Impact of the extraction-site location on wound infections after laparoscopic colorectal resection

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ABSTRACT

Background: The purpose of this study was to determine the impact of the incision used for specimen extraction on wound infection during laparoscopic colorectal surgery.

Methods: All patients undergoing elective laparoscopic colorectal resection in a single specialized department from 2000 to 2011 were identified from a prospectively maintained institutional database. Specific extraction-sites and other relevant factors associated with wound infection rates were evaluated with univariate and multivariate analyses.

Results: 2801 patients underwent specimen extraction through infra-umbilical midline (N = 657), RLQ/LLQ (N = 388), stoma site (N = 58), periumbilical midline (N = 629), Pfannenstiel (N = 789) and converted midline (N = 280). The overall wound infection rate was 10% and was highest in converted midline (14.6%) and Pfannenstiel (11.4%) incisions, while the lowest rate was associated with RLQ/LLQ (N = 13, 3.3%). Independent factors associated with wound infection were increased BMI (p < 0.001), extraction site location (p = 0.006), surgical procedure (p = 0.020, particularly left-sided colectomy and total proctocolectomy), diagnosis (p < 0.001, particularly sigmoid diverticulitis and inflammatory bowel disease), intraabdominal adhesions (p = 0.033) and intrabdominal rather than pelvic procedure (p = 0.005).

Conclusions: A RLQ/LLQ extraction site is associated with the most reduced risk of wound infection in laparoscopic colorectal surgery.

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Introduction

Minimally invasive surgery is associated with a number of benefits including decreased postoperative pain, improved cosmesis, accelerated postoperative recovery and decreased rates of superficial surgical site (SSI) infections compared to open surgery.[1–3] Despite advancements in technology and increasing expertise in laparoscopic surgery, most operations still require an abdominal incision for specimen extraction, which remains the most common site for wound infections after laparoscopic surgery.

Wound infection is a common postoperative complication, associated with patient discomfort, prolonged recovery time and decreased quality of life.[4,5] In addition, a wound infection substantially increases the risk of readmission and results in increased health care costs. Colorectal surgery is inherently a major contributor to wound infection rates, with reported superficial SSI rates ranging from 5% to 30%.[6]

However, the impact of the specific extraction-site location on wound infection relative to other possible relevant factors remains poorly investigated. In this study, we aimed to evaluate factors associated with wound infection rates after laparoscopic colorectal surgery and in particular assess the individual impact of the specific extraction site location.

Methods

All patients undergoing elective laparoscopic colorectal resection for any primary colorectal pathology from January 2000 to December 2011 in the Department of Colorectal Surgery at the Cleveland Clinic, Ohio, were queried. Data were obtained from our Institutional Review Board-approved, prospectively maintained

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electronic laparoscopic database, supplemented by patient charts as necessary. Patients were divided into five groups according to their specimen extraction-site locations: infra-umbilical midline, right lower quadrant (RLQ)/left lower quadrant (LLQ) site/stoma site, periumbilical midline, Pfannenstiel, and midline converted. Patients undergoing specimen extraction through their perineal incision were excluded, which practically resulted in the exclusion of all patients undergoing permanent stoma creation. Exclusion criteria were also upper abdominal transverse incision, which have been infrequently used in our institution (9 patients), synchronous laparoscopic treatment of organs other than bowel, follow-up shorter than one month and operations without bowel resection.

Conversion to open surgery was defined as the creation of a conventional midline laparotomy to perform the operation rather than what was initially planned for specimen retrieval. Simple enlargements of the extraction site to accommodate a large specimen, mechanical stapler anvil placement or extracorporeal anastomoses were not considered as conversions. Patients whose operations were started laparoscopically but ultimately required conversion to laparotomy were considered as laparoscopic operations, in an intention-to-treat analysis, and the midline incision resulting from conversion to open surgery was considered as an individual extraction site for the purpose of assessing wound infection rates.

Variables included in the analysis were demographics, American Society of Anesthesiologists (ASA) classification, BMI, tobacco use, comorbidities (including diabetes mellitus, cardiac, renal, and pulmonary comorbidities), previous abdominal surgery, preoperative steroid use (defined as steroid administration within one month preceding surgery), postoperative steroid use, type of surgical and laparoscopic procedures, length of hospital stay, operative time, incision size when reported in the operative note, diagnosis, and wound infection.

Surgical technique included routine placement of a wound protector prior to specimen extraction. Midline specimen extraction fascial wounds were closed with mass closure technique using 0-monofilament, polyglyconate (Maxon, Syneture, USA) or PDS sutures (Polydioxane, Ethicon, Norderstedt, Germany), and a sub-cuticular, polyglactin-910 (Vicryl, Ethicon, Cincinnati, OH, USA) suture was utilized for skin closure. Skin staples were not utilized. A transverse closure of the anterior fascia using running 1 polyglactin-910 (Vicryl) was carried out for a muscle-splitting Pfannenstiel extraction site. Muscle-splitting incisions in the right lower quadrant and left lower quadrant were closed with a full-thickness running 1 polyglactin-910 (Vicryl) encompassing all abdominal wall layers. Fascial closure was performed by either the attending surgeon or by a closely supervised trainee.

All patients received mechanical bowel preparation and intravenous antibiotic prophylaxis. Oral antibiotic prophylaxis was not used for this study population. Postoperative recovery was based on the principles of enhanced recovery based on our institutional protocol.[7] In particular, they were encouraged to ambulate and were offered liquids on the day of surgery and started on oral analgesia on day 2 after operation. Discharge criteria were resumption of bowel function, good pain control with oral medications alone, and ability to comfortably tolerate both liquid and solid meals.

The term "wound infection" was synonym with superficial SSI, classified according to the definitions of the Centers for Disease Control and Prevention.[8] The definition of pelvic procedure was rectal dissection conducted below the sacral promontory, including the intestinal anastomosis when applicable.

Statistical significance was assumed when P value (two-sided) was less than 0.05. Categorical variables were reported as frequency (%) and quantitative variables were reported as mean ± standard deviation except where otherwise noted. Categorical variables were analyzed with Chi-square or Fisher's exact test. Quantitative variables were analyzed with a Wilcoxon rank-sum test. Univariate analyses were carried out to define the risk factors for wound infection at the extraction-site in all patients. Subsequently, further multivariate logistic regression analyses were conducted to assess the associations between SSI and risk factors with further covariate adjustments for variables which were significantly associated with superficial SSI on univariate analysis. Factors with p-value < 0.05 on univariate analysis were entered into the multivariate model.

Results

A total of 2801 patients undergoing laparoscopic colorectal resection during the study period (mean age: 51.0 ± 17.9 years, 51.2% females) had the following specimen extraction site locations: infra-umbilical midline (N = 657), RLQ/LLQ (N = 388), stoma site (N = 58), periumbilical midline (N = 629), Pfannenstiel (N = 789) and midline converted (N = 280). Table 1 shows the details of the primary surgical procedures performed, diagnoses and type of laparoscopic approaches, patient characteristics, demographics, and comorbidities and comparative perioperative outcomes among each extraction site group. A Pfannenstiel incision was the most commonly used extraction site for pelvic procedures, while a periumbilical or infra-umbilical midline incisions were the most commonly used extraction sites among patients undergoing abdominal operations. BMI, age, gender, ASA, diabetes mellitus, pulmonary and cardiac comorbidities were statistically different among the groups with healthier patients in the Pfannenstiel group based on ASA classification, age, DM, current smoking status, pulmonary and cardiac comorbidities rates.

When considering all patients combined, the overall wound infection rate was 10% (N = 281). Among those patients, 6 of them had concomitant wound infection both in their extraction site and in other port sites (4 with Pfannenstiel, one with RLQ/LLQ site and one with infra-umbilical extraction site location). Superficial surgical site infection rates were comparable whether patients had a concomitant organ space infection or not (15.2% vs 10.0%, respectively; p = 0.11) and were statistically similar regardless of the individual operating surgeon (SSI rate range: 3.3%–10.8%, p = 0.06). The extraction sites specifically associated with the highest wound infection rates were the midline incision used for conversion to open surgery (N = 41, 14.6%) and a Pfannenstiel incision (N = 90, 11.4%), while the extraction site associated with the lowest rate was RLQ/LLQ site (N = 13, 3.3%). A direct comparison between RLQ and LLQ indicated no significant differences (4% vs. 3.1%, respectively; p = 0.34). When assessing whether the incidence of superficial wound infection changed over time, the yearly wound infection rates ranged between 9.7% and 18.3% over the study period, which was not statistically significant (p = 0.07).

Univariate analysis and the subsequent logistic regression model indicated the following independent risk factors as significantly associated with wound infection: increased BMI, specimen extraction site location, surgical procedure, diagnosis, intrabdominal adhesions, and level of anastomosis/dissection (Table 2). Operative time and estimated blood loss did not quite reach statistical significance.

Discussion

Our data indicate that an extraction site off the midline, located in one of the lower abdominal quadrants or in the opening subsequently utilized as stoma aperture is associated with the best chance to avoid a wound infection. Other independent factors

Table 1
Comparative primary surgical procedures, diagnoses, patient characteristics, demographics, comorbidities and perioperative outcomes.

	Infraumbilical midline (N = 657)	RLQ/LLQ (N = 388)	Stoma site (N = 58)	Periumbilical midline (N = 629)	Pfannenstiel (N = 789)	Midline (converted) (N = 280)	P value
Surgical Procedures							<0.001
Abdomen	459 (69.9)	29 (7.5)	35 (60.4)	503 (80.0)	328 (41.6)	139 (49.6)	
Pelvis	198 (30.1)	359 (92.5)	23 (39.6)	126 (20.0)	461 (58.4)	141 (50.4)	
Surgical Procedures							<0.001
Left-sided colectomy	128 (19.5)	114 (29.3)	2 (3.4)	76 (12.1)	263 (33.3)	67 (23.9)	
Right-sided colectomy	310 (47.2)	15 (3.6)	3 (5.2)	430 (68.4)	75 (9.5)	104 (37.1)	
Total abdominal colectomy	140 (21.3)	14 (3.8)	30 (51.7)	70 (11.1)	249 (31.6)	35 (12.5)	
Proctectomy	41 (6.2)	239 (61.6)	8 (13.8)	42 (6.7)	107 (13.6)	60 (21.4)	
Total proctocolectomy	38 (5.8)	6 (1.7)	15 (25.9)	11 (1.7)	95 (12.0)	14 (5.0)	
Diagnosis							<0.001
Crohn's disease	133 (20.2)	6 (1.5)	10 (17.2)	195 (31.0)	83 (10.5)	51 (18.2)	
Diverticulitis	108 (16.4)	235 (60.6)	5 (8.6)	55 (8.7)	187 (23.7)	65 (23.2)	
Ulcerative Colitis	90 (13.7)	15 (3.9)	36 (62.0)	32 (5.1)	220 (27.9)	29 (10.4)	
Colorectal cancer	255 (38.8)	78 (20.1)	2 (3.6)	289 (45.9)	176 (22.3)	105 (37.5)	
Other benign diseases[a]	71 (10.8)	54 (13.9)	5 (8.6)	58 (9.2)	123 (15.6)	30 (10.7)	
Laparoscopic approach							<0.001
Multiport	402 (61.2)	375 (96.6)	21 (36.2)	513 (81.6)	738 (93.5)	259 (92.5)	
HALS	252 (38.4)	0 (0)	0 (0)	45 (7.2)	45 (5.7)	18 (6.4)	
SILS	3 (0.46)	13 (3.4)	37 (63.8)	71 (11.3)	6 (0.76)	3 (1.1)	
BMI, kg/m^2	27.9 ± 7.6	27.3 ± 5.3	25.1 ± 5.4	27.4 ± 6.7	27.2 ± 7.9	28.9 ± 8.9	<0.001
Age, years	51.9 ± 18.9	54.9 ± 14.2	42.2 ± 15.3	52.6 ± 19.4	46.2 ± 16.6	55.0 ± 17.9	<0.001
Gender (female)	314 (47.8)	185 (47.6)	26 (44.8)	323 (51.4)	446 (56.5)	117 (41.8)	<0.001
ASA class							<0.001
I	17 (2.6)	8 (2.2)	3 5.3)	14 (2.2)	33 (4.2)	7 (2.6)	
II	382 (59.0)	271 (71.8)	37 (64.9)	352 (56.3)	528 (67.2)	141 (51.8)	
III	233 (36.0)	90 (23.8)	16 (28.1)	243 (38.9)	213 (27.1)	112 (41.2)	
IV	16 (2.5)	8 (2.2)	1 (1.7)	16 (2.6)	11 (1.4)	12 (4.4)	
Current smoker	50 (18.0)	37 (23.1)	2 (2.4)	33 (14.6)	60 (13.7)	16 (15.8)	0.005
Pulmonary comorbidities	125 (29.1)	83 (39.5)	9 (18.7)	107 (27.2)	114 (20.6)	46 (31.9)	<0.001
Renal comorbidities	12 (3.4)	8 (4.8)	3 (4.3)	26 (7.7)	27 (5.2)	10 (8.0)	0.09
DM	52 (14.3)	27 (12.0)	4 (6.5)	66 (19.2)	54 (10.2)	37 (25.3)	<0.001
Previous abdominal surgery	257 (39.7)	174 (45.6)	12 (21.8)	220 (37.2)	279 (36.0)	120 (43.8)	<0.001
Cardiac comorbidities	287 (59.3)	152 (54.4)	15 (31.9)	273 (60.3)	274 (45.4)	134 (73.6)	<0.001
Incisional length, cm	6.5 ± 2.8	4.2 ± 1.1	3.3 ± 1.3	5.1 ± 1.6	5.5 ± 1.8	14.2 ± 18.5	<0.001
Operative time, minutes	147 ± 93	96 ± 76	172 ± 92	130 ± 89	185 ± 85	127 ± 116	<0.001
Superficial SSI	72 (11.0)	13 (3.3)	3 (5.1)	62 (9.9)	90 (11.4)	41 (14.6)	<0.001
LOS, days	5.9 ± 5.2	3.8 ± 4.5	8.1 ± 7.1	5.8 ± 4.6	6.8 ± 7.9	7.5 ± 7.3	<0.001
	4 (1–46)	2 (1–66)		4 (1–46)	5 (2–131)	6 (1–67)	

Values are reported as mean ± SD or absolute values (%). Length of hospital stay was reported both as mean (SD) and median (range). RLQ/LLQ: Right Lower Quadrant/Left Lower Quadrant; LAP: Laparoscopic; HALS: Hand-Assisted Laparoscopic Surgery; SILS: Single Incisional Laparoscopic Surgery. BMI: Body Mass Index; ASA: American Society of Anesthesiologists classification; DM: Diabetes Mellitus. SSI: Surgical Site Infection; LOS: Length of Hospital Stay.
[a] Include polyp, rectal prolapse, motility disorders and endometriosis.

significantly associated with the risk of wound infection were BMI, diagnosis and specific surgical procedure performed. Our study provides novel data on a relatively large number of patients undergoing laparoscopic colorectal resection and significantly adds to the sparse literature on this particular topic by assessing the relative impact of not only multiple possible extraction sites but also multiple relevant covariates.

The adverse effect of the diagnosis of inflammatory bowel disease, particularly ulcerative colitis, and increased BMI are not surprising and reflect what previously reported by Drosdeck et al.[9] With respect to the specific extraction site, at least 2 previous series have retrospectively compared wound infection rates associated with Pfannenstiel versus midline extraction site among patients undergoing minimally invasive colorectal cancer surgery. In one of them Pfannenstiel extraction site was identified as an independent factor associated with wound infection, which was estimated as an individual factor associated with a fivefold decreased risk of wound infection.[10] In the other series the Pfannenstiel incision was associated with a decreased rate of wound infection in absolute percentages when directly compared with a midline extraction site (4.8% vs. 13.6%), but this difference did not

reach statistical significance on multivariate analysis, which the authors suggested could be due to small numbers.

It is notable that in our dataset the specific minimally invasive technique used did not have any association with the risk of wound infection and in particular was not associated with any increase in infection rate, unlike what reported elsewhere when using HALS.[9] On the other hand, use of single-incision laparoscopic surgery was not associated with a decreased risk of wound infection, as the reported incidence of approximately 1% in a European series including 159 consecutive colorectal procedures could suggest.[11] This likely depends on our patient population, with a significant proportion of obese individuals and patient selection for the various minimally-invasive techniques, which were largely associated with the individual surgeon's preferences within our specialized unit. Similarly, our superficial SSI rate associated with midline extraction site reflects most of the data reported for laparoscopic colorectal surgery, while some studies have advocated the use of periumbilical extraction site based on a wound infection rate as low as 3.3%.[12,13] These reports are based on a population having a significantly different body habitus and we believe that their findings cannot be easily applied to the heavier Western

Table 2
Multivariate analysis of factors associated with the risk of extraction site surgical site infection.

Variable	Odds Ratio (95% CI)	P-value
BMI (per 5-Kg/m^2 increments)	1.2 (1.1–1.3)	<0.001
Extraction Site Locations		0.006
RLQ/LLQ[a]	1	
Infraumbilical midline	2.8 (1.4–5.5)	0.003
Midline (converted)	3.8 (1.9–7.6)	<0.001
Periumbilical midline	3.0 (1.5–6.0)	0.002
Pfannenstiel	2.6 (1.3–4.9)	0.004
Stoma site	1.1 (0.30–4.3)	0.84
Dissection/anastomosis above peritoneal reflection	2.9 (1.4–6.0)	0.005
Intraoperative adhesions	1.4 (1.03–1.8)	0.033
Surgical Procedure		0.020
Total abdominal colectomy[a]	1	
Left-sided colectomy	1.9 (1.05–3.5)	0.034
Right-sided colectomy	1.4 (0.79–2.5)	0.24
Proctectomy	2.2 (0.97–5.1)	0.059
Total proctocolectomy	3.2 (1.4–7.2)	0.005
Diagnosis		<0.001
Neoplasm[a]	1	
Crohn's disease	1.6 (1.04–2.5)	0.033
Diverticulitis	1.9 (1.2–3.1)	0.009
Ulcerative colitis	3.0 (1.6–5.4)	<0.001
Others[b]	1.2 (0.72–2.1)	0.44
Operative time (per 30-min increments)	1.04 (0.99–1.10)	0.099
Incision Length (per 1-cm increments)	1.02 (0.97–1.08)	0.40
Estimated blood loss (per 100-cc increments)	1.04 (0.98–1.1)	0.23

RLQ/LLQ: Right Lower Quadrant/Left Lower Quadrant; BMI: Body Mass Index; LOS: Length of Stay; SILS: Single Incisional Laparoscopic Surgery; HALS: Hand-Assisted Laparoscopic Surgery; ASA: American Society of Anesthesiologists classification; SSI: Surgical Site Infection.
[a] Reference.
[b] Other benign diseases include polyp, rectal prolapse, motility disorders and endometriosis.

individuals.

While providing novel data on the specific endpoint of wound infection, our study only addressed one of the many variables influencing the ultimate decision on where to create the extraction site, for which operation and on which specific patient. A number of other clinically important factors could not be specifically addressed by our study, including surgeon's experience, preference and familiarity with specific extraction sites, and the risk of other wound complications including incisional hernia. In this respect, the benefits associated with an extraction site off the midline have been previously pointed out.[14] Our dataset was the same as the one previously used to assess the specific risk of incisional hernia when comparing the same extraction sites.[15] The individual extraction site associated with the lowest risk of incisional hernia development was a Pfannenstiel incision, while the risk of incisional hernia associated with RLQ/LLQ site was increased by a factor of 3.6 and the stoma site extraction was the most likely extraction site associated with incisional hernia, having a risk 28 times greater than Pfannenstiel incision.[15] Therefore, a Pfannenstiel extraction site might provide the best compromise between wound infection rate and incisional hernia formation for an operation performed on the left colon or rectum.

One of the limitations of our data is that we could not assess the effectiveness of the seldom-used upper abdominal transverse incision for right–sided resections, which have been traditionally managed with a midline extraction site in our institution. The other limitations of the present series revolve on its retrospective study design, which also reflects the characteristics of our institution as a referral center. In particular, our study population included a substantial number of younger patients with inflammatory bowel disease undergoing surgery utilizing a Pfannenstiel extraction site. While the multivariate analysis was specifically intended to account for the impact of several covariates, the conclusions in our papers might not easily apply to other practices which might have, for example, a larger proportion of patients operated using the same extraction site for sigmoid diverticulitis or rectal cancer, an inherently older population associated with increased comorbidity rates.

In conclusion, an extraction site off the midline is associated with a reduced risk of superficial SSI, once all the other factors affecting the decision on where to extract the specimen are considered.

Disclaimer

None.

Conflicts of interest and source of funding

The authors have no conflicts of interest including relevant financial interests, activities, relationships, and affiliations.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2018.10.034.

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