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Splenic flexure mobilization for sigmoid and low anterior resections in the minimally invasive era: How often and at what cost?

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ABSTRACT

Background: Splenic flexure mobilization (SFM) increases left colonic reach for a better vascularized and tension-free anastomosis. Open SFM is challenging due to anatomic position. Minimally invasive SFM improves visualization and minimizes splenic traction.
Methods: We retrospectively reviewed all sigmoid and low anterior resections (LAR) by a colorectal surgical group over 10-year period. We analyzed indications, surgical methods and perioperative outcomes of open and MIS SFM cohorts.
Results: 793 patients were included; 122 (15.5%) open, 671 (84.5%) MIS (60% laparoscopic-assisted (LA), 40% hand-assisted (HA)). Overall, indications were cancer (56%), diverticulitis (31%), and other benign diseases (13%). Compared to MIS, open cases had more complex disease (45% vs. 18%, $p < 0.01$), with fewer SFM performed (40% vs. 86%, $p < 0.01$), required more frequent diversion (30% vs. 21%, $p = 0.02$) and were complicated by higher leak/abscess (7% vs. 3%, $p = 0.06$) and reoperation rates (10% vs. 6%, $p = 0.11$). 1% of SFM required conversion (LA to HA 0.5%, MIS to open 0.5%). There were no open SFM complications. There were 26 (5%) MIS SFM complications; bleeding (18; 12 splenic capsular tears (0 splenectomy/splenorraphy), 6 mesenteric) and organ injury (bowel (3), pancreatic (4), renal (1)).
Conclusions: Our SFM rate was high in the MIS group, with a low overall complication rate. Of note, the anastomotic leak/abscess rate was 3%, and may be related to the high SFM rate. It is the authors' opinion that a major advantage of MIS is to facilitate SFM, hence SFM is more likely to be performed with these methods compared to open procedures.

Introduction

In patients undergoing sigmoidectomy or low anterior resection (LAR), splenic flexure mobilization (SFM) frees the descending and distal transverse colon from their respective attachments such that the descending colon will reach into the pelvis for a tension free anastomosis. SFM also permits a longer proximal margin to be taken and, because the bowel end is closer to the feeding blood vessels, provides better vascularized proximal bowel for the anastomosis. By avoiding tension and improving the blood supply, SFM is believed by many to lower the anastomotic leak rate.[1–3] Although some patients have a very lengthy sigmoid colon, which eliminates the need for mobilization, in many patients undergoing LAR or sigmoid resection SFM is necessary.

Owing to its location high in the left upper quadrant adjacent to the spleen and cephalad to the costal margin, mobilization of the flexure can be challenging. This is especially true during open colectomy in an obese or tall patient, where, despite extension of the midline incision to the epigastrium, it proves difficult to expose the splenic flexure attachments. In these situations it may be necessary to apply heavy traction to the transverse or descending colon in an effort to bring the flexure's splenic attachments into view.[4,5] This traction can result in splenic capsular tears or other splenic injuries. Although most of these splenic injuries are minor and can be handled with cautery, pressure and hemostatic agents, in 0.46–1.4% of open patients it is necessary to perform splenorrhaphy or splenectomy.[3,6–13] Perhaps because of these issues, the rate of SFM in the majority of open colectomy series varies between

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25 and 60%.[4,5,18–21]

MIS methods facilitate SFM by making it possible to move the camera, laparoscopic retractors, and cutting instrument to the left upper quadrant.[3,4,15] The improved visualization allows the colon, spleen, splenic attachments, tail of pancreas, and lesser sac to be better seen and also permits division of the flexure attachments without applying heavy traction. Importantly, MIS SFM can be done without extending the abdominal incision. It is logical to assume that because of these advantages SFM would be performed more frequently in the MIS setting and that the complication rate of flexure takedown would be lower. This retrospective study reviewed the experience of a group of colorectal surgeons regarding the use of SFM during sigmoid resection and LAR in open and MIS cases.

Materials and methods

A retrospective review of patients undergoing elective MIS (either laparoscopic assisted (LA) or hand-assisted laparoscopic (HA)) and open sigmoid resection and LAR for all indications by the section of colorectal surgery at two hospitals over a 16 year period was carried out (New York Presbyterian Hospital, Columbia Campus from October 1, 2000 to June 30, 2009 and Mount Sinai West Hospital [formerly St. Luke's Roosevelt Hospital] from July 1, 2009 to October 30, 2016). Demographic data as well as information regarding co-morbidities, prior surgical history, BMI, surgical indication, SFM (when performed), intraoperative complications (SFM related and other), need for diversion, incision length, conversions, pathology, and perioperative complications was obtained for all patients. Also, the need for additional ports and/or conversion to either HA or open methods was also noted as were the reasons for conversion. Extraction incisions greater than 7 cm were considered open conversions for LA cases whereas final incisions greater than 11 were considered conversions for HAL cases. Postoperative data collected included time to flatus and bowel movement, blood transfusion requirement, perioperative major morbidity and mortality occurring within 30 days of surgery, reoperation rates, length of stay (LOS), and readmission rates. The data was obtained from IRB approved prospective internal databases. Patients undergoing right, transverse, or descending colon resections as well as patients undergoing abdominoperineal or Hartmann resection were excluded as were patients undergoing emergency operations.

Operative techniques

Minimally invasive

The decision to utilize LA or HA methods (hand port placed via lower midline or Pfannenstiel transverse 8–10 cm long incision) was made by each surgeon on a case-by-case basis. There was no set criteria or guidelines for the use of MIS methods.

Port placement

LA approach: A total of five trocars were used; a 5 mm periumbilical camera port (above or below umbilicus based on body habitus), two 5 mm ports on the right side and 2 on the left (more cephalad ports at level of umbilicus and lower ports just above the level of anterior iliac spine; all 4 fingerbreadths from midline). For distal bowel transection, a 12 mm port was placed at the planned site of the specimen extraction incision in the lower midline or suprapubic transverse position.

HA approach: The hand port was placed in either the lower midline (pubic symphysis upward) or Pfannenstiel position. The periumbilical camera port and the right-sided ports were placed as described above (ports placed well lateral to the hand device so as to avoid being trapped beneath the hand port's wound protector). A single left lateral port was placed in the superior portion of the LLQ at least 4 fingerbreadths from the midline.

For all LA/HA cases, an additional RUQ port was placed if required to facilitate SFM.

Splenic flexure mobilization

At the discretion of the surgeon, SFM was done using either the lateral to medial or medial to lateral approach. The timing of the SFM (initially or after the pelvic dissection) was determined on a case-by-case basis.

Lateral to medial approach: The proximal sigmoid colon was retracted medially and cephalad to place traction on the lateral attachments which were then divided with scissors or energy device. As mobilization proceeded, the medial and cephalad retraction was increased in order to maintain traction as well as to keep the small bowel out of the operative field. Placing the patient in reverse Trendelenburg position with the right side down improved the exposure and facilitated SFM. The key was to find the plane between Gerota's fascia anteriorly and the posterior aspect of the colonic mesentery. The tendency is to follow a more lateral plane, which, if continued, mobilizes the kidney. Once the proper plane was found, the line of dissection was usually clear and the dissection atraumatic. If mistakenly dissecting on the renal side of Gerota's fascia occurred, minor bleeding was usually encountered. As the dissection proceeded the retraction points on the colon were moved proximally towards the flexure until full medial mobilization was achieved. Near the flexure, the retroperitoneal dissection plane transitioned from the anterior Gerota's fascia level to a plane that was ventral to the tail of the pancreas. With regards the distal transverse colon, it was the custom of the surgeons in this series to reflect and retract the omentum cephalad and the colon caudal, after which the avascular attachments between the two structures were divided and the lesser sac entered. Lastly, the remaining spleno-colic attachments were divided.

Medial to lateral approach: Two distinct methods were used. The standard medial to lateral mobilization method was started by scoring the peritoneum at the base of the rectosigmoid mesentery at the sacral promontory and proceeding into the pelvis for a distance. The dissection was then continued beneath the mesentery towards the left side and also in a cephalad direction beneath and caudal to the takeoff of the inferior mesenteric artery. After defining the cephalad aspect of the IMA as well as the location of the left ureter, the IMA was divided and the cut edge of the sigmoid mesentery was lifted cephalad. The dissection between the posterior aspect of the mesentery and the retroperitoneal structures (uretero-gonadal bundle) was continued towards the flexure beneath the mesentery and the lateral attachments were divided last. The distal transverse colon portion of the SFM was carried out as described above. The second medial to lateral method was initiated at the level of the IMV, just lateral to the ligament of Treitz. The patient was placed in reverse Trendelenburg position and right side down. The omentum and distal transverse colon were retracted anteriorly and cephalad while the proximal descending colon was retracted anteriorly. This revealed the location of the left colic vessels and IMV (at the mesentery's base towards the pancreas). The dissection was begun by scoring the peritoneum either dorsal or ventral to the IMV, depending on whether that vessel was to be divided or preserved. The dissection then proceeded laterally and the plane between the posterior aspect of the mesentery and the anterior border of Gerota's fascia established. The dissection was then continued laterally. Care was taken not to dissect beneath the pancreas. The transition to a more ventral plane was made as the pancreas is approached. Alternately, the medial to lateral dissection was stopped at the inferior edge of the pancreas and SFM continued by dividing the colon's thin lateral attachments after which the tail of the pancreas was identified from the lateral view point. After mobilizing the proximal descending colon the dissection was continued distally. Next, the omentum was detached from the transvers colon and the splenocolic attachments divided.

Statistical analysis

All statistical analyses were performed using SAS® software, version 9.4. Categorical variables were compared using Chi squared tests and are reported as totals with percentages. Continuous variables were compared using Student's t tests and are reported as median values with ranges. Normality of distribution was assessed using Shapiro-Wilk tests. A p value of <0.05 was considered to be statistically significant.

Results

There were 793 total resections (sigmoid colectomies and LARs) over the study period; 671 (85%) were performed using MIS methods and 122 (15%) with an open technique. The MIS data is reported first, followed by the open results.

Demographics of the 671 patients who underwent MIS sigmoid resection (n = 350, 52%) or LAR (n = 321, 48%) during the 16-year period are reported in Table 1. The mean age was 59.7 years and 47% were male. 33% of patients had undergone prior abdominal surgery. Indications for surgery were malignancy (56%), diverticulitis (33%), benign neoplasm (7%), and other benign diseases (4%) (Table 2). 60% of MIS resections were LA and 40% HA. The mean incision length (IL) for the overall cohort was 8 cm; 6.8 cm and 10.1 cm in the LA and HAL cohorts, respectively. In the LA cohort, the rate of conversion to HA was considerably lower (n = 15, 4%) than conversion to open (n = 46, 11%). In the HA cohort, 21% (n = 56) were converted to open. Perioperative outcomes are reported in Table 3. Mean LOS was 7 days (range 2–67). Regarding return of bowel function, mean time to flatus was 3 days (range 1–15) and first bowel movement was 3 days (range 1–15). Complications in the MIS cohort included anastomotic leak (2%), deep organ space infection (3%), ileus (12%), perioperative blood transfusion (10%), and reoperation (6%). There was one mortality (0.15%).

Outcomes of all patients who underwent SFM to those who did not are reported in Table 4. SFM was carried out in 85% (n = 577) of patients. Demographics including co-morbidities and prior abdominal surgery were comparable between the two cohorts. However, patients in the SFM cohort had a higher mean BMI (27.4 versus 25.8, p = 0.01) and more underwent surgery for diverticulitis (20.5 versus 33.2, p < 0.05) compared to the no SFM cohort. Roughly half of the SFM cases were LAR and the other half sigmoid resections. SFM was performed using both HA (n = 251, 44%) and LA methods (n = 326, 56%). With regards to conversion rates of SFM patients done by LA method (Table 5), 5% (n = 26) required placement of an extra 5 mm port, 1% (n = 4) were converted to HA, and 1% (n = 4) were converted to open. A lateral to medial approach was used in 75%; the remaining 25% had a medial to lateral technique.

Table 1
Demographics of open and MIS cohorts.

Characteristic	Open (n = 122)	MIS (n = 671)	p-value
Age, years	64.4 (27–97)	59.7 (15–93)	<0.01
BMI	25.9 (16.1–58.5)	26.6 (15.7–58.6)	0.06
Gender (male/female)	64 (52.5)/58 (47.5)	318 (47)/353 (53)	0.30
Comorbidities			
Hypertension	53 (53.4)	235 (42.3)	0.04
Coronary Artery Disease	14 (14.1)	58 (10.5)	0.28
Respiratory disease	7 (7.2)	34 (6.1)	0.68
Diabetes Mellitus	14 (14.3)	79 (14.3)	0.99
End Stage Renal Disease	0 (0)	9 (1.6)	0.21
Hypothyroidism	3 (3.1)	39 (7.0)	0.14
Cerebral Vascular Accident	5 (5.2)	12 (2.2)	0.09
Previous malignancy	18 (18.2)	55 (10)	0.02
Tobacco use	22 (23.2)	142 (25.8)	0.58
Prior abdominal surgery	49 (47.1)	222 (39.0)	0.12

Table 2
Disease and surgical characteristics of open and MIS cohorts.

Characteristic	Open (n = 122)	MIS (n = 671)	p-value
Indication for surgery			<0.01
Benign neoplasm	1 (0.8)	44 (6.6)	
Malignant neoplasm	67 (54.9)	376 (56.0)	
Diverticular disease	25 (20.5)	223 (33.2)	
Other benign disease	29 (23.8)	28 (4.2)	
Disease complexity			
Overall	54 (44.6)	121 (18)	<0.01
Fistula	9 (7.4)	23 (3.4)	<0.01
Phlegmon	4 (3.3)	26 (3.8)	0.90
Abscess	6 (5)	14 (2.1)	<0.01
Other organ involvement/procedure performed	46 (38)	77 (11.5)	<0.01
Type of resection			<0.01
Low anterior resection	86 (70.5)	319 (47.5)	
Sigmoid resection	36 (29.5)	352 (52.5)	
Surgical technique			N/A
Laparoscopic assisted		402 (59.9)	
Hand assisted		269 (40.1)	
Splenic flexure mobilization	51 (41.8)	577 (85.9)	<0.01
Length of incision, cm	19.4 (5–35)	8.0 (2.5–30)	<0.01
Laparoscopic assisted		6.8 (2.5–30)	
Hand assisted		10.1 (9–28)	
Diversion rate	37 (30.3)	140 (20.9)	0.02
Conversion rate			N/A
Laparoscopic to hand		15 (3.7)	
Laparoscopic to open		46 (11.4)	
Hand to open		56 (20.8)	

Table 3
30-day perioperative outcomes and complications for open and MIS cohorts.

Characteristic	Open (n = 122)	MIS (n = 671)	p-value
Time to flatus, days	3.7 (1–11)	2.6 (1–15)	<0.01
Time to bowel movement, days	4.3 (1–11)	3.2 (1–15)	<0.01
Length of stay, days	10.5 (3–85)	6.6 (2–67)	<0.01
Blood transfusion	37 (30.3)	67 (10.0)	<0.01
Abscess/Anastomotic Leak	8 (6.6)	21 (3.1)	0.06
Ileus	28 (22.9)	83 (12.4)	<0.01
Pneumonia	4 (3.3)	8 (1.2)	0.08
Wound infection	11 (9.0)	61 (9.1)	0.98
Return to operating room	12 (9.8)	40 (6.0)	0.11
Readmission	6 (4.9)	39 (5.8)	0.69
Death	2 (1.6)	1 (0.2)	0.01

Table 4
30-day perioperative outcomes and complications for SFM and no SFM cohorts.

Characteristic	SFM (n = 577)	No SFM (n = 94)	p value
Time to flatus, days	2.7 (1–15)	2.5 (1–5)	0.06
Time to bowel movement, days	3.2 (1–15)	3.2 (1–12)	0.76
Length of stay, days	6.9 (2–67)	6.3 (3–38)	0.34
Blood transfusion	59 (10)	8 (9)	0.61
Abscess/anastomotic leak	27 (5)	5 (5)	0.72
Ileus	75 (13)	8 (9)	0.22
Pneumonia	8 (1)	0 (0)	0.25
Wound infection	57 (10)	5 (5)	0.16
Return to operating room	35 (6)	5 (5)	0.78
Readmission	36 (6)	4 (4)	0.46
Death	1 (0)	0 (0)	0.69

Table 5
Characteristics and complications of MIS SFM.

Characteristic	SFM (n = 577)
SFM approach	
Lateral to medial	435 (75)
Medial to lateral	142 (25)
Additional 5 mm laparoscopic port needed	26 (8)
Conversion	
Hand port	4 (1)
Open	4 (1)
Total complications	26 (5)
Pancreatic	4 (1)
Splenic	12 (2)
Renal	1 (0)
Gastrointestinal	3 (1)
Mesenteric Bleeding	6 (1)

With regards to perioperative outcomes, the two cohorts had no significant difference in LOS (6.9 versus 6.3 days, $p = 0.34$), time to first flatus (2.7 versus 2.5 days, $p = 0.06$) and bowel movement (3.2 versus 3.2 days, $p = 0.76$) or complications including leak (5% versus 5%, $p = 0.72$) and deep organ space infections (10% versus 5%, $p = 0.16$). The overall complication rate for SFM was 5% (n = 26). 12 patients had splenic injuries which were either capsular tears or parenchymal injuries causing bleeding. In 9 patients, the bleeding either stopped spontaneously or was controlled with electrocautery. The remaining 3 cases required application of hemostatic agents (Gelfoam or Surgicel) and packing for hemostasis. Estimated blood loss from these 3 injuries was around 75–150 ml. No patients required splenectomy. There were 4 suspected pancreatic injuries, all to the tail of the pancreas. 2 patients developed postoperative pancreatitis which resolved with medical management. 1 patient developed a peripancreatic fluid collection which was managed conservatively. 1 patient had a JP drain left in the lesser sac intraoperatively; however, neither clinical pancreatitis nor enzymatic leak occurred postoperatively. 3 patients had bowel injuries; 1 colotomy (repaired with linear stapler), 1 serosal tear (sutured closed), and 1 small bowel cautery burn (inverted with seromuscular sutures). There were 3 mesenteric injuries all of which resulted in significant blood loss (estimated 400–600 ml/case); the bleeding was controlled via ligasure or loop tie, however, 2 cases required conversion for adequate hemostasis (1 to HA and 1 to open). There were 2 omental injuries causing bleeding which were managed with ligasure device. There were 2 genitourinary injuries; 1 renal capsular injury, and 1 inferior pole of kidney injury which both of which resulted in bleeding that was controlled laparoscopically.

When comparing HA to LA, there were many differences in perioperative outcomes. The LA cohort had a slightly shorter time to flatus (2.6 vs 2.9 days) and first bowel movement (3.1 vs 3.4 days) as well as shorter LOS by 1.5 days (6.2 versus 7.7 days, $p < 0.01$). Although there was no significant difference in leak rates or intra-abdominal abscesses between the two cohorts, there were significantly lower rates of ileus (8% versus 20%, $p < 0.01$), superficial surgical site infections (6% versus 14%, $p < 0.01$), and pneumonia (0.3% versus 3%, $p < 0.01$) in the LA cohort (Table 6).

During the study period, there were 122 open resections performed by the same group of surgeons. Demographics of the open cohort are reported in Table 1. The patients were older (mean age 64 versus 60 years, p=<0.01) and had more significant medical history including hypertension (53% versus 42%, $p = 0.04$) and prior history of malignancy (18% versus 10%, $p = 0.02$) compared to the MIS cohort. As expected, more patients also had a history of prior open abdominal surgery (47% versus 39%, $p = 0.12$). Intraoperatively, the open cohort had more complex surgical disease involving adjacent organs, which, in 38% of cases (versus 12% MIS, $p = 0.001$) required additional surgical procedures. They had a significantly higher percentage of LARs (71% versus 48%, $p < 0.01$) and lower rates of SFM (42% versus 86%, $p < 0.01$) (Table 2). Median incision length was 19.4 cm (23.5 cm for SFM, 16.5 cm for no SFM). There was only one minor complication related to SFM which was a serosal tear managed with topical hemostatic agents. With regards to perioperative outcomes (Table 3), the transfusion rate was much higher in the open cohort (30% versus 10%, $p < 0.01$) as were the rates of anastomotic leakage (7% versus 3%, $p = 0.06$), diversion (30% versus 21%, $p = 0.02$), and reoperation (10% versus 6%, $p = 0.11$). Expectedly, the open cohort had a longer LOS (11 versus 7 days, $p < 0.0001$).

Discussion

The present study is the largest single colorectal surgical group series of MIS SFM cases and the first to include hand-assisted MIS cases. While the primary focus was MIS cases, we also analyzed concurrent open sigmoid/LAR data, ultimately showing that SFM is done notably less often in the open setting. The data was obtained from a prospective perioperative database, which facilitated the detection of takedown related complications beyond splenic injury that is described in the literature. The MIS SFM rate in this series is the highest in the literature (86%) and is associated with low anastomotic leak and deep organ space abscess rates.

The SFM rate noted in prior single center MIS studies ranges from 60% to 73%.[16–18] The takedown rate in most open, single center, case series ranges from 4.5% to 68% and in the majority the rate is less than 50%.[4,5,18–21] Thus, the current study, as well as other studies well demonstrate that, in general, SFM is more likely to be done in the MIS setting. It should be noted that when very large numbers of patients are considered (NSQIP reviews) that the MIS SFM rate, although significantly higher than the open rate, falls below 50%.[21]

Table 6
30-day perioperative outcomes and complications for Laparoscopic and Hand assisted cohorts.

Characteristic	Laparoscopic (n = 402)	Hand assisted (n = 269)	p value
Time to flatus, days	2.6 (1–11)	2.9 (1–15)	<0.01
Time to bowel movement, days	3.1 (1–12)	3.4 (1–15)	<0.01
Length of stay, days	6.2 (2–38)	7.7 (3–67)	<0.01
Blood transfusion	37 (9.2)	30 (11.2)	0.41
Abscess/Anastomotic leak	12 (3.0)	9 (3.4)	0.79
Ileus	30 (7.5)	53 (19.8)	<0.01
Pneumonia	1 (0.3)	7 (2.6)	<0.01
Wound infection	24 (6.0)	37 (13.8)	<0.01
Return to operating room	19 (4.7)	21 (7.8)	0.10
Readmission	18 (4.5)	21 (7.8)	0.07
Death	1 (0.3)	0 (0)	0.41

In order to perform MIS SFM, an extra 5 mm port was placed in 5% of patients and conversion to hand or open techniques were required in 1% of patients. MIS SFM-related complications were noted in 26 patients (5%) in the present series, the majority were minor injuries that could be dealt with laparoscopically and none required splenectomy. Interestingly, splenic injuries accounted for less than half of the complications. Another 7 patients had injuries to the bowel mesentery or left kidney all of which resulted in bleeding. There were 2 serosal injuries and 1 colotomy that were recognized and repaired promptly. Finally, pancreatic injury was suspected in 4 patients (pancreatitis developed in 2 and a fluid collection in 1 patient). Two patients (1 splenic injury and 1 mesenteric injury) required transfusion prompted by SFM related blood loss. In 4 patients with injuries an extra port was placed and in 1 laparoscopic patient it was necessary to convert to hand-assisted and then open methods to deal with the injury.

In the literature, with few exceptions, the only SFM related complications that are discussed and tracked are splenic injury and bleeding. The most commonly cited treatment for splenic injuries is splenectomy with a small proportion of patients undergoing splenorraphy. The incidence of SFM related splenic injuries in open colorectal resection series ranges from 1.2% to 8%.[9,16,22,23] The splenectomy rate ranges from 0.42 to 1.4% in open series,[6,9,12,14] however, it should be noted that in several large reviews all patients undergoing colorectal resection were considered, including those who did not undergo SFM, thus, the incidence for patients undergoing SFM would be higher than stated.[6,14] In published series concerning laparoscopic colorectal resection, the SFM related complication rates range from 0 to 5%.[16,18] The MIS SFM splenectomy rate ranges from 0 to 0.39%.[8,18,19] A NSQIP review of 93,633 colorectal cases reported that the rate of splenectomy or splenorraphy was 6 times higher for open vs laparoscopic cases (0.35 vs 0.06%, $p < 0.01$).[8] Another NSQIP review of 975,825 colorectal resection patients also noted that splenic injuries occurred more commonly in open surgery vs laparoscopic patients (Odds ratio 3.41, $p < 0.01$).[6]

Review of the SFM literature reveals that there are very different opinions regarding the need to take the flexure down for sigmoid and LAR cases. There are a number of papers that present small to middle sized series wherein the SFM rate was very low (4.5–26%) and was associated with good or reasonable outcomes (low leaks and abscess rates).[4,5,20] These authors make the case that for the great majority patients SFM is simply not necessary. They point out that SFM adds time to the case; they also cite high SFM related complication rates that can be avoided by leaving the flexure in place. Another group of investigators believe SFM is necessary in less than 50% of cases.[19] A third group, present authors included, support SFM in the majority of cases. An international questionnaire study of 368 laparoscopic surgeons found that 71.2% routinely mobilize the splenic flexure when doing a TME for rectal cancer.[2] It is difficult to reconcile these different viewpoints since reasonable clinical outcomes have been reported by both the no-SFM and pro-SFM proponents.

It has been the experience of the authors of the current series that in that the majority of cases SFM is needed in order to do both an acceptable cancer operation and a tension free anastomosis. As per 1 clinical and 2 cadaveric studies, SFM gains about 28 cm of colon length (distance the sigmoid descending colon junction will reach into the pelvis as measured from the sacral promontory).[24–26] It is important to note that MIS methods facilitate SFM because the camera and tissue cutting device can be brought to the flexure where the attachments can be divided under good visualization without strong traction. Further, MIS SFM can be done without enlarging the extraction incision except for those cases where a conversion to hand-assisted methods is made solely for SFM. Also, although SFM takes time and can be quite challenging in some patients, with practice and repetition SFM methods can be mastered. The authors hypothesize that once facile with MIS SFM methods, in situations where the need for SFM is equivocal, the surgeon is more likely to mobilize the flexure. Schussel et al.'s results support this position; it was noted that the MIS SFM rate rose during the time period assessed.[18] In contrast to the MIS situation, in the open setting, the difficulty of SFM and the need for extension of the incision are negative incentives for SFM.

Aside from the issue of SFM, this data set provides very interesting data regarding the choice of surgical methods and the short term outcomes associated with each method. Clearly, as is demonstrated by the open surgery subgroup in this study, in the MIS era open methods are most often utilized for the most complex pathologies (diverticular phlegmons, fistulas, locally advanced (T4b) cancer, etc) or in patients with hostile abdomens (prior abdominal surgery).[27] Because the open patients are "sicker" it is not reasonable to compare their short term outcomes such as LOS, bowel function return, transfusions rates, etc to the MIS groups who were healthier and had, on average, more straightforward pathology.

The rationale for choosing between laparoscopic-assisted and hand-assisted laparoscopic methods and the ramifications of that decision as regards short term outcome is also a fertile area for discussion and is worthy of a separate paper.[28] The authors would argue that the use of hand-assisted methods allowed a notably greater percentage of the patients to undergo an MIS resection and, thus, avoid a supraumbilical extension of the incision. However, the results of this data set and others strongly suggest that the short term outcome of the hand-assisted subgroup is clearly inferior to the laparoscopic assisted groups outcomes.[28,30] Although the choice of MIS method did not impact the rate of leaks/deep organ space infections, the hand-assisted method was associated with a higher rate of sSSI's as well a longer LOS and bowel recovery times. Others have noted similar results. It is the author's strong belief, backed up by NSQIP data, that the incidence of sSSI's is directly proportional to incision length.[29] In the author's view, hand-assisted methods are reserved for cases where, for whatever reasons, the surgeon feels that completion of case using straight laparoscopic methods is not likely.

Brief comment is warranted regarding the high conversion rates noted in this study. It is important to note that a strict incision length criteria was used to determine conversion (>7 cm for lap cases and >11 cm for HAL's cases). This is an objective criteria that does not take into account how much of the case was accomplished intracorporeally. If an 8 cm incision is needed to remove a large tumor after a fully laparoscopic resection then the case is considered converted. This is not the case for the vast majority of published MIS colorectal resection series that have utilized criteria that do not take into account the final largest incision length. Application of a strict incision length criteria will result in higher conversion rates when compared to the subjective criteria used by many surgeons.[31] Since the whole point of MIS is to minimize the abdominal wall trauma, in the authors opinion, conversion should be defined by the length of the largest incision.

Summary

In this series of 793 sigmoid and LAR cases MIS methods were used for 84.5% of patients. Open methods were reserved for the most complex and sickest patients, thus, their worse short term outcomes are not surprising and cannot be attributed to the choice of surgical method. The rate of SFM was very high in the MIS group (more than 2 times greater than the Open SFM rate). The conversion rate related to SFM was very low although in 4.5% an additional port was needed. SFM was associated with low leak and deep SSI rates and a 4.5% SFM related complication rate. Of note this is the first paper to note mesenteric, bowel, pancreatic, and other injuries in relation to SFM; less than half of the complications involved the spleen. Most complications were easily managed laparoscopically and none required splenectomy. Of note, regarding hand-assisted methods, the rate of sSSI's, ileus, LOS, and bowel recovery times were significantly higher than noted in the LA group.

As mentioned, as regards sigmoidectomy and LAR, it is difficult to draw firm conclusions regarding the need for SFM or to draw up objective criteria as to when SFM should be performed. Surgeons viewpoints vary widely and the clinical results for both the pro-SFM and the minimalist SFM approaches are acceptable. Having said this, a purview of the literature and this study's data allows the following statements. SFM is more likely to be done in MIS vs open colorectal resections and the rate of splenic injury (as reflected by the splenectomy rate for the most part) is significantly lower in the MIS setting. Routine SFM is associated with low or better than average leak and abscess rates. Adding SFM to an operation lengthens the procedure. In cases where the surgeon is concerned about tension at the anastomosis (many LAR's, proctectomy with coloanal anastomosis, sigmoid resection in patients with short colon's) it is logical to mobilize the splenic flexure. If SFM is done the descending and distal transverse colon should be fully mobilized. The use of hand-assisted laparoscopic methods selectively in challenging patients (obesity, complex pathology, difficult flexure, etc) will increase the percentage of cases done using MIS methods but the short term functional outcomes and LOS as well as the rate of sSSI's are significantly higher than for straight laparoscopic methods.

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Declaration of competing interest

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