6613
E-mail: sahaphola@yahoo.com

Material and Method

The Royal Thai Army Institutional Review Board approval was obtained prior to the present

study initiation. The authors conducted a prospective SSI surveillance of 229 consecutive patients who underwent open colon and rectal resections performed in Phramongkutklao Royal Thai Army Hospital between October 1, 2008 and September 30, 2010. Patients who underwent laparoscopic surgery, creation, or reversal of colostomy without midline open laparotomy, parastomal hernia repairs without manipulation of the colon or rectum were excluded.

Patients baseline characteristics and surgical protocols

Demographic and patient baseline characteristics included: age, sex, body mass index (BMI) calculated as kg/m^2 (< 25, ≥ 25), history of diabetes, preoperative serum albumin (< 3.5, ≥ 3.5) and preoperative steroid use (within the last six months). Diagnoses were stratified into three categories: 1) colorectal tumor, 2) diverticulitis and 3) other benign colorectal conditions were recorded prospectively. All operations were performed or supervised by surgeons in the Division of Coloproctology (SA, CB). All elective procedures had preoperative bowel preparation with either polyethylene glycol or sodium phosphate solution. Systemic prophylactic antibiotics were administrated to all patients before incision then repeated every three hours during surgery. Antibiotics were continued after surgery and then stopped within 24 hours.

Independent variables

Operation procedures were classified according to the procedure manipulating only above the peritoneal reflection (colon surgery) or below peritoneal reflection (rectal surgery), as preoperative skin shaving, operative procedures, length of operation, postoperative hypothermia ($T < 36°C$), perioperative blood transfusion, perioperative hypotension (SBP < 90 mmHg) and subcutaneous drainages. ASA scoring was assigned by the anesthesiologist immediately before surgery and wound classification was classified according to the Guidelines of the American College of Surgeons adapted by the US Center for Disease Control and prevention (CDC)[5]. Ostomy creation/closure and multivisceral resection were considered as additional procedures.

Dependent variables

Attending physicians and nurses observed all wounds at least once a day until the patients were discharged and all patients were followed-up for SSI at least 30 days postoperatively in the outpatient clinic. The diagnosis of SSI (superficial, deep, or organ/space) was based on the definitions stated in the guidelines issued by the CDC[5].

Statistical analysis

The incidence of SSI was calculated for every subject. Values were expressed as means $\pm$ SD for continuous variables or as percentage of the group of origin for categorical variables. All continuous data were tested for normality with Kolmogorov-Smirnov (KS) test. Comparative analysis of continuous variables was performed using the Student t-test for normally distributed variables; otherwise, the Mann-Whitney U-test was used. Categorical variables were analyzed using Pearson's Chi-square test or Fisher's exact test where appropriate. A series of univariate analyses to determine the variables associated with SSI were performed. All tests of significance were two-tailed. A p-value of < 0.05 was considered statistically significant. Variables associated with SSI with a value of $p < 0.15$ in the univariate analysis were selected for stepwise logistic regression. Potentially associated variables were then tested using multivariate logistic regression analysis with a Wald statistic backward stepwise selection. The results of the logistic regression are reported as odds ratios (ORs) with 95% confidence intervals (CIs).

Results

During the two-year period of the present study, 229 patients underwent colon and rectal surgery in PMK Hospital. The mean age was 63 $\pm$ 14 years (58% (n = 134) males, 42% (n = 95) females). Of these 191 (83.4%) underwent elective surgery whereas 38 (16.6%) underwent urgent or emergency surgery. In all, 127 (55.5%) colon surgeries and 102 (44.5%) rectal surgeries were performed. Operations were performed for colorectal tumors in 193 patients (84%), diverticular disease in seven (3%) and other benign conditions in 29 (13%). Stomas creation was performed in 114 (49.8%) patients. Incisional SSI rate was 54 (24%) during this period and the median (range) time to diagnose of incisional SSI was five (1-26) days. Twenty-nine wound swabs for bacterial culture were taken, including: poly-microorganisms in 15 (51.7%) samples, single organisms in 11 (37.9%) samples and the remaining three samples had no bacterial growth. In the present study, the most frequent isolated organism was *E. coli* 51.7% and half of these were ESBL-producing strains. The other

organisms isolated were *P. aeruginosa, E. cloacae, Aeromonas sobria* and *K. pneumoniae*.

Univariate analysis results are summarized in Table 1 and 2. Eight variables were found to be significantly associated ($p < 0.05$) with a higher risk of SSI: low anterior resection, Hartmann's procedure, hypoalbuminemia (< 3.5 g/dl), prolonged length of operation, intraoperative hypotension, postoperative hypothermia and postoperative hypotension. Variables associated with SSI with a value of $p < 0.15$ in the univariate analysis were selected for stepwise logistic regression. Multivariate logistic regression was used to identify independent risk factors for incisional SSI. The multivariate analysis results summarized in Table 3 revealed the following six independent risk factors significantly associated with a higher risk of SSI: BMI ≥ 30 (odd ratio (OR), 4.4; 95% confidence interval (CI), 1.235-15.502; $p = 0.022$), hypoalbuminemia (< 3.5 g/dl) (odd ratio (OR), 2.8; 95% confidence interval (CI), 1.003-7.587; $p = 0.049$), Hartmann's procedure (odd ratio (OR), 2.6; 95% confidence interval (CI), 1.037-6.729; $p = 0.042$), postoperative hypotension, (odd ratio (OR), 2.3; 95% confidence interval (CI), 1.043-5.268; $p = 0.039$), and postoperative hypothermia (Odd ratio (OR), 5.6; 95% confidence interval (CI), 1.112-28.482; $p = 0.037$).

Discussion

SSI remains an important cause of postoperative morbidity and mortality. Presently, decrease the use of the RIC as a tool to predict SSI in elective colorectal surgeries is ongoing[3] because most patients undergoing elective colorectal procedures have low ASA score and similar class of wounds. For this reason, the RIC score does not reflect the real risk of infection[6-8]. In order to improve quality of care by prevention of postoperative SSI, knowledge of specific risk factors for SSI is essential. In order to create a SSI risk stratification index in specific colorectal surgery patients, the authors conducted the present study to identify specific risk factors for SSI focusing on factors that had not been included in RIC. The prospective nature of the present study allowed for more reliable and higher quality in data collection. The risk factors identified in the present study were considered for adoption to create a new

Table 1. Patients' factors: univariate analysis for factors associated with incisional SSI

Characteristics	No SSI (n = 175), n (%)	SSI (n = 54), n (%)	p-value
Sex			0.448
Male	100 (57.1)	34 (63.0)	
Female	75 (42.9)	20 (37.0)	
Body mass index (kg/m^2)			0.084
≤ 24	133 (77.8)	36 (67.9)	
25-29	30 (17.5)	10 (18.9)	
≥ 30	8 (4.7)	7 (13.2)	
Diabetes	35 (20.0)	8 (14.8)	0.394
Preoperative albumin < 3.5 g%	23 (13.1)	13 (24.1)	0.049
Previous laparotomy	53 (30.3)	19 (35.2)	0.498
Preoperative chemotherapy	30 (17.1)	9 (16.7)	0.935
Preoperative radiation	25 (14.3)	6 (11.1)	0.551
Diagnosis			
Tumor	150 (85.7)	43 (79.6)	0.283
Diverticular disease	4 (2.3)	3 (5.6)	0.360
Others	21 (12.6)	8 (14.8)	0.587
ASA score > 2	36 (20.6)	7 (13.0)	0.211
Elective vs. non-elective surgery			0.987
Elective	146 (83.4)	45 (83.3)	
Non-elective	29 (16.6)	9 (16.7)	
Colon vs. rectal surgery			0.062
Colon	103 (58.8)	24 (44.4)	
Rectum	72 (41.1)	30 (55.6)	

ASA = American Society of Anesthesiologists

Table 2. Operative factors: univariate analysis for risk factors associated with incisional SSI

Characteristics	No SSI (n = 175), n (%)	SSI (n = 54), n (%)	p-value
Skin shaving	40 (22.8)	12 (22.2)	0.922
Operative procedure[+]			
Rt. hemicolectomy	17 (9.7)	3 (5.6)	0.413
Lt. hemicolectomy	12 (6.8)	3 (5.6)	1
Anterior resection	33 (18.8)	8 (14.8)	0.428
Low anterior resection	51 (29.1)	24 (9.0)	0.039*
APR	17 (9.7)	4 (9.0)	0.56
Hartmann's procedure	17 (9.7)	12 (22.2)	0.018*
Additional procedures			
Ostomy Formation	85 (48.6)	29 (53.7)	0.510
Ostomy Closure	3 (1.7)	3 (5.6)	0.145
Multivisceral resection	19 (10.8)	8 (14.8)	0.430
Duration of operation			0.031*
< 3 hr	39 (22.3)	4 (7.4)	
3-5 hr	103 (58.8)	36 (66.7)	
> 5 hr	33 (18.8)	14 (25.9)	
Subcutaneous drainage	47 (26.8)	14 (25.9)	0.892
Blood transfusion	56 (32.0)	21 (38.9)	0.349
Intraoperative hypotension (SBP < 90)	53 (30.3)	26 (48.1)	0.016*
Postoperative hypotension (SBP < 90)	7 (4.0)	7 (13.0)	0.024*
Postoperative hypothermia (T < 36°C)	72 (41.1)	32 (59.2)	0.019*

[+] Not included cases solely creation or reversal of colostomy without intestinal resection
APR = abdominoperineal resection; SBP = systolic blood pressure
* Fisher's exact test

Table 3. Multivariate analysis for risk factors associated with incisional SSI

	OR	95% CI		p-value
		Lower	Upper	
BMI (kg/m^2)				
≤ 24	1.0	Ref		
25-29	1.9	0.715	5.207	0.194
≥ 30	4.4	1.235	15.502	0.022*
Preoperative albumin (< 3.5 g%)	2.8	1.003	7.580	0.049*
Hartmann's procedure	2.6	1.037	6.729	0.042*
Postoperative hypotension (SBP < 90)	2.3	1.043	5.268	0.039*
Postoperative hypothermia (T < 36°C)	5.6	1.112	28.482	0.037*

OR = indicates odds ratio; CI = confidence interval; BMI = body mass index; SBP = systolic blood pressure

SSI risk stratification index for colorectal surgery patients depending on the impact and the predictive ability of the individual risk factor. The incidence of SSI in the present study (23.6%) was higher than the reported NNSI data with overall SSI rate for colonic surgeries (COLO category) was 3.1% for RIC 0 comparing to 22.2% for RIC 3[1].

However, the authors agree with Konishi et al[8] that SSI surveillance for colon and rectal surgeries should be performed separately, in order to obtain a more reliable risk factors and more efficient reduction in SSI. A major break in aseptic technique should be taken into account in cases of gross spillage of feces. This will turn the wound to class

three contaminated wound and the risk of infection is higher. Regarding postoperative hypothermia, a common problem after major operation may promote surgical-wound infection. The hypothesis proposed by Kurz A et al[12] explained the triggering of thermoregulatory vasoconstriction, which decreases subcutaneous oxygen tension. Both hypothermia and hypotension leads to a reduction of oxygen levels in tissue. The impairment of oxidative killing activity of neutrophils and the strength of the healing wound also loosen due to the reduction of the deposition of collagen[12]. The present study provided evidence that Hartmann's procedure was an independent risk factor for incisional SSI while colonic and rectal surgeries were not found to differ with regard to the incidence of incisional SSI. This possibly means the creation of colostomy may be a causative factor leading to wound infection rather than whether the procedure should be manipulated only above or below the peritoneal reflection (colon or rectal surgery). Since the effect of colostomy creation was not analyzed separately in the present study then the impact of colostomy creation on SSI was possibly diluted when it was analyzed in combination to other additional procedures. An important limitation to be noted with the present study is that other known risk factors not otherwise identified in the variables studied but could predispose a patient to SSI included: surgical wound class, preoperative steroid use, complexity of surgery, and intraoperative colonoscopy. In spite of this limitation, the present study revealed several factors increasing the risk of SSI that could be adopted to create a specific SSI risk stratification index for colorectal surgery patients in the future. This should lead to be a more efficient tool for predicting and comparing surgical site infection rates among surgeons and institutions performing the same type of procedure for colorectal surgery patients.

Conclusion

The present study revealed six independent risk factors significantly associated with a higher risk of SSI, *i.e.*, BMI $\geq$ 30, hypoalbuminemia (< 3.5 g/dl), Hartmann's procedure, postoperative hypotension and postoperative hypothermia to establish a more efficient tool for predicting and comparing surgical site infection rates among surgeons and institutions. Some risk factors identified in the present study could be considered for creating a specific SSI risk stratification index for colorectal surgery patients.

Potential conflicts of interest

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การติดเชื้อของแผลผ่าตัดในผู้ป่วยที่ได้รับการผ่าตัดลำไส้ใหญ่และลำไส้ตรง

สหพล อนันต์นำเจริญ, สิทธิชัย วชิระศรีศิริกุล, ชินกฤต บุญญอัศดร

วัตถุประสงค์: *การสร้างดัชนีวัดความเสี่ยงการติดเชื้อของแผลผ่าตัดในผู้ป่วยที่ได้รับการผ่าตัดลำไส้ใหญ่และลำไส้ตรงจำเป็นต้องอาศัยความรู้เกี่ยวกับที่ปัจจัยเสี่ยงของการติดเชื้อ การศึกษานี้จึงมีวัตถุประสงค์ที่จะค้นหาถึงปัจจัยที่เพิ่มโอกาสของการติดเชื้อที่แผลผ่าตัด ดังกล่าวเพื่อเป็นประโยชน์ในการสร้างดัชนีวัดความเสี่ยงการติดเชื้อที่มีประสิทธิภาพที่สามารถใช้เป็นเกณฑ์ในการเปรียบเทียบถึง อัตราการติดเชื้อของแผลผ่าตัดระหว่างศัลยแพทย์และระหว่างสถาบันที่ทำการผ่าตัดลำไส้ใหญ่และลำไส้ตรง ด้วยวิธีการเดียวกัน*

วัสดุและวิธีการ: *ผู้นิพนธ์ทำการศึกษาผู้ป่วยจำนวน 229 ราย ภายหลังการผ่าตัดผ่าตัดลำไส้ใหญ่และลำไส้ตรงในโรงพยาบาลพระมงกุฎเกล้า โดยติดตามไปข้างหน้า ระหว่าง 1 ตุลาคม พ.ศ. 2551 ถึง 30 กันยายน พ.ศ. 2553 โดยการศึกษาเพื่อหาปัจจัยอิสระที่เพิ่มความเสี่ยงของการติดเชื้อ*

ผลการศึกษา: *การศึกษานี้พบว่ามี 6 ปัจจัย ที่เป็นปัจจัยอิสระที่เพิ่มความเสี่ยงการติดเชื้อของแผลผ่าตัด คือ ดัชนีมวลกาย มากกว่าหรือเท่ากับ 30 (OR, 4.4; 95% CI, 1.235-15.502; p = 0.022) ภาวะอัลบูมินต่ำกว่า 3.5 กรัม/เดซิลิตร (OR, 2.8; 95% CI, 1.003-7.587; p = 0.049) การผ่าตัดแบบ Hartmann's procedure (OR, 2.6; 95% CI, 1.037-6.729; p = 0.042) ภาวะความดันเลือดตกในช่วงหลังการผ่าตัด (OR, 2.3; 95% CI, 1.043-5.268; p = 0.039) และภาวะอุณหภูมิร่างกายต่ำในช่วงหลังการผ่าตัด (OR, 5.6; 95% CI, 1.112-28.482; p = 0.037)*

สรุป: *ปัจจัยเสี่ยงที่ค้นพบ ในการศึกษานี้น่าจะมีประโยชน์ในการใช้สร้างดัชนีวัดความเสี่ยงของการติดเชื้อแผลผ่าตัดสำหรับผู้ป่วยลำไส้ใหญ่และทวารหนักในอนาคต ซึ่งดัชนีวัดความเสี่ยงที่มีประสิทธิภาพจะเป็นเกณฑ์ที่ใช้ในการเปรียบเทียบอัตราการติดเชื้อ ระหว่างศัลยแพทย์และระหว่างสถาบัน*