

Incisional and port-site hernias following robotic colorectal surgery

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Abstract

Background The association between extraction site location, robotic trocar size, and the incidence of incisional hernias in robotic colorectal surgery remain unclear. Laparoscopic literature reports variable rates of incisional hernias versus open surgery, and variable rates of trocar site hernias. However, conclusions from these studies are confusing due to heterogeneity in closure techniques and may not be generalized to robotic cases. This study evaluates the effect of extraction site location on incisional hernia rates, as well as trocar hernia rates in robotic colorectal surgery.

Materials and methods A retrospective review of multiport and single incision robotic colorectal surgeries from a single institution was performed. Patients underwent subtotal, segmental, or proctocolectomies, and were compared based on the extraction site through either a muscle-splitting (MS) or midline (ML) incision. Hernias were identified by imaging and/or physical exam. Demographics and risk factors for hernias were assessed. Groups were compared using a multivariate logistic regression analysis. **Results** The study included 259 colorectal surgery patients comprising 146 with MS and 113 with ML extraction sites. Postoperative computed tomograms were performed on 155 patients (59.8 %) with a mean follow-up of 16.5 months. The overall incisional hernia rate was

5.8 %. A significantly higher hernia rate was found among the ML group compared to the MS group (12.4 vs. 0.68 %, $p < 0.0001$). Of the known risk factors assessed, only increased BMI was associated with incisional hernias (OR 1.18). No trocar site hernias were found.

Conclusion Midline extraction sites are associated with a significantly increased rate of incisional hernias compared to muscle-splitting extraction sites. There is little evidence to recommend fascia closure of 8-mm trocar sites.

Keywords Incisional hernias · Robotic surgery · Colorectal surgery · Surgical extraction site · Trocar site hernias

The advantages of laparoscopic colorectal surgery include decreased pain, length of stay, wound complications, cardiac complications, and incidence of pneumonia [1–3]. Similarly, laparoscopic incisional hernia rates are significantly decreased compared to open colorectal surgery approaches [4–6]. This finding was thought to be due to the smaller incision of the extraction site or hand-assisted port. However, some reports document no difference in incisional hernia rates between open and laparoscopic cases despite differences in incision length, including a randomized clinical trial [7, 8]. More recently, there is some evidence that the incisional hernia rate in laparoscopic colorectal surgery is associated with extraction site location rather than the size of the incision. Midline extraction sites have accounted for up to 100 % of incisional hernias in some series of laparoscopic colorectal surgeries, compared to Pfannenstiel or muscle-splitting extraction sites [9–11].

Additionally, laparoscopic colorectal surgery is associated with a trocar site hernia rate that may be as high as 5.2 % [12]. However, trocar site hernias may be under-

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reported since they may be asymptomatic and difficult to diagnose clinically. The risk of trocar site hernias has been associated with trocar size, with up to 86.3 % occurring with trocar diameters of at least 10 mm [13]. Another factor associated with trocar site hernias may also be location. Midline trocar sites have a higher hernia rate associated with complications compared to lateral trocar sites [14].

As robotic-assisted colorectal surgery increases, there is little evidence that evaluates extraction site and trocar site hernias. The current laparoscopic literature may not be generalizable to robotic colorectal surgery since hand-assist ports are often used for laparoscopic extraction sites and indications for surgeries differ between series. Regardless of robotic or laparoscopic technique, it appears that fascial closure is performed for trocar sites >10 mm, while the fascia at 5-mm trocar sites is not primarily closed. However, it remains unclear if fascial closure is required for robotic 8-mm trocar sites. Therefore, the purpose of this study is to evaluate the effect of extraction site location on incisional hernia rates and the rate of trocar site hernias in robotic colorectal surgery.

Materials and methods

After obtaining institutional review board approval, a retrospective review of patients undergoing robotic colorectal surgeries from a prospectively maintained database in a single institution was performed. Consecutive patients undergoing multiport and single incision robotic colorectal surgeries from October 1, 2009, to June 30, 2014, were included. Patients included underwent total, subtotal, segmental, or proctocolectomies, and were divided into two groups based on the specimen extraction site through either a muscle-splitting (MS) or midline (ML) incision. Standard trocar placement was used for right segmental, left segmental, sigmoid, subtotal, and proctocolectomies (Fig. 1). A 12-mm trocar is used for the camera port, and a 13-mm trocar is used for the robotic stapling device in the right lower quadrant port for left segmental, sigmoid, subtotal/total, and proctocolectomies, or the left upper quadrant port for right segmental colectomies. A 5-mm trocar is used for the assist ports. Typically, the left lower quadrant trocar site is extended as the extraction site for left segmental, sigmoid, subtotal, and proctocolectomies, while the midline camera port is extended as the extraction site for right segmental colectomies. Differences in extraction site location were noted and properly categorized as MS or ML. All single incision robotic surgeries were performed through a midline umbilical incision using the GelPOINT Advanced Access Platform (Applied Medical, Rancho Santa Margarita, CA) device, which also served as the

extraction site. Patients were excluded if there was a conversion to a laparotomy or if there was no extraction site. Patients converted from a robotic single incision surgery to a multiport approach remained in the study. Electronic medical records were reviewed for physical exam findings or computed tomography imaging demonstrating incisional or trocar site hernias. All CT scans were reviewed by the authors to specifically identify hernias, which may not have been reported in radiology reports.

In all cases, wound protectors were used for the extraction sites, and fascia was closed with a running 0-polydioxanone suture (PDS). Additionally, all bladeless trocars were used. Fascia of trocar sites >10 mm were closed with an 0-vicryl suture, and the fascia of 8-mm trocar sites were not primarily closed. All 8-mm trocars were placed lateral to the midline. Data collected included demographic characteristics, procedure performed, extraction site, indication for surgery, and risk factors for hernias [body mass index (BMI), pre-operative albumin, current smoking status, diabetes mellitus, and immunosuppressive agents] were assessed. Results are expressed as mean \pm SD for parametric data. Results were analyzed using a multivariate logistic regression analysis to adjust for confounding factors.

Results

Of the 271 consecutive patients in the prospective database, 259 were included in this study. All 12 patients excluded were due to conversion to laparotomy. Of the 259 patients remaining, 146 (56.4 %) were female, the mean age was 59.15 ± 13.10 years, and the mean BMI was 28.56 ± 7.28 kg/m². A total of 188 patients underwent a multiport surgery and 71 had a single incision approach. For all cases, 161 (62.1 %) were segmental colectomies, 89 (34.4 %) were proctocolectomies, and 9 (3.5 %) were total/subtotal colectomies. Postoperative CT scans were performed on 155 patients (59.8 %) with a mean radiologic follow-up of 16.5 ± 14.6 months. The overall incisional hernia rate was 5.8 % ($n = 15$). Most incisional hernias were identified on post-operative imaging 9 (60 %), while 6 (40 %) were clinically evident on physical exam.

Patients were then compared based on extraction site location, and 146 (56.4 %) patients had a MS extraction site, while 113 (43.6 %) had a ML extraction site. Demographics, type of surgery, risk factors, and indication for surgery were compared between groups (Table 1). The ML extraction site patients were older ($p = 0.02$), had fewer proctocolectomies ($p = 0.001$) and had fewer cancer indications for surgery ($p = 0.021$). Of the 15 hernias discovered by physical exam and imaging, 1 (0.68 %) occurred in the MS group, and 14 (12.4 %) occurred in the ML group. Therefore, a significantly lower hernia rate was found

Fig. 1 Trocar sites for multiport colorectal surgeries. **A** Trocar sites for right segmental colectomy. Trocar site 1 is often not used if an extracorporeal anastomosis is performed. If an intracorporeal anastomosis is performed, a 13-mm trocar is used for the robotic stapler. **B** Trocar sites for left segmental, sigmoid, subtotal/total, and proctocolectomy. Trocar site 3a is not used for sigmoid colectomies since splenic flexure mobilization is often unnecessary. Trocar site 3b is not used for left segmental colectomies since pelvic dissection is often unnecessary

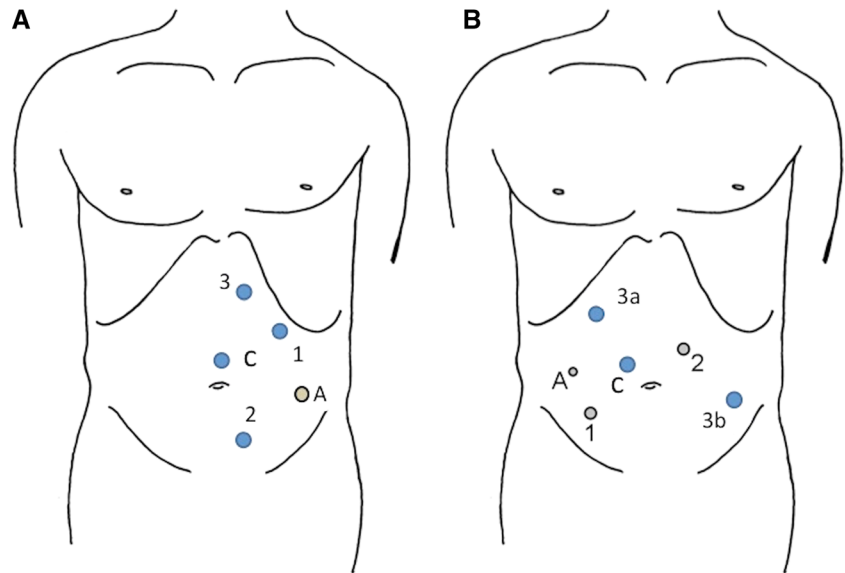


Table 1 Demographics, type of surgery, risk factors, and indication for surgery between muscle-splitting and midline incision extraction site groups

	Muscle splitting (MS) (<i>N</i> = 146)	Midline (ML) (<i>N</i> = 113)	<i>p</i> value
Mean age	57.5 ± 12.44	61.5 ± 13.84	0.02
Mean BMI	28.9 ± 7.03	27.8 ± 6.71	0.20
Gender: male	54 (47.8 %)	59 (52.2 %)	0.72
Surgery			
Proctocolectomy	86 (58.9 %)	3 (2.7 %)	
Segmental	57 (39.0 %)	104 (92.0 %)	
Total/subtotal	3 (2.1 %)	6 (5.3 %)	0.001
Diabetes mellitus	25 (17.1 %)	14 (12.4 %)	0.291
Albumin	4.0 ± 0.61	4.0 ± 0.62	0.700
Smoking	30 (20.6 %)	19 (16.8 %)	0.447
Immunosuppression	9 (6.2 %)	8 (7.1 %)	0.786
Diagnosis			
Benign	56 (38.4 %)	63 (55.8 %)	
Cancer	81 (55.5 %)	45 (39.8 %)	
IBD	9 (6.2 %)	5 (4.4 %)	0.021

A *p* value <0.05 is considered statistically significant

BMI body mass index, IBD inflammatory bowel disease

among the MS group compared to the ML group ($p < 0.0001$). Regarding imaging for each group, a total of 57 (50.4 %) patients in the midline extraction site group had a CT scan with a mean follow-up of 17.25 ± 15.21 months, and a total of 96 (65.7 %) patients in the muscle-splitting group underwent a CT scan with a mean follow-up of 16.17 ± 14.38 . Overall, even with similar radiological follow-up between groups, ML incisional hernias accounted for 93.3 % of all hernias. Of the known risk factors assessed, only an increased BMI > 30 was associated with incisional hernias (OR 1.18) after adjusting for confounding variables. There was no difference in the hernia rates between those undergoing robotic multiport and single

incision approaches. A total of 9 patients who underwent robotic multiport surgery developed an extraction site hernia, while 6 patients in the single incision group developed a hernia ($p = 0.837$). There was no evidence of 5-, 8-, 12-, or 13-mm trocar site hernias on physical exam or radiologic studies.

Discussion

Incisional hernia is one of the most common late complications of surgery, and most recently reported as high as 33 % following open colorectal surgery [5]. Although most

retrospective studies demonstrate a decreased incisional hernia rate in laparoscopic colorectal surgery compared to open cases, a handful of small prospective randomized studies show no difference between laparoscopic and open incisional hernia rates in colorectal surgery [8, 15–18]. In fact, incisional hernia rates have been reported as high as 24.3 % in the laparoscopic group [8]. Therefore, other factors besides incision length must be considered.

Specifically, these data suggest that extraction site location is associated with incisional hernia rates. In this study, midline extraction sites had an incisional hernia rate 18 times higher compared to lateral, transverse muscle-splitting extraction sites. Many factors are attributed to increased hernia rates such as obesity, poor nutrition, smoking, and immunosuppression. However, these factors did not significantly differ between extraction site groups in this study. The predominant variable predicting incisional hernia was the location of the extraction site itself. Therefore, the choice of incisions may be paramount in the risk of developing incisional hernias. A meta-analysis comparing randomized trials of open vertical midline incisions versus transverse incisions found a significantly higher incisional hernia rate in the midline vertical incision group compared to the transverse incision group with an odds ratio of 1.68 [19]. Furthermore, a small number of retrospective studies have implicated midline extraction sites as a risk factor for incisional hernias [9–11].

A recent retrospective study comparing standard laparoscopic (multiport) approaches with laparoscopic single-site techniques in colorectal surgery found a significantly increased incidence of incisional hernias in the single-site group compared to the multiport group (17 vs. 7.6 %) [20]. In our study, there was no difference in incisional hernia rates between patients undergoing robotic multiport and single incision surgeries. The reason for this difference is unclear since the sample size and follow-up time is similar between studies. However, in the study by Sangster et al., a higher proportion of single-site patients were on steroids, multiple closure techniques were used, and patients requiring urgent operations were included. Despite these differences, only the operative approach was found to be significant. However, the authors allude to the fact that the midline extraction site of single-site surgery may account for the differences since the predominant extraction site in the multiport group was a Pfannenstiel incision.

However, a Pfannenstiel or transverse, muscle-splitting extraction site may be difficult with respect to certain colorectal surgeries. Midline extraction sites are often used for right colectomies with an extracorporeal anastomosis since the middle colic vessels may limit exteriorizing the bowel into a lateral or Pfannenstiel incision. Laparoscopic intracorporeal anastomoses can be performed allowing the

surgeon to select the ideal extraction site, but can be technically challenging. An advantage of a robotic segmental right colectomy may be a technically easier intracorporeal anastomosis, allowing the surgeon to avoid a midline extraction site.

The pathophysiology of midline incisional hernias is not fully understood, but great impetus is placed on the technical aspect of closing the fascial defect including type of suture, running versus interrupted techniques, suture length to wound length ratios, and depth of fascial bites compared to full thickness bites. Despite many studies evaluating these techniques, very few studies report significant differences in incisional hernia rates, and the studies that did show differences had several limitations. Therefore, the anatomical components and physiology of the abdominal wall may contribute more to incisional hernia formation than closure technique. The aponeuroses of the external oblique, internal oblique, and transversus abdominis all fuse and insert into the linea alba. This insertion line runs from the xiphoid process to the pubis and is an area of intense shearing forces. This group of muscles and aponeurotic sheets sustain the majority of the work for the abdominal wall [21]. Therefore, the linea alba is the major contributing factor to the mechanical stability of the abdominal wall. With midline incisions, the structural integrity of the linea alba is lost, leading to the development of incisional hernias.

Accordingly, trocar site hernias many follow a similar pattern, with a higher rate in the midline, especially the umbilicus [12, 14, 22, 23]. This study demonstrated no trocar site hernias in either the 5-, 8-, 12-, or 13-mm trocar sites. A large review of laparoscopic port-site hernias in gastrointestinal surgery found that laparoscopic colorectal surgery had the highest rate of trocar site hernias at 1.47 % [24]. Robotic trocars may prevent hernia formation by employing a fixed remote center mechanism for each trocar, which minimizes trauma to the abdominal wall. Another factor is that no trocars are placed in the midline except for the camera 12-mm port for right colectomies, since this site is often extended and used for specimen extraction (Fig. 1). Also, the fascia of all trocar sites >10 mm was primarily closed. Since the implementation of robotic 8-mm trocars, there have been very few studies, and none in the general surgery or colorectal literature, evaluating hernias from trocars this size. Some studies suggest routine fascial closure of laparoscopic port sites >5 mm, but some even recommend closure of 5-mm trocar sites especially with prolonged procedures and excessive manipulation of the 5-mm trocars [25–27]. However, based on the broad, laparoscopic literature, there is little evidence to suggest that the fascia of 8-mm trocar sites should be closed, especially if they are placed off the midline. Consideration should be made to close the fascia of 8-mm

trocar sites in high-risk patients if the trocar is placed in the midline.

There are several limitations to this study, including its retrospective nature conducted at a single institution. However, this also minimizes variations in technique since the described methods are standard for this colorectal group. Also, the sample size is relatively small compared to other laparoscopic and open series. Despite this limitation, this robotic colorectal series is the largest reported to date, and a significant difference in incisional hernia rates was observed between groups. However, this relatively small sample could contribute to the lack of trocar site hernias observed. Additionally, the radiologic follow-up occurred in only 59.8 % of patients, and the follow-up time is relatively shorter compared to other series. The radiologic follow-up is important since many incisional hernias are asymptomatic and may not be evident on physical exam, as seen in this study. However, CT scans were not routinely ordered on patients in this study, and the majority of CT scans performed were for oncologic follow-up. Therefore, most patients received CT scans between 6 and 48 months. Other patients in the database required CT scans to evaluate for abdominal pain, bowel obstructions, or trauma. Obviously, a prospective study with interval imaging and longer follow-up would be beneficial. Although the majority of incisional hernias occur within 12 months of surgery, the literature notes that the cumulative incidence increases with time, and a 5-year follow-up would be optimal [28–30].

In conclusion, extraction site and trocar site location may contribute to the development of incisional site hernias in robotic colorectal surgery. Retrieval of the colorectal specimen should be tailored to each individual patient, and the midline should be avoided if possible. Alternative extraction sites include a Pfannenstiel incision, or a transverse, muscle-splitting incision employing a previously made trocar incision. Current evidence suggests that the fascia of trocar sites >10 mm should be primarily closed, and the fascia of 8-mm robotic sites do not need to be routinely closed, especially if off the midline.

Compliance with ethical standards

Disclosures Dr. Obias is a consultant for Intuitive Surgical. Drs. Harr, Juo, Luka, Agarwal, and Brody have no conflicts of interest or financial ties to disclose.

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