SILS Sigmoidectomy Versus Multiport Laparoscopic Sigmoidectomy for Diverticulitis

Mathieu D'Hondt, MD, Hans Pottel, Phd, Dirk Devriendt, MD, Frank Van Rooy, MD, Franky Vansteenkiste, MD, Barbara Van Ooteghem, MD, Wouter De Corte

ABSTRACT

Background and Objectives: In this single-institution study, we aimed to compare the safety, feasibility, and outcomes of single-incision laparoscopic sigmoidectomy (SILSS) with multiport laparoscopic sigmoidectomy (MLS) for recurrent diverticulitis.

Methods: Between October 2011 and February 2013, 60 sigmoidectomies were performed by the same surgeon. Forty patients had a MLS and 20 patients had a SILSS. Outcomes were compared.

Results: Patient characteristics were similar. There was no difference in morbidity, mortality or readmission rates. The mean operative time was longer in the SILSS group ($P = .0012$). In a larger proportion of patients from the SILSS group, 2 linear staplers were needed for transection at the rectum ($P = .006$). The total cost of disposable items was higher in the SILSS group ($P < .0001$). No additional ports were placed in the SILSS group. Return to bowel function or return to oral intake was faster in the SILSS group ($P = .0446$ and $P = .0137$, respectively). Maximum pain scores on postoperative days 1 and 2 were significantly less for the SILSS group ($P = .0014$ and $P = .047$, respectively). Hospital stay was borderline statistically shorter in the SILSS group ($P = .0053$). SILSS was also associated with better cosmesis ($P < .0011$).

Conclusion: SILSS is feasible and safe and is associated with earlier recovery of bowel function, a significant reduction in postoperative pain, and better cosmesis.

Department of Digestive Surgery, Groeninge Hospital, Kortrijk, Belgium (Drs. D'Hondt, Devriendt, Van Rooy, Vansteenkiste).

Interdisciplinary Research Center, Catholic University Leuven, Kortrijk, Belgium (Dr. Pottel).

Department of Anesthesia, Groeninge Hospital, Kortrijk, Belgium (Drs. Van Ooteghem, De Corte).

Address correspondence to: corresponding author: Mathieu D'Hondt, MD, Department of Digestive Surgery, Groeninge Hospital, President Kennedylaan 4, 8500 Kortrijk, Belgium. Telephone: +3256633000, Fax: ++3256633009, E-mail address-es: mathieudhondt2000@yahoo.com, mathieu.d'hondt@azgroeninge.be

INTRODUCTION

The multiport laparoscopic approach for sigmoid resection has been shown to ameliorate patient recovery.[1–3] More recently, Gervaz et al reported a 30% reduction in the duration of postoperative ileus and hospital stay when comparing laparoscopic versus open resection.[4] Single-incision laparoscopic surgery (SILS) has developed over recent years and is gaining popularity in several surgical specialties including colorectal surgery.[5] The theoretical benefits of SILS include less pain, earlier discharge, and a better cosmetic result. However, technical challenges in SILS include a lack of triangulation and limited space to manipulate the surgical instruments. Well-designed studies comparing conventional multiport laparoscopic sigmoidectomy (MLS) with SILS sigmoidectomy (SILSS) are limited. In this single-institution study, we aimed to examine the safety, feasibility, and outcomes of SILSS for recurrent diverticulitis compared with a cohort undergoing MLS in the same time period.

PATIENTS AND METHODS

Patients

The indications for surgery were established according to the guidelines of the American Society of Colon and Rectal Surgeons.[6] All patients underwent elective MLS or SILSS with primary anastomosis. Surgery was performed a minimum of 6 weeks after the patient's last episode of acute diverticulitis. After institutional review board approval, we retrospectively reviewed the charts of all patients who underwent a SILSS or MLS procedure for recurrent diverticulitis performed between October 2011 and February 2013 at our institution.

For each patient, the following variables were collected from our prospectively maintained database: age, gender, body mass index, previous abdominal surgery, number of episodes of acute diverticulitis, Hinchy classification of the

most severe episode , Hinchy classification of the most recent episode, duration of operation, amount of blood loss, conversion to open surgery or addition of extra trocars, and postoperative data including morbidity, mortality, duration of epidural anesthesia, use of intravenous analgesics, and length of hospital stay. The Clavien-Dindo classification system, validated and tested for interobserver variation, was used to classify the severity and nature of complications.[7,8] Furthermore, overall satisfaction and evaluation of the cosmetic result were evaluated on a scale ranging from 0 (very unhappy) to 10 (completely satisfied). These scores were previously used in a recent published randomized trial comparing open versus laparoscopic sigmoid resection for diverticulitis.[9]

Finally, a cost analysis was performed comparing the total cost of the disposable surgical items (linear staplers, energy devices, circular staplers, trocars or single-incision access platform) in both groups.

Anesthesia Protocol

Our protocol for general anesthesia consists of a balanced anesthesia using volatile anesthetics such as sevoflurane in association with a continuous infusion of remifentanil, a potent ultrashort-acting synthetic opioid analgesic.[10] Before patient induction, an epidural catheter was inserted into the 10–11 thoracal epidural space. After preoxygenation (6 L/min for 5 min through a face mask), anesthesia was induced using an intravenous bolus of propofol, a hypnotic agent, until the patient lost consciousness. A continuous infusion of remifentanil was started 2 minutes before induction at 0.25 g/kg/min based on the patient's ideal body weight. After complete induction, a 0.5-mg/kg intravenous bolus of atracurium, a nondepolarizing neuromuscular blocker, was administered. Two minutes after atracurium administration, the patient was intubated and top-up doses of atracurium were given every 20 minutes. The dose of remifentanil, initiated at 0.25 μg/kg/min, was adjusted up or down according to the patient's hemodynamic responses. Each patient received either sevoflurane or desflurane in an air-oxygen admixture. The protocol was based on the measurement of end-tidal anesthetic gas concentrations. Oxygen saturation was maintained 95% and end-tidal carbon dioxide was maintained between 35 and 45 mm Hg, with ventilatory settings left to the discretion of the anesthesiologist. The positive end-expiratory pressure was set at 5 cm H_2O. After intubation, patients received 1 g of intravenous (IV) paracetamol and IV ibuprofen 75 mg if they were not contraindicated.

Surgical Technique

Preoperatively, we administered a phosphate-based enema. Patients were given standard IV prophylactic antibiotics to treat gram-negative and anaerobic bacteria. A urinary catheter and compression lower-leg boots were placed. The patient was placed in the lithotomy position with moderate Trendelenburg and right-sided tilt. The rectum was irrigated with povidone-iodine.

SILS Sigmoidectomy

A pneumoperitoneum was created with a Veress needle in the umbilicus. A 3-cm incision was made through the umbilicus. The Gelpoint access platform (Applied Medical, Rancho Santa Margarita, California) was used in all cases. The pneumoperitoneum was maintained at 15 mm Hg. No curved or articulating instruments were used. The left and sigmoid colon were mobilized using the medial to lateral approach. The left gonadal vessels and the ureter were identified. The inferior mesenteric artery and vein were transected with a 45-mm EndoGIA white stapler (Covidien, EndoGIA Universal roticulator 45–2-0, Norwalk, Connecticut). The hypogastric plexus nerves were preserved. The lateral attachments (line of Toldt) were released. The mesorectum was dissected from the bowel at the level of the proximal rectum to prepare the distal margin of resection using the LigaSure dolphin tip (Covidien, Boulder, Colorado). The high rectum was transected with a linear cutting roticulating stapler (EndoGIA, 60 mm purple cartridge, Covidien). The sigmoid colon was recovered through the umbilical wound protector that is part of the Applied Gelpoint access platform. The sigmoid was resected and the anvil of a 28-mm circular stapler (DST series PCEEA; Covidien) was inserted in the descending colon and secured with a 2–0 Prolene purse-string suture (Ethicon, Norderstedt, Germany). The bowel was returned to the peritoneal cavity and the pneumoperitoneum was re-established. The procedure was completed by joining the anvil to the circular stapler passed transanally, creating an end-to-end double-stapled anastomosis. Once completed, the anastomosis was tested under a water bath for evidence of leakage. No drains were left. At the end of the procedure, the wound protector was removed and the wound was closed in layers.

Conventional Multiport Laparoscopic Sigmoidectomy

Most of the steps in performing the MLS are the same as those described for the SILSS.

A pneumoperitoneum was created with a Veress needle in the left hypochondrium. Four ports were used; a 5-mm port was placed just to the right of the umbilicus for the 30-degree 5-mm camera and 3 additional trocars were placed as follows: a 12-mm trocar just medial and superior to the anterior superior iliac spine, a 5-mm trocar in the left iliac fossa, and a 5-mm trocar in the right flank lateral to the epigastric vessels. The pneumoperitoneum was maintained at 15 mm Hg. A medial to lateral approach was used for submesocolic dissection as in the SILSS group. The mesorectum was dissected from the bowel at the level of the proximal rectum to prepare the distal margin of resection using the Harmonic ACE dissector (Ethicon EndoSurgery GmbH, Norderstedt, Germany). The same stapling devices were used in the SILSS group. For extracting the sigmoid colon, a 5-cm incision was made at the position of the left trocar in the left iliac fossa and a wound protector (ALEXIS Wound Retractor, small; Applied Medical, Rancho Santa Margarita, California) was inserted. At the end of the procedure, the wound protector was removed and the incision was closed in layers.

Postoperative Care

Although we have not implemented an enhanced recovery after surgery program for colectomy at our institution, postoperative management of these patients includes avoidance of using nasogastric tubes, early dietary advancement, and early ambulation.

For postoperative pain management, all patients received a patient-controlled analgesia device (GemStarTM Infusion System, Hispira, Inc, Lake Forest, Illinois). A patient-controlled epidural analgesia device was preferred. A loading dose was administered at the end of the surgical procedure; pain therapy using IV paracetamol and IV ibuprofen had already been undertaken during anesthesia and was continued afterward. Intravenous paracetamol 1 g was administered every 6 hours; IV ibuprofen 75 mg was given only on demand. Postoperative pain control was assessed using a 10-cm visual analog scale (VAS) (0 = no pain, 10 = worst pain) and recorded in the patient's file by nurses.

Regular laboratory tests were performed on postoperative days 1, 3, and 5. Average time to flatus and bowel movement was recorded.

Data Collection and Statistical Analysis

Data were retrieved from routine prospective electronic and paper patient files. For all statistical analyses, SAS version 9.1.3 (SAS Institute, Cary, North Carolina) was used. Analysis was performed using the Fisher exact test (discrete variables), the Student t test or the Wilcoxon rank-sum test (continuous variables) depending on normality (or non-normality) of variables. The Mantel-Haenszel χ^2 test was used as appropriate to test differences between the groups. Statistical significance was set at an alpha of .05 for all analyses.

RESULTS

Demographics—Clinicopathological Characteristics

Patient and clinicopathological characteristics are summarized in **Table 1**. Age, gender, American Society of Anesthesiologists (ASA) score, and body mass index were comparable between the 2 groups. Furthermore, the percentage of patients who had undergone previous abdominal surgery, the number of episodes of acute diverticulitis, the severity of attacks, and the severity of the most recent attack of diverticulitis were also comparable between the 2 groups.

Surgical and Postoperative Outcomes

Surgical outcomes of SILSS versus MLS are shown in **Table 2**. The mean operative time for SILSS was 13 minutes longer than it was for MLS ($P = .0012$). Estimated blood loss was similar and minimal in both groups. In a larger proportion of patients in the SILSS group, 2 linear staplers were needed for transection at the rectum compared with the MLS group (11/20 [55%] vs 7/40 [17.5%]). However, this did not result in a higher anastomotic leak rate. There was one conversion to open surgery in the MLS group. In 2 patients in the MLS group, an additional 5-mm port was required. No additional ports were needed in patients in the SILSS group.

The specimen length was similar in both groups ($P = .1629$). All postoperative outcomes are summarized in **Table 3**. All patients received patient-controlled epidural analgesia. The rate of postoperative complications was not significantly different between the 2 groups. In all, 22 (36.7%) patients had a Clavien-grade complication; all complications were Clavien grade I or II. One anastomotic leak occurred in the MLS group. This patient had a 25-mm large intraabdominal abscess along with a small anastomotic defect at the stapler line, which was confirmed by a computed tomography scan. The patient was readmitted because of fever 10 days after surgery and was treated conservatively with IV antibiotics (meropenem 3×2 g/d for 1 week). There were no deaths in either group. Postoperative recovery with respect to return to bowel function or return to oral intake was faster in the SILSS group than in the MLS group ($P = $

Table 1.
Clinicopathologic Characteristics of Patients Undergoing Sigmoidectomy for Diverticulitis

Variable	Overall (n = 60)	SILSS Group (n = 20)	MLS Group (n = 40)	*P* value
Age, y (range)	61 (39–78)	60 (39–77)	61 (44–78)	.7866
Sex (F/M)	23/37	7/13	16/24	.7833
ASA score				1.000
1	30	9	21	
2	20	10	11	
3	9	1	8	
4	0	0	0	
BMI, kg/m² (range)	24.5 (19–36)	25 (21–31)	24 (19–36)	.8993
Previous abdominal surgery	20	6	14	.7775
No. episodes diverticulitis (range)	3 (2–5)	3 (2–5)	3 (2–6)	.8860
Most severe episode (Hinchy I/II))	41/19	14/6	27/13	1.000
Last episode (Hinchy I/II)	47/13	16/4	31/9	1.000

Table 2.
Surgical Outcomes

Variable	Overall (n = 60)	SILSS Group (n = 20)	MLS Group (n = 40)	*P* value
Operating time (± SD)	95.2 (±15.3)	104 (±12.1)	90.9 (±14.9)	**.0012**
Blood loss (mL) (± SD)	14.2 (±24.5)	15 (±23.5)	13.7 (25.3)	.9414
Preoperative complication	0	0	0	1.000
Conversion to open	1	0	1	1.000
Additional ports placement	2	0	2	.548
Number of linear staplers (1/2)	(42/18)	(9/11)	(33/7)	**.006**
Length of specimen* (cm)	18 (15–24)	19 (15–24)	18 (16–24)	.1629

*After fixation.

.0446 and *P* = .0137, respectively). Although duration of epidural anesthesia was equal in both groups and there was no difference in nonsteroidal antiinflammatory drug (NSAID) use, a significant reduction in pain was noted on days 1 and 2 postoperatively when comparing VAS scores. Length of hospital stay was shorter in the SILSS group but not statistically significant (*P* = .0536). There were 3 readmissions: one from the SILSS group because of gastroparesis with nausea and vomiting and two in the MLS because of, respectively, pneumonia and a pelvic abscess at the stapler line that was considered a small clinical anastomotic leakage. All patients were treated conservatively using IV antibiotics.

Cost Analysis and Long-Term Outcomes

The cosmetic result was better in the SILSS group. Results for overall satisfaction reached borderline statistical significance

and hospital stay was also borderline statistically shorter when compared with MLS (**Table 4**). The average total cost of the disposable surgical items was higher in the SILSS group (€2599) than in the MLS group (€2320) (*P* < .0001). The hernia rate was low and similar in both groups.

DISCUSSION

As is shown in **Table 5**, several case series of SILS colectomy have been published recently. However, few comparative studies have been published comparing single-incision laparoscopic colectomy with standard laparoscopic multiport colectomy. As stated in a recent systematic review, there is significant heterogeneity in study group characteristics, indications for surgery and operative techniques.[30] Most reports are case series that include benign

Table 3.
Postoperative Outcomes

Variable	Overall (n = 60)	SILSS Group (n = 20)	MPS Group (n = 40)	*P* value
Postoperative complication	22	7	15	1.000
Clavien I	6	2	4	1.000
Clavien II	16	5	11	1.000
Clavien III	0	0	0	1.000
Clavien IV	0	0	0	1.000
Bowel function (movement/gas)*	2 (1–8)	2 (1–2)	2 (1–8)	**.0446**
Oral intake*	1 (1–6)	1 (1–2)	1.5 (1–6)	**.0137**
Epidural out*	3 (1–4)	2 (2–4)	3 (1–4)	.1673
Need for NSAID	24	7	17	.7804
Pain scores				
Max pain score day 1 (1–10)	2.77 (0.65)	2.40 (0.50)	2.95 (0.64)	**.0014**
Max pain score day 2 (1–10)	2.08 (0.46)	1.85 (0.49)	2.2 (0.41)	**.0047**
Max pain score day 3 (1–10)	1.40 (0.53)	1.55 (0.60)	1.6 (0.50)	.7337
Discharge*	6.03 (±1.78)	5.5 (±1.15)	6.3 (±1.99)	.0536
Readmission rate	3	1	2	1.000

*Days postoperatively.

Table 4.
Cost Analysis and Long-Term Outcomes

Variable	Overall (n = 60)	SILSS Group (n = 20)	MPS Group (n = 40)	*P* value
Cost disposable*	2413.09 (±178.19)	2599.02 (±127.28)	2320.13 (±116.40)	**< .0001**
Cosmetic result	7.98 (±1.33)	8.75 (±1.07)	7.60 (±1.30)	**.0011**
Overall satisfaction	8.18 (±1.89)	8.5 (±0.89)	8.02 (± 0.86)	.0511
Hernia rate	3	1	2	1.000

*In Euros (€).

(ie, diverticulitis, endometriosis, colitis, polyps not amendable to colonoscopic polypectomy) and malignant conditions and include different types of resections (ie, right, transverse, total and left colectomies). In our comparative study, we only included one specific type of benign colonic disease. All patients underwent the same type of colonic resection by the same surgeon, which reduces the heterogeneity of this study. We currently do not perform SILS colectomies for malignant conditions. Questions remain about the safety of SILS for colorectal cancer resection and there are no data on its long-term outcomes (disease-free or disease-specific survival).[31]

The SILSS and MLS groups were comparable for age, gender and ASA distribution and body mass index. There was no significant difference between the 2 groups in terms of history of previous abdominal surgery, number and severity of episodes of diverticulitis and severity of the last episode of diverticulitis. These factors could potentially influence the operative difficulty and subsequently the complication rate and further outcome.

Several aspects of SILSS differ from the MLS procedure, including the camera view, crossing hands during dissection, and lack of triangulation. This is reflected in a longer average operative time for SILSS in our study. Operative time was 104 minutes for the SILSS procedure, which is only 13.1 minutes longer than the 90.9 minutes required for the MLS. However, this difference was statistically different. Estimated blood loss was equivalent in both

Table 5.
Overview of Published SILS Colectomy Series Including ≥20 Patients

Series	Case Series Comparative	No. Cases	Benign/Malignancy/Mixed	Right-Sided/Left-Sided/Mixed
Champagne et al[11]	Comparative	147	Mixed	Mixed
Geisler and Garrett[12]	Case series	63	Mixed	Mixed
Ramos-Valadez et al[13]	Comparative	20	Mixed	Left
Gajoux et al[14]	Comparative	22	Benign	Mixed
Chew et al[15]	Case series	28	Mixed	Mixed
Champagne et al[16]	Comparative	29	Mixed	Mixed
McNally et al[17]	Comparative	27	Malignancy	Mixed
Katsuno et al[18]	Case series	31	Malignancy	Mixed
Papaconstantinou et al[19]	Comparative	29	Mixed	Right
Lee et al[20]	Comparative	42	Mixed	Mixed
Van den Boezem and Sietses[21]	Case series	50	Mixed	Mixed
Ross et al[22]	Case series	38	Mixed	Mixed
Boni et al[23]	Case series	36	Mixed	Right
Ramoz-Valadez et al[24]	Case series	35	Mixed	Mixed
Kwag et al[25]	Comparative	24	Malignancy	Left
Lu et al[26]	Comparative	27	Malignancy	Mixed
Fujii et al[27]	Comparative	23	Malignancy	Mixed
Vestweber et al[28]	Case series	224	Mixed	Mixed
Keshava et al[29]	Case series	22	Mixed	Right
Current series	Comparative	20	Benign	Left

Most published series are either not comparative or include different types of resections or different types of colonic disease, creating significant heterogeneity.

groups. Regarding conversion, a recently published German single-center experience with SILS colectomy reported a conversion rate to open surgery of 6.3%, half of which were in patients undergoing sigmoid colectomy with a high anterior resection or left hemicolectomy, 95% of whom had diverticulitis.[28] In the current series, no cases were converted to open surgery and no additional ports were placed in the SILSS group. One case in the MLS group had to be converted to open surgery because of extensive adhesions. This 52-year-old female patient had a previous history of extensive surgery for endometriosis including hysterectomy and ovariectomy. The proportion of cases requiring 2 linear staplers to achieve full transection of the proximal rectum was higher in the SILSS group. This indicates a higher risk of oblique stapling in the SILS procedures. In the SILSS group, the linear stapler device was placed through the single-port device in the umbilicus, creating a difficult angle for complete tranverse rectal stapling because the axis of the stapler is in parallel with the axis of the rectum. Therefore an additional stapler was needed in more than half of single-port procedures. In the MLS group, the stapler was placed through the 12-mm port in the left lower quadrant, facilitating transverse stapling of the proximal rectum.

In another recent case-matched study, the same findings were published regarding the number of staplers.[25] However, in their series the leakage rate was higher in the SILSS group. We did not find a higher leakage rate in the SILSS group compared with the MLS group or in the subset of cases in which 2 staplers were used.

In patients requiring 2 linear staplers, the area where the 2 stapler lines crossed was used for the circular stapled anastomosis. In this study, the Clavien-Dindo classification system, validated and tested for interobserver variation, was used to classify the severity and nature of complications.[7,8] The overall complication rate was 36.7% (35% in the SILSS group and 37.5% in the MLS group, $P = 1.000$). Not only the

frequency but also the severity of complications was the same when the Clavien-Dindo classification was used to compare both groups. One clinical anastomotic leak was noted in the MLS group. Only one stapler was used to transect the rectum in this patient. The patient was readmitted because of fever and was treated conservatively with IV antibiotics, so this was graded as a Clavien II complication. There were no deaths in either group. Another theoretical benefit of SILS is that there is less postoperative pain. There have been 2 randomized controlled trials comparing SILS with laparoscopic cholecystectomy, and both showed better pain profiles in the SILS group.[32,33] Of all nonrandomized case-comparison studies comparing SILS and multiport or hand-assisted laparoscopic colonic resections, only 3 studies assessed postoperative pain. Papaconstaniou et al found a significant reduction in postoperative pain in patients undergoing SILS colonic resection when looking at VAS scores on postoperative days 1 and 2. By postoperative day 3, the difference in pain scores was no longer significant. Their series included different resections and multiport and hand-assisted laparoscopic resections, which makes it a heterogeneous patient population. In our standardized population containing only SILSS and MLS, we found identical results. Furthermore, there was no statistical difference in the length of epidural analgesic use in our series nor need for NSAID usage between both groups. In contrast to these results, Lu et al reported that patients in the SILS group experienced more pain on postoperative day 1, and Wolthuis et al found no difference in pain levels.[26,34] In these 2 last reports, several types of resections were included in both groups. Currently, health care providers and health care systems are under extreme pressure to provide treatment modalities that are cost effective without compromising patient care. Therefore a cost analysis of the SILS approach compared with the traditional MLS approach was performed to compare total cost of the disposables. Total cost for disposables was higher in the SILSS group (€2599) than in the MLS group (€2320) ($P <$ .0001). However, the cost of the shorter hospital stay should be taken into consideration because hospital stay was also borderline statistically shorter when compared with MLS.

Our study had certain limitations. First, although we matched the 2 groups for different variables and although the patient characteristics in the 2 groups were comparable, this was not a randomized study and thus may have been prone to certain bias. Second, we do acknowledge interobserver variability and bias affecting the results, because the patients were reviewed in the clinic by the surgeon who performed the surgical procedure. Furthermore, several findings may be the result of a type 1 error because there are only 20 patients

included in the SILSS group. Finally, a better comparison group would probably have been an MLS group with a comparable size extraction site at the midline as opposed to a muscle-splitting incision.

CONCLUSION

Our results show that SILSS for diverticulitis is safe and can be performed without increasing morbidity. It is associated with significantly better short-term benefits including earlier recovery of bowel function and a significant reduction in postoperative pain and better cosmesis. Results for overall satisfaction reached borderline statistical significance, and hospital stay was also borderline statistically shorter when compared with MLS. Further well-conducted comparative studies are needed to confirm our findings.

References:

1. Braga M, Vignali A, Zuliani W, Frasson M, Di Serio C, Di Carlo VW. Laparoscopic versus open colorectal surgery: cost-benefit analysis in a single center randomized trial. *Ann Surg*. 2005;242:890–895.

2. Guller U, Jain N, Hervey S, Purves H, Pietrobon R. Laparoscopic versus open colectomy; outcomes comparison based on large nationwide database. *Arch Surg*. 2003;138:1178–1186.

3. Klarenbeek BR, Veenhof AA, Bergamaschi R, et al. Laparoscopic sigmoid resection for diverticulitis decreases major morbidity rates: a randomized control trial: short-term results of the Sigma Trial. *Ann Surg*. 2009;249:39–44.

4. Gervaz P, Inan I, Perneger T, Schiffer E, Morel T. A prospective, randomized, single-blind comparison of laparoscopic versus open sigmoid colectomy for diverticulitis. *Ann Surg*. 2010;252:3–8.

5. Pfluke JM, Parker M, Stauffer, et al. Laparoscopic surgery performed through a single incision: a systematic review of the current literature. *J Am Coll Surg*. 2011;212:113–118.

6. Wong WD, Wexner SD, Lowry A, et al. Practice parameters for the treatment of sigmoid diverticulitis—supporting documentation. The Standards Task Force, The American Society of Colon and Rectal Surgeons. *Dis Colon Rectum,* 2000;43:290–297.

7. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. *Ann Surg*. 2009;250:187–196.

8. Dindo D, Demartines N, Clavien PA. Classification of surgical complications:a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg*. 2004;240:205–213.

9. Gervaz P, Mugnier-Konrad B, Morel P, Huber O, Inan I. Laparoscopic versus open sigmoid resection for diverticulitis: long-term results of a prospective, randomized trial. *Surg Endosc*. 2001;25:3373–3378.

10. De Corte W, Delrue H, Vanfleteren LJ, et al. Randomized clinical trial on the influence of anaesthesia protocol on intestinal motility during laparoscopic surgery requiring small bowel anastomosis. *Br J Surg*. 2012;99:1524–1529.

11. Champagne BJ, Papaconstantinou HT, Parmar SS, et al. Single-incision versus standard multiport laparoscopic colectomy: a multicenter, case-controlled comparison. *Ann Surg*. 2012;255:66–69.

12. Geisler D, Garrett T. Single incision laparoscopic colorectal surgery: a single surgeon experience of 102 consecutive cases. *Tech Coloproctol*. 2011;15:397–401.

13. Ramos-Valadez DI, Ragupathi M, Nieto J, et al. Single incision versus conventional laparoscopic sigmoid colectomy: a case-matched series. *Surg Endosc*. 2012;26:96–102.

14. Gaujoux S, Maggiori L, Bretagnol F, Ferron M, Panis Y. Safety, feasibility, and short-term outcomes of single port access colorectal surgery: a single institutional case-matched study. *J Gastrointest Surg*. 2012;16:629–634.

15. Chew MH, Wong MT, Lim BY, Ng KH, Eu KW. Evaluation of current devices in single-incision laparoscopic colorectal surgery: a preliminary experience in 32 consecutive cases. *World J Surg*. 2011;35:873–880.

16. Champagne BJ, Lee EC, Leblanc F, Stein SL, Delaney CP. Single-incision vs straight laparoscopic segmental colectomy: a case-controlled study. *Dis Colon Rectum*. 2011;54:183–186.

17. McNally ME, Todd Moore B, Brown KM. Single-incision laparoscopic colectomy for malignant disease. *Surg Endosc*. 2011;25:3559–3565.

18. Katsuno G, Fukunaga M, Nagakari K, Yoshikawa S, Ouchi M, Hirasaki Y. Single-incision laparoscopic colectomy for colon cancer: early experience with 31 cases. *Dis Colon Rectum*. 2011;54:705–710.

19. Papaconstantinou HT, Sharp N, Thomas JS. Single-incision laparoscopic right colectomy: a case-matched comparison with standard laparoscopic and hand-assisted laparoscopic techniques. *J Am Coll Surg*. 2011;213:72–82.

20. Lee SW, Milsom JW, Nash GM. Single-incision versus multiport laparoscopic right and hand-assisted left colectomy: a case-matched comparison. *Dis Colon Rectum*. 2011;54:1355–1361.

21. van den Boezem PB, Sietses C. Single-incision laparoscopic colorectal surgery, experience with 50 consecutive cases. *J Gastrointest Surg*. 2011;15:1989–1994.

22. Ross H, Steele S, Whiteford M, et al. Early multi-institution experience with single-incision laparoscopic colectomy. *Dis Colon Rectum*. 2011;54:187–192.

23. Boni L, Dionigi G, Cassinotti E, et al. Single incision laparoscopic right colectomy. *Surg Endosc*. 2010;24:3233–3236.

24. Ramos-Valadez DI, Patel CB, Ragupathi M, Bokhari MB, Pickron TB, Haas EM. Single-incision laparoscopic colectomy: outcomes of an emerging minimally invasive technique. *Int J Colorectal Dis*. 2011;26:761–767.

25. Kwag SJ, Kim JG, OH ST, Kang WK. Single incision vs conventional laparoscopic anterior resection for sigmoid colon cancer: a case-matched study. *Am J Surg*. 2013 [Epub ahead of print]

26. Lu CC, Lin SE, Chung KC, Rau KM. Comparison of clinical outcome of single incision laparoscopic surgery using a simplified access system with conventional laparoscopic surgery for malignant colorectal disease. *Colorectal Dis*. 2012;14:e171–e176.

27. Fujii S, Watanabe K, Ota M, et al. Single-incision laparoscopic surgery using colon-lifting technique for colorectal cancer: a matched case-control comparison with standard multiport laparoscopic surgery in terms of short-term results and access instrument cost. *Surg Endosc*. 2012;26:1403–1411.

28. Vestweber B, Galetin T, Lammerting K. Single incision laparoscopic surgery: outcomes from 224 colonic resections performed at a single center using SILS. *Surg Endosc*. 2013;27:434–442.

29. Keshava A, Young CJ, Mackenzie S. Single-incision laparoscopic right hemicolectomy. *Br J Surg*. 2010;97:1881–1883.

30. Fung AK, Aly EH. Systematic review of single-incision laparoscopic colonic surgery. *Br J Surg*. 2012;99:1353–1364.

31. Gill IS, Advincula AP, Aron M, et al. Consensus statement of the consortium for laparoendoscopic single-site surgery. *Surg Endosc*. 2010;25:762–768.

32. Tsimoyiannis EC, Tsimogiannis KE, Pappas-Gogos G, et al. Different pain scores in single incision laparoscopic cholecystectomy versus classic laparoscopic cholecystectomy: a randomized controlled trial. *Surg Endosc*. 2010;24:1842–1848.

33. Bucher P, Pugin F, Buchs NC, Ostermann S, Morel P. Randomized clinical trial of laparoendoscopic single-site versus conventional laparoscopic cholecystectomy. *Br J Surg*. 2011;98:1695–1702.

34. Wolthuis AM, Penninckx F, Fieuws S, D'Hoore A. Outcomes for case-matched single port colectomy are comparable with conventional laparoscopic colectomy. *Colorectal Dis*. 2012;14:634–641.