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Title

Effect of Specimen Extraction Site on Postoperative Incisional Hernia after Minimally Invasive Right Colectomy.

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Abbreviations and Acronyms

ECA	=	extracorporeal anastomosis
ICA	=	intracorporeal anastomosis
IH	=	incisional hernia
LOS	=	length of stay
MIS	=	minimally invasive surgery

site infection, and previous abdominal surgery.^{3,8} As we advance minimally invasive techniques, the specimen extraction site has been identified as an independent risk factor for IH.^{8,9} The most common sites for specimen extraction are periumbilical, midline, and low-transverse (Pfannenstiel) incisions. It is well documented that midline extraction site has a higher rate of IH and more frequently requires surgical repair.^{2,10} Previous studies have not consistently relied on CT scan to diagnose IH and may underestimate hernia rates due to loss of follow-up and subjective physical examinations.^{8,9,11,12} Intracorporeal anastomosis (ICA) may allow the surgeon to use a smaller and off-midline extraction site and can be associated with a lower rate of IH.^{13,14} Overall, most of the evidence on outcomes in MIS surgery for right colectomies has been limited to single-center studies, small cohort sizes, and a lack of variety in MIS approaches.

In this study, we hypothesize that patients who undergo specimen extraction via Pfannenstiel specimen extraction will have a lower rate of IH than patients who undergo midline specimen extraction. Additionally, we aim to better characterize IH occurrence related to operative technique.

METHODS

This is a multi-institutional retrospective cohort study. Status of IRB exemption at the University of California, Irvine (IRB number: 2019-5549) and New York Presbyterian Weill Cornell Medical Center (IRB number: 22-04024714) was obtained, and informed consent was waived. Patients at both institutions were identified through internal bioinformatics queries after obtaining IRB exemption. Patients 18 years of age and older were included in our analysis if they underwent minimally invasive right colectomy from 2012 to 2020. Both laparoscopic and robotic colectomies were included in our analysis. Patients were excluded if they underwent open right-sided colectomy, underwent urgent or emergent surgery, or had no follow-up CT scan. Patients with preexisting ventral hernias or previous ventral hernia repairs were also excluded from our analysis.

Outcomes

The primary objective was to compare the rate of IH in patients undergoing minimally invasive right-sided colectomy with specimen extraction via a midline approach vs a Pfannenstiel approach. The primary outcome is the occurrence of IH on follow-up CT scan at least 1 year after surgery. Secondary outcomes included the hospital length of stay (LOS), surgical site infection, sepsis, anastomotic leak, reoperation, urinary tract infection, and postoperative bleeding.

Statistical analysis

Descriptive statistics were used to describe the overall cohort. Subjects were divided into 2 groups based on the site of specimen extraction: midline specimen extraction or Pfannenstiel specimen extraction. Chi-square and Fisher's exact tests were performed as appropriate for comparisons of categorical variables between the 2 groups. For continuous variables, Wilcoxon rank sum tests were used to compare the 2 groups. Three separate multivariable Firth's logistic regression models were used to estimate the effect of specimen extraction site, operative approach, and anastomosis on odds of postoperative hernia. Each model was adjusted for potential confounders age, sex, BMI, smoking status, previous abdominal surgery, immunosuppression, type of suture used for fascial closure, postoperative anastomotic leak, and institution. Multivariable logistic regression was used to estimate the independent effect of type of suture used for fascial closure on odds of postoperative hernia, adjusting for all potential confounders listed earlier, except for type of suture used for fascial closure. All p values are 2-sided with statistical significance evaluated at the 0.05 alpha level. All data analyses were performed using R version 4.2.1 (The R Foundation for Statistical Computing).

RESULTS

A total of 341 patients were included in the analysis with operative data from 13 surgeons across 2 academic institutions, all of whom completed colorectal surgery or complex general surgery oncology fellowship ranging from first year in practice to more than 20 years. All patients underwent primary anastomosis without end ostomies. There were 12 patients excluded from analysis due to lack of surveillance CT scan at follow-up. Of the 341 patients analyzed, 194 (57%) patients underwent midline specimen extraction and 147 (43%) patients underwent Pfannenstiel specimen extraction. The median time from colectomy to diagnostic CT was 37.25 months and median time to clinical follow-up was 24 months. The patients in the

midline specimen extraction group were older compared with the Pfannenstiel specimen extraction group (66 ± 15 vs 58 ± 16 years, $p < 0.001$). There was no difference in associated comorbidities between the 2 groups (Table 1). Midline specimen extraction patients had a higher rate of previous abdominal surgery compared with Pfannenstiel specimen extraction patients (51% vs 37%, $p = 0.012$). Midline specimen extraction patients were more likely to have surgery for cancer compared with the Pfannenstiel specimen extraction (87% vs 76%, $p < 0.001$). Patients in the Pfannenstiel specimen extraction group were more likely to have inflammatory bowel disease as their surgical indication compared with the midline specimen extraction group (22% vs 8.8%, $p < 0.001$; Table 1). Intracorporeal anastomosis was performed at a higher rate in Pfannenstiel specimen extraction (133, 90%) compared with the midline specimen extraction group (18, 9.3%; $p < 0.001$). Multifilament suture was used in 73% of midline specimen extraction compared 46% in Pfannenstiel specimen extraction ($p < 0.001$). There was no difference in robotic vs laparoscopic approach rates for midline specimen extraction vs Pfannenstiel specimen extraction (Table 2).

Midline specimen extraction had a higher rate of postoperative IH at 25% (48) compared with 0% in Pfannenstiel specimen extraction ($p < 0.001$). The average LOS was longer for midline specimen extraction compared with Pfannenstiel specimen extraction (5.1 ± 2.5 vs 3.4 ± 3.1 days, $p < 0.001$). The rate of anastomotic leak was

higher 4.1% for midline specimen extraction compared with Pfannenstiel specimen extraction (4.1% vs 0%, $p = 0.011$; Table 3).

On multivariable regression modeling controlling for confounding variables, midline specimen extraction was associated with a higher IH rate compared with Pfannenstiel specimen extraction (odds ratio [OR] 24.6; 95% CI 1.89 to 319.44; $p = 0.004$). Extracorporeal anastomosis (ECA) was also associated with higher odds of developing an IH (OR 25.8; 95% CI 2.10 to 325.71; $p = 0.002$). There was no difference in the odds of having an IH between patients undergoing robotic surgery compared with laparoscopic surgery (OR 0.16; 95% CI 0.01 to 2.7; $p = 0.12$). There was also no difference in the odds of developing a hernia between monofilament and multifilament suture closure groups (OR 1.62; 95% CI 0.46 to 5.8; $p = 0.44$).

DISCUSSION

To our knowledge, this is the largest multi-institutional study examining the effect of specimen extraction site on IH rates after minimally invasive colorectal surgery. The use of CT imaging to determine hernia incidence captured both symptomatic and asymptomatic IHs. We demonstrated that the use of a Pfannenstiel extraction site during minimally invasive right colectomy resulted in a significant reduction in IHs, with no patients in our Pfannenstiel

Table 1. Clinical Characteristics of Patient Cohort by Extraction Site

Clinical variable	Midline (n = 194)	Pfannenstiel (n = 147)	p Value*
Age, y, mean (SD)	66 (15)	58 (16)	<0.001
Sex, n (%)			0.55
Female	100 (52)	71 (48)	
Male	94 (48)	76 (52)	
BMI, kg/m ² , mean (SD)	26.9 (6.1)	26.9 (6.6)	0.99
Diabetes mellitus	31 (16)	14 (9.5)	0.08
Hypertension	98 (51)	66 (45)	0.30
Peripheral vascular disease	10 (5.2)	4 (2.7)	0.26
COPD	4 (2.1)	4 (2.7)	0.73
Smoking	20 (10)	11 (7.5)	0.37
Previous abdominal operation	99 (51)	55 (37)	0.01
Immunosuppression†	14 (7.2)	30 (20)	<0.001
Operative indication			<0.001
Cancer	168 (87)	112 (76)	
Inflammatory bowel disease	17 (8.8)	33 (22)	
Other‡	9 (4.6)	2 (1.4)	

*Fisher's exact test; Wilcoxon rank sum test; and Pearson's chi-square test.

†Patients who were on immunosuppressive medications at least 4 weeks before surgery were considered immunosuppressed. This included steroids, biologics, and chemotherapy.

‡One patient each had a surgical indication of angiodysplasia, appendiceal mucinous adenoma, tubular adenoma with high-grade dysplasia, and a sessile polyp. Seven patients had diverticulitis.

Table 2. Operative Characteristics of Patient Cohort by Extraction Site

Clinical variable	Midline (n = 194)	Pfannenstiel (n = 147)	p Value*
Operative approach, n (%)			0.22
Laparoscopic	190 (98)	140 (95)	
Robotic	4 (2.1)	7 (4.8)	
Estimated blood loss, mL, mean (SD)	67 (119)	44 (56)	<0.001
Anastomosis, n (%)			<0.001
Intracorporeal	18 (9.3)	133 (90)	
Extracorporeal	176 (91)	14 (9.5)	
Suture closure, n (%)			<0.001
Monofilament	48 (27)	80 (54)	
Multifilament	132 (73)	67 (46)	

*Fisher's exact test; Wilcoxon rank sum test; and Pearson's chi-square test.

Table 3. Surgical Outcomes by Extraction Site

Clinical variable*	Midline (n = 194)	Pfannenstiel (n = 147)	p Value†
Incisional hernia, n (%)	48 (25)	0 (0)	<0.001
Length of stay, d, mean (SD)	5.08 (2.50)	3.38 (3.13)	<0.001
Anastomotic leak, n (%)	8 (4.1)	0 (0)	0.011
Abscess, n (%)	2 (1.0)	3 (2.0)	0.66
Surgical site infection, n (%)	7 (3.6)	2 (1.4)	0.31
Other complication, n (%)	3 (1.5)	2 (1.4)	>0.99
Reoperation, n (%)	5 (2.6)	4 (2.7)	>0.99

*Except for the incisional hernia, outcomes were counted if occurred within 30 d of operation.

†Pearson's chi-square test; Wilcoxon rank sum test; Fisher's exact test.

specimen extraction cohort developing an IH. ECA was also associated with increased odds of developing an IH. We also found no difference in the rates of IH between laparoscopic and robotic approaches. Finally, patients with midline extraction sites had a longer LOS.

Specimen extraction site is a primary factor in the occurrence of IH after right colectomy. Using a Pfannenstiel extraction site provided a significant reduction in IH development, which is consistent with previous studies. Midline incisions are associated with substantially higher rates of IH compared with transverse, oblique, and paramedian incisions. Samia and colleagues¹⁵ reported a midline specimen extraction vs Pfannenstiel specimen extraction hernia rate of 8.9% and 3.8%, respectively ($p < 0.05$). In this cohort, midline IH accounted for 84% of all detected hernias. Several mechanisms have been suggested to account for the lower Pfannenstiel IH rate, including limited blood supply to the linea alba resulting in poor healing after transection, and vulnerability of midline incisions to increases in intra-abdominal pressure.¹² No IHs were observed in patients with Pfannenstiel extraction sites in our cohort.

We found that the use of an ICA reduced the risk of IH. In our study, ICA was primarily done in conjunction with

Pfannenstiel specimen extraction while ECA done with midline specimen extraction. Selznick and colleagues¹⁶ reported an 80% reduction of the incidence of IH with the use of ICA, 93.5% of Pfannenstiel specimen extraction cases utilized concomitant ICA. Widmar and colleagues¹³ found an IH rate of 2% for ICA compared with 12% in the ECA in patients undergoing MIS right colectomy ($p = 0.007$). ICA easily enables the use of off-midline extraction sites and shorter extraction site incision lengths, which are both associated with lower IH rates.^{13,17,18}

Advances in MIS surgery techniques may not mitigate the risk of IH after right colectomy. Our study found no difference in IH rate when comparing robotic and laparoscopic approaches to right colectomy. Indeed, an improvement of IH hernia rates between MIS and open surgery has not been well established.^{10,19} Widmar and colleagues²⁰ demonstrated no difference in IH rates between robotic and laparoscopic approaches, 17.4% vs 22.2%, respectively ($p = 0.39$). The relatively high and similar rates of IH seen in their study is likely related to the use of midline extraction sites in >90% of patients in their cohort. Tschann and colleagues²¹ performed a recent meta-analysis of patients undergoing MIS right colectomy and found that there was no difference in the odds of IH

between the robotic and laparoscopic group (OR 1.51, $p = 0.22$). Consistent with these studies, our findings did not support the use of robotic surgery to specifically reduce the risk of IH.

Our data did demonstrate a statistically significant difference in LOS between patients with midline and Pfannenstiel extraction sites (5.08 ± 2.50 vs 3.38 ± 3.13 days, $p < 0.001$). Previous studies have suggested that transverse incisions may contribute to fewer surgical site infections, less postoperative pain, and shorter hospital stays, although the literature is variable on these outcomes.^{15,22-26} A Cochrane review by Brown and Goodfellow²⁷ noted a trend toward lower analgesic requirements and improved pulmonary function in Pfannenstiel groups, but these potential advantages did not translate into shorter lengths of stay and we note significant methodological variability in reviewed studies. There are likely confounding factors accounting for the difference in the LOS in our study. More data are needed to determine if extraction site incisions have an effect on LOS.

Limitations of the data

The limitations of this study are inherent to the retrospective cohort nature. Operative details such as incision lengths, operative time, and suture spacing during closure were not readily available for all patients in the cohort. Additionally, given that our study included patients from multiple institutions, there was some inherent variability in surgical technique and postoperative care (**Supplemental Digital Content 1 and 2**, <http://links.lww.com/JACS/A372>). Therefore, we adjusted for institution during our multivariable analysis to minimize this effect.

CONCLUSIONS

Specimen extraction site is the most significant factor contributing to IH rates after right colectomies. Pfannenstiel extraction sites lead to a lower rate of IH compared with midline extractions, regardless of other factors of operative approach and patient characteristics. Therefore, we recommend the use of Pfannenstiel incisions for specimen extraction wherever feasible.

Author Contributions

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Invited Commentary

There Is No Doubt: Avoid Midline Extraction When Feasible in Minimally Invasive Colorectal Surgery to Minimize Risk of Incisional Hernia

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Incisional hernia is a significant source of morbidity and mortality in postoperative surgical patients. Minimally invasive colorectal surgery presents 2 unique challenges regarding risk of incisional hernia compared with other surgical specialties: need to extract a (sometimes sizeable) specimen and exposing incisions to contamination, and therefore, surgical site infection when the bowel is opened. It is well documented that surgical site infection is an independent risk factor for incisional hernia.¹ Strategies to mitigate both unique risk factors in colorectal operation include modifying the extraction site, including natural orifice extraction and use of mesh at the time of incision closure.

The article by Johnson and colleagues² in this issue of the *Journal of the American College of Surgeons* raises several points to consider regarding strategies to decrease the incidence of incisional hernia after colon operation. The article included 341 patients at 2 academic institutions who underwent minimally invasive right colon operation. Their main outcome was the development of incisional hernia at least 1 year postoperatively as visualized on CT scan. They found that the rate of incisional hernia was higher in midline specimen extraction at 25% (48) compared with Pfannenstiel specimen extraction (0, 0%; $p < 0.001$). On multivariable regression modeling, midline specimen extraction was associated with incisional hernia development (odds ratio [OR] 24.6; 95% CI 1.89 to 319.44; $p = 0.004$) as was performing extracorporeal anastomosis (OR 25.8; 95% CI 2.10 to 325.71; $p = 0.002$). Of note, there was no difference in the odds of having an incisional hernia between patients undergoing robotic operation compared with laparoscopic operation (OR 0.16; 95% CI 0.01 to 2.7; $p = 0.12$). There was also no difference in the odds of developing a hernia between monofilament and multifilament suture closure groups (OR 1.62; 95% CI 0.46 to 5.8; $p = 0.44$).