ORIGINAL ARTICLE

Outcomes and Predictors of Incisional Surgical Site Infection in Stoma Reversal

Mike K. Liang, MD; Linda T. Li, MD; Andres Avellaneda, MD; Jennifer M. Moffett, MD; Stephanie C. Hicks, MS; Samir S. Awad, MD

Importance: Surgical site infection following stoma reversal (SR) poses a substantial burden to the patient and health care system. Its overall incidence is likely underreported and poorly characterized. Improving our understanding of surgical site infection following stoma reversal may help us identify methods to decrease this complication.

Objective: To evaluate the incidence of surgical site infection (SSI) and identify predictors of SSI following SR.

Design: A review of computerized hospital records on SR performed from January 1, 2005, until February 27, 2011.

Setting: An integrated medical system at the Michael E. DeBakey Veterans Affairs Medical Center.

Participants and Intervention: All adults undergoing SR during the study period.

Main Outcome Measures: Rates of SSI and characteristics of patients with and without SSI were compared. A logistic regression model was developed to identify predictors of SSI.

Results: One hundred twenty-eight patients underwent SR; 46 patients (36.0%) had an SSI. In comparison with no SSI, the infection was associated with seromas (17.4% vs 2.4%, $P=.004$), fascial dehiscence (15.2% vs 2.4%, $P=.01$), intensive care unit admission (34.8% vs 17.1%, $P=.03$), increased hospital length of stay (20 vs 9 days, $P=.02$), readmission (32.6% vs 13.4%, $P=.01$), delayed wound healing (91 vs 66 days, $P=.02$), and reoperation (32.6% vs 13.4%, $P=.01$). On multivariate analysis, history of fascial dehiscence (odds ratio, 16.9; 95% CI, 1.94-387), colostomy (5.07; 2.12-13.0), thicker subcutaneous fat (2.02; 1.33-3.21), and black race (0.35; 0.13-0.86) were associated with incisional SSI. There was no significant difference in patient satisfaction or functional status in late follow-up (1-73 months).

Conclusions and Relevance: Surgical site infection is common following SR and is associated with significant morbidity. Four factors are strongly associated with increased risk of SSI in SR: history of fascial dehiscence, thicker subcutaneous fat, colostomy, and white race. Patients with none of these risk factors had a 0% SSI risk; patients with all 4 risk factors had a 100% risk of SSI.

JAMA Surg. 2013;148(2):183-189

Creation of a temporary ostomy is a common surgical technique used to divert stool from a high-risk anastomosis or distal disease. Stoma reversal (SR) is often considered by many surgeons to be a low morbidity operation. However, SR is associated with anastomotic leak, hernia formation, surgical site infections (SSIs), and nonsurgical complications, such as pneumonia, deep venous thrombosis, and urinary tract infection.[1,2] Surgical site infection is the most common complication associated with SR, and the reported incidence of SSI varies widely, from 2% to 40%.[3,4] The direct economic costs of SSI are considerable, usually being approximately twice the inpatient costs for a patient without SSI.[5] It has been reported[6] that a single occurrence of SSI places a cost of $25 000 on the health care system. Home health care expenses after discharge also may be high, at $6200 per patient in one study[5] for infections after bowel surgery.

See Invited Critique at end of article

Despite the fact that SR is often performed, there is little in the surgical literature on morbidity, including the incidence of SSI, following SR. In our study, we evaluated the incidence of incisional SSI after SR at a single institution. Clinical outcomes, risk factors, and patient quality-of-life outcomes were also investigated.

METHODS

STUDY POPULATION

We reviewed the medical records of all patients undergoing ileostomy or colostomy reversal at the Michael E. DeBakey Veterans Affairs Medi-

Author Affiliations: Michael E. DeBakey Department of Surgery, Baylor College of Medicine, Michael E. DeBakey Veterans Affairs Medical Center (Drs Liang, Li, Avellaneda, Moffett, and Awad), and Department of Statistics, Rice University (Ms Hicks), Houston, Texas.

cal Center, Houston, Texas, from January 2005 to February 2011. Approval for the review was obtained through the Baylor College of Medicine Institutional Review Board and the Michael E. DeBakey Research and Development Committee. Mechanical bowel preparation and oral antibiotics were not used in any patients, and all patients had received standardized intravenous prophylactic preoperative antibiotics (ertapenem sodium and either cefoxitin sodium or fluoroquinolone plus metronidazole for those with penicillin allergy). All patients underwent standard skin preparation with povidone-iodine.

PATIENT VARIABLES

Incisional SSI was identified by review of clinician notes, procedure notes, and laboratory data using the Centers for Disease Control and Prevention[6] definitions of superficial and deep SSI. Patient characteristics documented included age, sex, body mass index (calculated as weight in kilograms divided by height in meters squared), subcutaneous fat determined by 2 surgeons (M.K.L. and A.A.) as a single measurement (in centimeters) at the umbilicus using preoperative computed tomography within 3 months before surgery, race, diabetes mellitus, coronary artery disease, peripheral vascular disease, reason for ostomy formation, smoking, alcohol use disorder, previous surgical incision, hemoglobin A_{1c} (HbA_{1c}), albumin, American Society of Anesthesiologists (ASA) score, and preoperative serum glucose level. Routine preoperative laboratory testing included complete metabolic panel, complete blood cell count, and blood type and screen. The preoperative albumin level was recorded within 3 months of surgery; the HgA_{1c} level was recorded within 6 months of surgery and was obtained at the discretion of the primary physician. Ostomy variables included end or loop ileostomy and end or loop colostomy, as well as the duration of the stoma.

Perioperative variables included the type of surgical procedure (open or trans-stomal/laparoscopic), presence of parastomal hernia and incisional hernia, mesh use, management of stoma and/or midline incision, core body temperature at the end of the intervention, and peak glycemic control at 24 hours. Management of the stoma and/or midline incision was classified into 3 groups: open (if the fascia was closed but the skin was left open), closed (if both the fascia and skin were closed), or loose (if the fascia was closed and the skin was closed loosely with interrupted staples or suture. No patients received delayed primary closure. The following standard perioperative glucose control regimen is used at our institution. All patients admitted to the intensive care unit with a blood glucose level higher than 145 mg/dL (to convert to millimoles per liter, multiply by 0.0555) receive insulin, with the dosage determined using a sliding scale and with the target glucose range 80 to 120 mg/dL. If an adequate glucose level was not achieved within 8 hours, an insulin intravenous infusion was started with the same therapy goals. At the clinician's discretion, an insulin infusion may be started directly in patients with severe hyperglycemia. For patients with severe underlying glucose dysregulation who were admitted to the regular postoperative unit, an insulin sliding scale regimen was started to maintain blood glucose at less than 200 mg/dL. No changes had been made to these protocols during the study.

Postoperative variables (in-hospital) included the presence of SSI, type of treatment, microorganism identified, date of hospital discharge, presence of other medical and surgical complications, and death. Incisional SSI was identified by review of clinician notes, procedure notes, and laboratory data using the Centers for Disease Control and Prevention[6] definition of superficial and deep SSI. The presence of a seroma or hernia was identified by documentation in the clinician notes or radiographic evidence. For wounds that were left open or were opened at the bedside, time to wound healing was determined by review of the clinical notes to determine the first time that no wound was noted. Postdischarge variables included readmission because of an SSI, presence or absence of an SSI 30 days after the operation, or a deep SSI up to a year after the operation if mesh was used. Postoperative patient satisfaction and functional status assessments were obtained on clinical follow-up using a standardized quality-of-life follow-up questionnaire, addressing overall and cosmetic satisfaction, chronic pain scores, and functional status. Postoperative pain scores were obtained at late follow-up (≥6 months after surgery), with the level of the worst pain experienced assessed on a 10-point Likert-type scale (1, least pain; 10, most pain). Overall satisfaction with the operation and satisfaction with the cosmetic results were recorded using a 10-point Likert-type scale (1, least satisfied; 10, most satisfied). Patient functional status was assessed using a series of 13 questions in accordance with the AAS Table 7.[7] The AAS scores were reported on a 100-point scale (1, worst function; 100, best function).

Microbiologic data were obtained in all patients with SSI. Gram stains, culture results, and sensitivities were reviewed and categorized.

STATISTICAL ANALYSIS

Patient characteristics were assessed using an unpaired 2-tailed t test, χ^2 test, or Fisher exact test, depending on whether the variables were continuous or categorical. Ordinal variables, such as postoperative pain scores, were assessed using the Mann-Whitney test. The level for statistical significance was set at $P = .05$. Missing data were omitted from the descriptive analysis. Univariate logistic regression models were built to estimate the odds of SSI when considering the effect of each variable separately.

Multivariate logistic regression models were built to assess the effect of a given predictor on SSI while controlling for other predictors in the model. To identify the most significant predictors, a multivariate model including all variables at $P < .20$ from the initial assessment of patient characteristics were initially entered into the multivariate model and then reduced in a stepwise manner to identify the best fit according to the Akaike information criterion. Deterministic imputation was used to predict values for the missing data for logistic regression. Diagnostics of the multivariate logistic regression model were assessed, and validation was performed using a 10-fold cross-validation. All statistical analyses were performed using the statistical software R, version 2.15.0 (Vienna University of Economics and Business).

RESULTS

PATIENT CHARACTERISTICS

A total of 128 patients were included: 46 patients (36.0%) had SSI and 82 patients (64.1%) had no SSI (**Figure 1**). **Table 1** summarizes the patient demographics, comorbidities, and surgical history at the time of ostomy creation. Preoperative albumin values were available for 126 of 128 patients and HbA_{1c} levels (within 6 months of surgery) were recorded for 58 of 128 patients (no SSI, 37; SSI, 21). Preoperative computed tomography data were available for 88 patients. Patients with SSI were more likely to have elevated HbA_{1c} levels (6.5% vs 5.9%, $P = .02$) (to convert to a proportion of total hemoglobin, multiply by

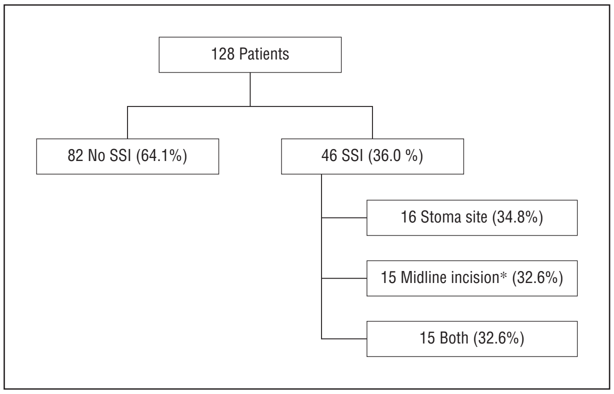

Figure 1. Incidence of surgical site infection (SSI). *Of all the patients, 80 had a midline incision.

0.01), morbid obesity (body mass index [BMI], 31 vs 27, *P* = .01), thicker subcutaneous fat (3.0 vs 2.4 cm, *P* = .03), history of fascial dehiscence (15.2% vs 3.6%, *P* = .03), and prior emergency surgery (73.9% vs 54.9%, *P* = .04) at the time of their ostomy creation.

Table 2 summarizes operative and perioperative data. Patients with SSI were more likely to have an end colostomy (45.6% vs 15.2% [end ileostomy] vs 28.3% [loop ileostomy] vs 10.9% [loop colostomy], *P* = .03), an open takedown (73.9% vs 56.1%, *P* = .05), a concurrent incisional hernia repair (23.9% vs 8.5%, *P* = .03), and an elevated peak perioperative glucose level (154 vs 136 mg/dL, *P* = .02). One patient underwent laparoscopic SR and did not develop an SSI.

OUTCOMES

Late follow-up data were available for 103 patients (no SSI, 63; SSI, 40). Ninety-seven of 128 patients (75.8%) had postoperative computed tomography imaging to confirm radiographic evidence of hernia. Surgical site infection was associated with seromas (*P* = .004), fascial dehiscence (*P* = .01), intensive care unit admission (*P* = .03), increased hospital length of stay (*P* = .02), hospital readmission (*P* = .01), delayed wound healing (*P* = .02), and reoperation (*P* = .01) (**Table 3**). There was a trend toward hernia formation in patients with SSI (stoma site, 23% vs 40%, *P* = .08; midline incision, 46% vs 67%, *P* = .13). Median (range) follow-up for the overall cohort was 31 (1-73) months.

Quality-of-life follow-up data were available for 68 of 128 patients (no SSI, 39; SSI, 29). Overall, there was no significant difference in patient satisfaction or functional status in late follow-up.

PREDICTORS OF SSI

On multivariate analysis, we found that patients with a history of fascial dehiscence, morbid obesity (measured by thicker subcutaneous fat), colostomy reversal, and white race had a significantly higher risk of developing an SSI (**Table 4**). Thicker subcutaneous fat was defined as greater than 2.5 cm, measured at the umbilicus. Patients with no risk factors had a 0% risk of SSI; those with all 4 risk factors had a 100% risk of SSI.

Table 1. Baseline Characteristics

Characteristic	No. (%) No SSI (n = 82)	No. (%) SSI (n = 46)	*P* Value
Demographics			
Age, mean (SD), y	64 (9.3)	59 (10.9)	.01
Black race	34 (41.5)	10 (21.7)	.03
Male sex	77 (94.0)	44 (95.6)	>.99
Comorbidities			
ASA 2	8 (9.8)	5 (10.9)	
ASA 3	69 (84.1)	38 (82.6)	.97
ASA 4	5 (6.1)	3 (6.5)	
Coronary artery disease	9 (11.0)	6 (13.0)	.78
Chronic obstructive pulmonary disease	6 (7.3)	6 (13.0)	.35
Diabetes mellitus	19 (23.2)	14 (30.4)	.40
HbA_{1c}, mean (SD), %	5.9 (0.7)	6.5 (1.4)	.02
Albumin, g/dL, mean (SD)	3.5 (0.08)	3.7 (0.07)	.13
Peripheral vascular disease	2 (2.4)	5 (10.9)	.10
BMI, mean (SD)	27 (6.3)	31 (6.1)	.01
Subcutaneous fat on CT, umbilicus, mean (SD), cm	2.4 (1.1)	3.0 (1.1)	.02
History of fascial dehiscence	3 (3.6)	7 (15.2)	.03
Current tobacco use	31 (37.8)	18 (39.1)	>.99
Alcohol use disorder	9 (11.0)	4 (8.7)	.77
Surgical history, ostomy formation			
Emergency	45 (54.9)	34 (73.9)	.04
Open	63 (76.8)	30 (65.2)	.21
Laparoscopic	19 (23.2)	16 (34.8)	.21
History of skin infection	16 (19.5)	8 (17.4)	.82
History of fascial dehiscence[a]	1 (1.2)	5 (10.9)	.02
History of reoperation	7 (8.5)	8 (17.4)	.16
Duration of stoma, mean (SD), mo	10 (7.0)	10 (6.0)	.97

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CT, computed tomography; HbA_{1c}, hemoglobin A_{1c}; SSI, surgical site infection.

SI conversion factor: To convert HbA_{1c} to proportion of total hemoglobin, multiply by 0.01.

[a] History of fascial dehiscence after stoma creation but before stoma reversal.

MICROBIOLOGIC EVALUATION OF SSI

The SSIs of 45.6% of patients were not cultured (**Figure 2**). Gram-positive bacteria grew in 72% of cultures; gram-negative bacteria grew in only 32% of cultures (eTable; http://www.jamasurg.com). Compared with historical controls of elective colorectal surgery,[8] stoma reversal surgery appears to have a substantially higher incidence of gram-positive organisms in SSI (eTable). The most common gram-positive organisms were *Enterococcus* species (33%), and methicillin-resistant *Staphylococcus aureus* (MRSA) (27%). The most common gram-negative organism was *Pseudomonas* (38%).

COMMENT

Overall, we found SSIs in 46 patients (35.9%), with an SSI rate of 23.2% at the stoma site and 37.5% at the midline incision. Our reported incidence of incisional SSI is on the higher spectrum of the studies reported in **Table 5**. Likely, SSI in SR is underreported, since many of the stud-

Table 2. Stoma Reversal Operative Data

Characteristic	No. (%) No SSI (n = 82)	SSI (n = 46)	P Value
Type of stoma			
End ileostomy	16 (19.5)	7 (15.2)	.03
Loop ileostomy	41 (50.0)	13 (28.3)	
End colostomy	18 (22.0)	21 (45.6)	
Loop colostomy	7 (8.5)	5 (10.9)	
Surgical technique			
Open takedown	46 (56.1)	34 (73.9)	.05
Trans-stomal/laparoscopic takedown	36 (44.0)	12 (26.1)	
Management of hernia			
Parastomal hernia repair	9 (11.0)	9 (19.6)	.30
Midline incisional hernia repair	7 (8.5)	11 (23.9)	.03
Hernia repair, mesh (n = 25)	9 (11.0)	16 (34.8)	.01
Hernia repair, no mesh (n = 13)	8 (9.8)	5 (10.9)	.70
Midline incision management (n = 80)			
Open	35 (76)	25 (74)	.50
Closed	11 (24)	8 (23)	
Loose	0	1 (3)	
Stoma incision management			
Open	49 (60.0)	19 (41.3)	.07
Closed	20 (24.4)	20 (43.5)	
Loose	13 (15.8)	7 (15.2)	
Peak glucose level 24 h postoperatively, mean (SD), mg/dL	136 (35.9)	154 (44.5)	.02
Postoperative temperature, mean (SD), °C	36 (0.5)	36 (0.6)	.70

Abbreviation: SSI, surgical site infection.
SI conversion factor: To convert glucose to millimoles per liter, multiply by 0.0555.

Table 3. Outcomes

Outcome	No SSI (n = 82)	SSI (n = 46)	P Value
Early, No. (%)			
Seroma	2 (2.4)	8 (17.4)	.004
Fascial dehiscence	2 (2.4)	7 (15.2)	.01
Anastomotic leak	4 (4.9)	3 (6.5)	.70
Sepsis/bacteremia	1 (1.2)	4 (8.7)	.06
ICU admission	14 (17.1)	16 (34.8)	.03
ICU LOS, mean (SD), d	3 (3.5)	16 (24.9)	.07
Hospital LOS, mean (SD), d	9 (13.4)	20 (36.5)	.02
Readmission	11 (13.4)	15 (32.6)	.01
Days to wound closure, mean (SD)	66 (44.9)	91 (55.0)	.02
Additional minor procedure[a]	2 (2.4)	38 (82.6)	<.001
Reoperation	11 (13.4)	15 (32.6)	.01
Late, No. (%)[b]			
Stoma site hernia	15 (24)	16 (40)	.08
Midline incisional hernia	16 (46)	20 (67)	.13
Quality-of-life score, mean (SD)[c]			
Satisfaction	7.9 (2.9)	7.4 (3.0)	.38
Cosmetic	6.0 (3.0)	5.0 (3.4)	.20
Chronic pain	0.6 (1.6)	0.3 (0.5)	.37
Pain score	4.0 (3.1)	3.1 (2.9)	.16
AAS	70.2 (13.9)	74.7 (10.5)	.39
Follow-up, median (range), mo	32 (1-71)	30 (2-73)	.79

Abbreviations: AAS, Activities Assessment Score; ICU, intensive care unit; LOS, length of stay; SSI, surgical site infection.
[a] Included procedures such as wound opened at bedside and suture or staple removed.
[b] Late outcomes for stoma site hernia were available in 103 patients (no SSI, 63 patients; SSI, 40 patients) and for incisional hernia were available in 65 patients (no SSI, 35 patients; SSI, 30 patients).
[c] Quality-of-life outcomes for incisional hernia were available in 68 patients (no SSI, 39 patients; SSI, 29 patients).

ies reported rates lower even than class I incisions. Historically, the incidence of SSI in SR has ranged widely, mostly resulting from differences in the definition of SSI and a variable follow-up period.[3] Recent studies[4,14] continue to show a wide range in incidence despite the fact that they used the currently accepted definitions for SSI. This variability may reflect the fact that different types of ostomies (eg, ileostomy, colostomy, loop, and end) are included and excluded in the studies and the different managements of surgical wound (eg, closure by secondary intention and primary closure) and different study protocols to capture events.

We also found that patient age and race affected the incidence of SSI. The incidence varied with race; specifically, black race was associated with a lower SSI risk. This is contrary to much of the current literature[21] that associates worse outcomes with black race in colorectal surgery. However, in those studies, race may be a surrogate for socioeconomic status and health care access rather than an inherent racial difference.[22] Because of similar access to medical care in the Veterans Affairs medical system, we believe that socioeconomic status is less likely to be a factor in our study. Surprisingly, ASA and smoking did not affect the rate of SSI. In other studies these factors did play a role.[23] Nearly all of our patients had significant comorbidities, including smoking, so ASA and smoking history may not have provided adequate stratification.

Table 4. Predictors of SSI

Predictor	OR (95% CI)[a]	P Value
History of fascial dehiscence	16.9 (1.94-387)	.03
Colostomy	5.07 (2.12-13.0)	<.001
CT subcutaneous fat, umbilicus	2.02 (1.33-3.21)	.002
Black race	0.35 (0.13-0.86)	.03

Abbreviations: CT, computed tomography; OR, odds ratio; SSI, surgical site infection.
[a] Ten-fold cross-validation, 0.20.

History of diabetes mellitus did not correlate with more SSI. However, we found that patients with SSI had elevated HbA_{1c} and elevated peak postoperative glucose levels. This suggests that the quality of blood glucose management was more important than the simple diagnosis of diabetes mellitus. Other studies[3,4] corroborate that diabetes mellitus is rarely a predictor of poor outcome in colorectal surgery or in predicting SSI with abdominal surgery. However, some studies[11,23] have suggested that elevated postoperative glucose and HbA_{1c} levels are associated with increased incidence of SSI. In our multivariate model, HbA_{1c} and perioperative blood glucose levels were no longer predictors; instead, obesity became the dominant factor demonstrating the interconnected relationship between obesity and blood glucose levels.

Obesity measured by BMI and subcutaneous fat were associated with SSI. This is consistent with other studies[4,11] demonstrating a correlation of obesity with SSI. Interestingly, our study found that increased subcutaneous fat had a stronger association with SSI compared with BMI. Body mass index fails to describe the anthropomorphic difference in fat distribution that may affect different outcomes. Recent studies[24] have suggested that increased subcutaneous fat vs mesenteric fat may affect outcomes differently. Intuitively, it follows that increased subcutaneous fat would predict incisional SSI more than BMI would, since it directly measures the amount of fat at the site of potential infection. Of note, we tested multivariate models with and without subcutaneous fat; without the fat, BMI became a predictive factor.

Surgical history played an important role in SSI in our study. A history of an emergency operation at the time of stoma formation and a history of fascial dehiscence were associated with SSI on bivariate analysis. On multivariate analysis, patients with a history of fascial dehiscence were 17 times more likely to develop an SSI. Prior complications may be a marker for a higher-risk patient, may inherently increase complications, or may create a more complicated operation. Studies[4] have indicated that patients at increased risk for fascial dehiscence include those at high risk and those who are obese. Alternatively, fascial dehiscence may affect local colonization of the wound, leaving dormant bacteria at the future surgical site or it may affect the vascularity of the local wound, inhibiting the healing of future wounds..[25] Another possibility may be that fascial dehiscence results in a more complicated operation with an incisional hernia (or a repaired incisional hernia/fascial dehiscence).

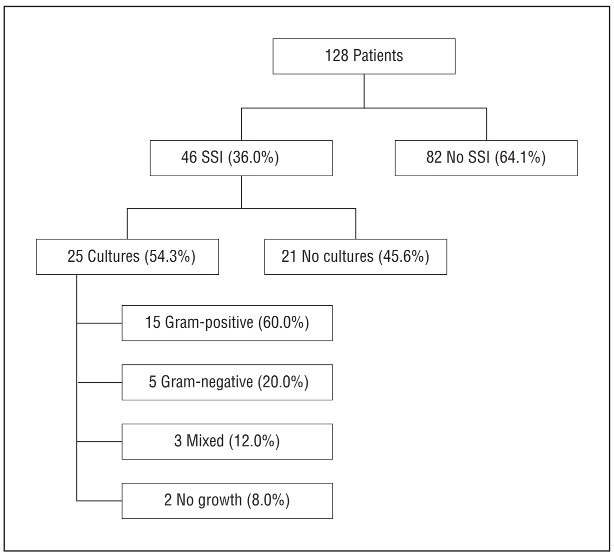

Figure 2. Microbiologic results of surgical site infection (SSI) with stoma reversal.

The type of stoma created and the surgical approach affected the incidence of SSI on bivariate analysis. An end colostomy takedown was most likely to become infected. This may be because the colon, particularly the descending colon, tends to harbor a higher bacterial count and be associated with increased risk of SSI.[11] Additionally, reversal of end colostomies requires an open takedown; loop stomas may be reversed in a trans-stomal fashion. We found that open SRs are also more likely to develop SSI compared with trans-stomal reversals. This may be because of a longer incision, multiple incisions, more complicated surgery, or more colostomy reversals. According to the multivariate model, only colostomy reversal, as opposed to an end/loop ostomy or an open/trans-stomal reversal, was associated with SSI. Colostomy reversal was associated with a 5-fold increase of SSI compared with ileostomy reversal.

Patients who had a concurrent incisional hernia—in particular, those who had mesh placed—were at increased risk for SSI. Concomitant incisional hernia repair is associated with additional dissection, increased length of surgery, and placement of foreign material and has been demonstrated to increase the risk of SSI.[26] Surprisingly, SSI in SR did not affect hernia formation in our study. Multiple other studies[26] have demonstrated that SSI is an independent predictor of fascial dehiscence and incisional hernia formation. Although our study is one

Table 5. Literature Review

Source	Stoma Type	No.	Incisional SSI, No. (%)	Predictors of SSI (OR)
Present study, 2012	Mixed	128	46 (36)	History of fascial dehiscence (16.90), colostomy (5.07), obesity (2.02), race (0.35)
Fauno et al,[9] 2012	Mixed	997	31 (3.1)	...
Tan et al,[10] 2012	Colostomy	49	3 (6.1)	...
Sehgal et al,[11] 2011	Mixed	183	27 (15)	Glucose level, drains, antibiotics <24 h
D'Haeninck et al,[12] 2011	Ileostomy	197	(4.6)	...
Kobayashi et al,[13] 2011	Ileostomy	51	12 (23.5)	...
Marquez et al,[4] 2010	Mixed	78	14 (18)	Type of skin closure: staple or transdermal suture (1.00), subcuticular suture (0.19)
Reid et al,[14] 2010	Ileostomy	61	14 (23)	Male sex (5.30), SSI after primary surgery (5.00)
Harold et al,[3] 2010	Mixed	75	4 (5.3)	...
Akiyoshi et al,[15] 2010	Ileostomy	125	20 (16)	...
Baraza et al,[20] 2010	Ileostomy	80	6 (7.5)	...
Shelygin et al,[16] 2010	Ileostomy	119	3 (2.5)	...
Fleming and Gillen,[17] 2009	Colostomy	110	12 (32)	...
Milanchi et al,[18] 2009	Ileostomy	25	10 (40)	...
Mazeh et al,[19] 2009	Colostomy	82	14 (17)	...

Abbreviations: ellipsis, no data or no additional information; OR, odds ratio; SSI, surgical site infection.

of the largest evaluating SSI in SR, an even larger sample size would likely demonstrate an association between SSI and incisional hernia formation.

Our microbiologic findings suggest that gram-positive organisms play a significant role in incisional SSI, representing more than 70% of the bacteria cultured. Compared with other studies[8] evaluating elective colorectal surgery, we noted more organisms that were resistant to our prophylactic antibiotics, more gram-positive organisms (in particular, *Enterococcus* species and MRSA) and *Pseudomonas*. Stoma reversal is an inherently different procedure than colorectal surgery because the skin and bowel colonization may be dramatically different. Ertapenem is the preferred preoperative antibiotic of choice in elective colorectal surgery,[8] and anecdotal evidence indicates that many surgeons have extrapolated these data to include SR. However, this may not be appropriate, since ertapenem is not effective against *Pseudomonas*, MRSA, *Acinetobacter*, or ampicillin-resistant *Enterococcus*.

Surgical site infection did not affect patient satisfaction on follow-up at least 6 months postoperatively. This may result from the interval between the clinical follow-up and the SSI, with possible recall bias. Alternatively, the factors associated with recovery from an SR are so complicated that SSI alone did not affect patient satisfaction. In addition, patient satisfaction primarily may be driven by relief of the ostomy bag, such that other factors are deemed insignificant from the patient's perspective.

This study provides information to help guide future studies to decrease SSI. Targets of future interventions may be improving perioperative glucose control, implementing weight loss programs prior to SR, or declining to perform SR in the morbidly obese patient. Changing technical aspects of the operation at the time of ostomy formation and at reversal may play a role as well. For example, minimally invasive surgery and preferential use of diverting loop ileostomy at the initial stoma formation may decrease the incidence of SSI. Additionally, laparoscopic stoma reversal may help decrease the incidence of SSI.[19] Interval hernia repair as opposed to concomitant incisional hernia repair with stoma takedown may be warranted. Our data demonstrated no effect on SSI with skin closure; however, other studies[4] have suggested that the technique used to close incisions may affect the incidence of SSI. Closure by secondary intention, delayed primary closure, loose primary closure, or circular closure may play a role. Finally, because SR appears to encounter more *Enterococcus* species, MRSA, and *Pseudomonas*, broadening the coverage of prophylactic antibiotics to cover these organisms may decrease SSI.

Our study has multiple limitations. The retrospective design is associated with selection biases, surgeon preference, and other unseen biases. However, there is a role for retrospective studies to establish baseline observations, without interventions, to help guide future prospective studies. This study was conducted in a high-risk tertiary-referral Veterans Affairs medical center. Our patients were largely ASA class III and IV; none was ASA class I. Nearly all our patients were male and almost half were smokers with multiple comorbidities. The applicability of these study results to other patient populations must be approached with caution.

The true rate of SSI in SR is probably higher than what is commonly reported. In future studies of SSI, the location criteria, definition of SSI, and time of follow-up should be standardized. Factors associated with SSI in SR are multiple and have a complicated relationship. Past surgical complication, type of ostomy, obesity, and patient demographics may all play a role in incisional SSI. Future studies evaluating preventive measures are warranted.[9,10,12,13,15-20]

Accepted for Publication: June 21, 2012.
Correspondence: Mike K. Liang, MD, Michael E. DeBakey Veterans Affairs Medical Center, Operative Care Line, Room 112, 2002 Holcombe Blvd, Houston, TX 77030 (ml3@bcm.edu).
Author Contributions: *Study concept and design:* Liang and Awad. *Acquisition of data:* Liang, Li, Avellaneda, and Moffett. *Analysis and interpretation of data:* Liang, Li, Avellaneda, Moffett, and Hicks. *Drafting of the manuscript:* Liang. *Critical revision of the manuscript for important intellectual content:* Liang, Li, Avellaneda, Moffett, Hicks, and Awad. *Statistical analysis:* Liang, Avellaneda, and Hicks. *Obtained funding:* Liang. *Administrative, technical, and material support:* Liang, Li, and Awad. *Study supervision:* Liang.
Conflict of Interest Disclosures: None reported.
Online-Only Material: The eTable is available at http://www.jamasurg.com.

REFERENCES

1. Wong KS, Remzi FH, Gorgun E, et al. Loop ileostomy closure after restorative proctocolectomy: outcome in 1,504 patients. *Dis Colon Rectum*. 2005;48(2):243-250.
2. Mileski WJ, Rege RV, Joehl RJ, Nahrwold DL. Rates of morbidity and mortality after closure of loop and end colostomy. *Surg Gynecol Obstet*. 1990;171(1):17-21.
3. Harold DM, Johnson EK, Rizzo JA, Steele SR. Primary closure of stoma site wounds after ostomy takedown. *Am J Surg*. 2010;199(5):621-624.
4. Marquez TT, Christoforidis D, Abraham A, Madoff RD, Rothenberger DA. Wound infection following stoma takedown: primary skin closure versus subcuticular purse-string suture. *World J Surg*. 2010;34(12):2877-2882.
5. Alexander JW, Solomkin JS, Edwards MJ. Updated recommendations for control of surgical site infections. *Ann Surg*. 2011;253(6):1082-1093.
6. Anderson DJ. Surgical site infections. *Infect Dis Clin North Am*. 2011;25(1):135-153.
7. McCarthy M Jr, Jonasson O, Chang CH, et al. Assessment of patient functional status after surgery. *J Am Coll Surg*. 2005;201(2):171-178.
8. Itani KM, Wilson SE, Awad SS, Jensen EH, Finn TS, Abramson MA. Ertapenem versus cefotetan prophylaxis in elective colorectal surgery. *N Engl J Med*. 2006;355(25):2640-2651.
9. Faunø L, Rasmussen C, Sloth KK, Sloth AM, Tøttrup A. Low complication rate after stoma closure: consultants attended 90% of the operations. *Colorectal Dis*. 2012;14(8):e499-e505. doi:10.1111/j.1463-1318.2012.02991.x.
10. Tan WS, Lim JF, Tang CL, Eu KW. Reversal of Hartmann's procedure: experience in an Asian population. *Singapore Med J*. 2012;53(1):46-51.
11. Sehgal R, Berg A, Figueroa R, et al. Risk factors for surgical site infections after colorectal resection in diabetic patients. *J Am Coll Surg*. 2011;212(1):29-34.
12. D'Haeninck A, Wolthuis AM, Penninckx F, D'Hondt M, D'Hoore A. Morbidity after closure of a defunctioning loop ileostomy. *Acta Chir Belg*. 2011;111(3):136-141.
13. Kobayashi S, Ito M, Sugito M, Kobayashi A, Nishizawa Y, Saito N. Association between incisional surgical site infection and the type of skin closure after stoma closure. *Surg Today*. 2011;41(7):941-945.
14. Reid K, Pockney P, Pollitt T, Draganic B, Smith SR. Randomized clinical trial of short-term outcomes following purse-string versus conventional closure of ileostomy wounds. *Br J Surg*. 2010;97(10):1511-1517.

15. Akiyoshi T, Fujimoto Y, Konishi T, et al. Complications of loop ileostomy closure in patients with rectal tumor. *World J Surg*. 2010;34(8):1937-1942.
16. Shelygin YA, Chernyshov SV, Rybakov EG. Stapled ileostomy closure results in reduction of postoperative morbidity. *Tech Coloproctol*. 2010;14(1):19-23.
17. Fleming FJ, Gillen P. Reversal of Hartmann's procedure following acute diverticulitis: is timing everything? *Int J Colorectal Dis*. 2009;24(10):1219-1225.
18. Milanchi S, Nasseri Y, Kidner T, Fleshner P. Wound infection after ileostomy closure can be eliminated by circumferential subcuticular wound approximation. *Dis Colon Rectum*. 2009;52(3):469-474.
19. Mazeh H, Greenstein AJ, Swedish K, et al. Laparoscopic and open reversal of Hartmann's procedure—a comparative retrospective analysis. *Surg Endosc*. 2009;23(3):496-502.
20. Baraza W, Wild J, Barber W, Brown S. Postoperative management after loop ileostomy closure: are we keeping patients in hospital too long? *Ann R Coll Surg Engl*. 2010;92(1):51-55.
21. Okolica D, Bishawi M, Karas JR, Reed JF, Hussain F, Bergamaschi R. Factors influencing postoperative adverse events after Hartmann's reversal. *Colorectal Dis*. 2012;14(3):369-373.
22. Mahmoud NN, Turpin RS, Yang G, Saunders WB. Impact of surgical site infections on length of stay and costs in selected colorectal procedures. *Surg Infect (Larchmt)*. 2009;10(6):539-544.
23. Pastor C, Baek JH, Varma MG, Kim E, Indorf LA, Garcia-Aguilar J. Validation of the risk index category as a predictor of surgical site infection in elective colorectal surgery. *Dis Colon Rectum*. 2010;53(5):721-727.
24. Fujii T, Tsutsumi S, Matsumoto A, et al. Thickness of subcutaneous fat as a strong risk factor for wound infections in elective colorectal surgery: impact of prediction using preoperative CT. *Dig Surg*. 2010;27(4):331-335.
25. Breuing K, Butler CE, Ferzoco S, et al; Ventral Hernia Working Group. Incisional ventral hernias: review of the literature and recommendations regarding the grading and technique of repair. *Surgery*. 2010;148(3):544-558.
26. Guzmán-Valdivia G. Incisional hernia at the site of a stoma. *Hernia*. 2008;12(5):471-474.

INVITED CRITIQUE

Surgical Site Infection

Still a Common Problem

Liang and colleagues[1] have presented data from a large series of stoma reversal cases at the Houston Veterans Affairs Medical Center. Surgical site infections (SSIs) occurred in more than a third of these high-risk patients, and multivariate analysis demonstrated a history of fascial dehiscence, colostomy, African American race, and obesity to be independent risk factors. The conclusion of the abstract should read 4 risk factors and African American race. Age seemed to protect a bit against SSI, and no mechanical bowel preparation was used in these cases. These patients were not monitored prospectively by a study coordinator to look for SSI, so this actually may be an underestimate. Three different skin closure techniques were used: open, loose, or closed. One patient underwent laparoscopic reversal and did not develop an SSI. Indeed, use of such minimally invasive approaches has been associated with dramatically fewer SSIs, and the consequences of such SSIs are usually minimal as well. It was surprising to see so many midline wounds become infected despite leaving them open. Patients with stomas have a high concentration of skin flora, and it would be interesting to measure bacterial concentrations on the skin and in the subsequent surgical wound before closure. The high rate of methicillin-resistant *Staphylococcus aureus* and enterococci seen in these patients may indicate that preoperative culturing and broader antimicrobial prophylaxis are needed. The use of mesh with concomitant hernia repair was associated with a high rate of SSI, and perhaps some of these patients should undergo a staged repair. Obesity remains a major risk factor, and perhaps motivation to have such a reversal should be used until satisfactory weight loss is achieved. We need to be on high alert to detect these infections, and early return to the clinic is essential. Use of minimally invasive techniques is the next major step to reduce such infections.

William G. Cheadle, MD

Author Affiliations: Department of Surgery, University of Louisville and Robley Rex Veterans Affairs Medical Center, Louisville Kentucky.
Correspondence: Dr Cheadle, Department of Surgery, University of Louisville, 550 S Jackson St, Louisville, KY 40202 (wg.cheadle@louisville.edu).
Conflict of Interest Disclosures: None reported.

1. Liang MK, Li LT, Avellaneda A, Moffett JM, Hicks SC, Awad SS. Outcomes and predictors of incisional surgical site infection in stoma reversal. *JAMA Surg*. 2013;148(2):183-189.