Original Article

Bernd Schneider, Anne Catharina Brockhaus, Marcos Gelos and Claudia Rudroff*

The single-incision laparoscopic surgery technique has questionable advantages in colorectal surgery

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Abstract

Background: Laparoscopic procedures have increasingly been accepted as standard in surgical treatment of benign and malignant entities, resulting in a continuous evolution of operative techniques. Since one of the aims in laparoscopic colorectal surgery is to reduce access trauma, one possible way is to further reduce the surgical site by the single-incision laparoscopic surgery technique (SLS). One of the main criticisms concerning the use of SLS is its questionable benefit combined with its technical demands for the surgeon. These questions were addressed by comparing SLS versus conventional laparoscopic multitrocar surgery (LMS) in benign and malignant conditions with respect to technical operative parameters and early postoperative outcome of the patients.
Methods: Between 2010 and 2013, we performed SLS for colorectal disease. Of the 111 patients who underwent colorectal resection, 47 patients were operated by SLS and 31 using the LMS technique. The collected data for our patients were compared according to operating time, postoperative morbidity and mortality, pain score numeric rating scale on day 1 and day 5 postoperatively and postoperative hospital stay. To complement the pain scores, the required pain medication for adequate pain relief on these days was given.
Results: There was no significant difference in age, BMI or sex ratio between the two groups. The intraoperative and early postoperative course was comparable as well. Postoperative hospital stay was the only parameter with a significant difference, showing an advantage for SLS.
Conclusion: SLS is a feasible surgical method and a technical option in laparoscopic colorectal surgery. However, we were not able to identify substantial advantages of SLS that would favor this technique.

Keywords: colorectal surgery; laparoscopic surgery; minimally invasive surgery; postoperative course; single-incision laparoscopic surgery.

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; LMS, laparoscopic multitrocar surgery; NOTES, natural orifice surgical approach; NRS, numeric rating scale for pain evaluation; NSAR, non-steroidal anti-rheumatic drug; PDC, peridural catheter; SLS, single-incision laparoscopic surgery.

Introduction

Laparoscopic procedures have increasingly been accepted as standard surgical treatment of benign and malignant entities [1, 2], leading to a continuous evolution of operative techniques. Laparoscopic surgery generally is accepted as an alternative to open colorectal surgery [3]. One of the aims in laparoscopic colorectal surgery is to reduce the access trauma to diminish postoperative pain, wound infection risks, and hernia formation in the abdominal wall. One way to achieve these goals is to further reduce the surgical site by the single-incision laparoscopic surgery technique (SLS). SLS uses only one port site. It was first described for cholecystectomy [4] and was successfully established for colorectal surgery in 2008 [5, 6]. It is a feasible technique for colorectal resection in both benign and malignant conditions [7–13]. Although SLS was shown to be suitable, relevant differences in

***Corresponding author: Claudia Rudroff,** MD, Department of General and Visceral Surgery, Evangelische Klinik Koeln-Weyertal, Weyertal 76, D-50931 Cologne, Germany, Phone: +49-221-4792212, E-mail: clro@gmx.de
Bernd Schneider: SUVA (Swiss National Accident Insurance Fund), Luzern, Switzerland
Anne Catharina Brockhaus: Department of Medical Biometry, Institute for Quality and Efficiency in Health Care (IQWiG), Cologne, Germany
Marcos Gelos: Department of Surgery, Alfred Krupp Krankenhaus Steele, Essen, Germany; and Faculty of Health Sciences, University of Witten-Herdecke, Witten, North Rhine-Westphalia, Germany

terms of local complications and cosmetic results between SLS and laparoscopic multitrocar surgery (LMS) have not been published [14]. One of the main shortcomings of SLS is that it is questionable whether it affords a real advantage for the patient [14]. Furthermore, the technical demands for the surgeon are considered high [15]. To investigate these issues, we compared SLS versus LMS in benign and malignant conditions concerning technical operative parameters and early postoperative outcomes of the patients. We performed SLS with standard straight laparoscopic instruments. Therefore, it was our particular interest to address the learning curve for laparoscopically experienced colorectal surgeons.

Materials and methods

In November 2010, the SLS was introduced for colorectal operations in our hospital. Without restrictions, all adult patients who were scheduled for colorectal resection and had provided their written consent were included in this study. Between November 2010 and March 2013, 111 patients underwent colorectal resection. Forty-seven patients were operated by SLS. Traditional LMS was performed in 31 patients. The open technique was applied in 33 patients, most of them emergency cases without comparable patient characteristics. These cases were, therefore, not considered in this study.

The present study compares the outcome of patients who were scheduled for laparoscopic colorectal surgery using two different procedures, namely SLS and LMS. The SLS technique was applied in left-sided resections only. For right-sided colon resections, we routinely recovered the specimen through an incision in the right upper quadrant. The types of resection are shown in Table 1.

Data were obtained from the patients' charts, which were prospectively documented. Details on patient characteristics [age, body mass index (BMI), sex, American Society of Anesthesiologists (ASA) category] were collected. The intraoperative and postoperative outcomes included operating time, the incidence and severity of postoperative morbidity and mortality according to the Clavien-Dindo classification [16], the pain score according to the numeric rating scale (NRS) [17] on day 1 and day 5 postoperatively, and the postoperative hospital stay.

Table 1: Surgical approach within the two groups of laparoscopic colorectal resections.

Type of resection	SLS	LMS
Sigma resection	38	21
Resection rectopexy (sigmoid resection + suture rectopexy)	6	0
Left colon, oncologic	3	3
Right colon, oncologic	0	3
Right colon, benign	0	4
Total	47	31

Postoperative pain was measured on a daily basis and analyzed on days 1 and 5 after surgery. On these days, we additionally considered the required pain medication for adequate pain relief, since this has an influence on the perceived pain by the patient. The applied pain medication was subdivided into the number of patients with a peridural catheter (PDC), non-steroidal anti-rheumatic drugs (NSARs) and opioid-based medications, and we calculated the precise amount of corresponding pain medication for NSAR and opioid use. Since this outcome is divided into several facets (i.e. different medications and dosages), we refrained from performing any statistical analysis for this outcome but rather presented the data descriptively.

The data were documented in a prospective manner and reviewed as well as analyzed retrospectively.

Statistical analysis

Categorical variables are presented as percentages and were assessed by χ^2 test or Fisher's exact test. Continuous variables are presented as median and range and were compared by the nonparametric Wilcoxon two-sample test. Due to the high number of outcomes considered, we performed the Bonferroni-Holm method [18] to adjust the overall significance level of 0.05. All evaluations were performed with SAS statistical software for Windows, version 9.4 (SAS, Cary, NC, USA).

Surgical technique for SLS

If applicable, patients received a PDC system for postoperative pain management. This was the case for 16 (34%) of 47 patients. We accessed the abdomen by a 3.5-cm-long skin incision at the umbilicus. After detaching the umbilical stump, the fascia was opened to a length of 4 cm. The Gel Point® system (Applied Medical, Rancho Santa Margarita, CA, USA) was applied as the access platform. The system consisted of a transparent ring foil with a flexible internal ring and a stiff outer ring and the actual access platform. The ring foil was applied first, and the platform was clipped on top of the outer ring of the foil. A pneumoperitoneum was created (14 mmHg). The sleeve of the access device was placed in the abdominal cavity. Regular 10-mm optical systems were used along with the regular straight laparoscopic equipment in 5- and 10-mm sizes. Angled or curved laparoscopic instruments were not required with the particular access platform used. An additional 12-mm trocar was placed in the left lower quadrant for the stapling device (Endopath® ETS articulating linear cutter; Ethicon Endo-Surgery, Cincinnati, OH, USA) and was used for later drainage, which was applied routinely. Since 2013, a modified Gel Point access platform with a 12-mm trocar site has been available and has made the additional trocar site unnecessary. A silicone drainage (Robinson Charrière 18; Mediland, Rudersberg, Germany) was routinely applied for SLS and LMS. For vessel sealing, the Harmonic Ace® curved shear (Ethicon Endo-Surgery) was used. The larger vessels were additionally ligated by resorbable clips (Lapro-Clip™, Covidien, Mansfield, MA, USA).

The left colonic flexure was mobilized in all cases. The colon was prepared by a lateral-to-medial approach. After mobilization of the colon and identification of the left ureter, the mesocolon was divided close to the colon in benign diseases in a tubular-resection

manner. In cases of carcinoma, the inferior mesenteric artery and the corresponding vein were primarily isolated and divided (high tie), and the mesocolon was dissected distant to the colon to ensure sufficient lymph node harvest. The specimen was divided with a cutter device (Endopath ETS articulating linear cutter) at the middle third of the rectum to ensure sufficient blood supply for the anastomosis. The specimen was extracted through the umbilical port, which was protected by the transparent ring foil supplied in the gel point set. Anastomosis was performed transanally with a circular stapler (Proximate® ILS curved intraluminal stapler; Ethicon Endo-Surgery). The anastomosis was routinely checked intraoperatively by rectoscopy and air insufflation for sufficiency and hemostasis. The fascia at the umbilicus was closed with 1 Vicryl resorbable sutures (Ethicon, Johnson & Johnson Medical, Norderstedt, Germany). The skin was closed with clips.

Results

Study population and clinical characteristics

In the study sample of 78 consecutively included subjects who underwent laparoscopic colorectal surgery, 31 patients were scheduled for LMS and 47 SLS. An overview of the study population and clinical characteristics, stratified for the two treatment groups, is given in Table 2. There was no significant difference in age, BMI or sex ratio between the two groups. The number of patients with ASA category 2 was slightly higher in the SLS group than in the LMS group, whereas the numbers of patients in ASA categories 1 and 3 were slightly higher in the LMS group.

Table 2: Distribution of characteristics of the study population (n = 78).

	SLS (n = 47)	LMS (n = 31)	p-Value
Age (years)	60 (37–83)	59 (28–84)	0.744
BMI (kg/m²)	25.0 (20.0–48.0)	26 (19–37)	0.782
Male sex (%)	40.4	48.4	0.488
ASA (%)			0.029
1	10.6	25.8	
2	85.1	58.1	
3	4.3	16.1	
4	0	0	

Distributions are presented as median (range) for continuous data and percentages (%) for binary data, p-values from χ^2 test or Fishers' exact test, as appropriate, for binary data and from Wilcoxon two-sample test for continuous data.

Histological findings

Histological findings and clinical classification according to Hinchey in cases of acute diverticular disease [19] stratified for the two techniques are shown in Table 3. Indication for surgery and the surgical access method were chosen as deemed suitable for the individual patient.

SLS was performed mainly in elective cases of recurrent diverticular disease and for obstructive bowel syndrome. With growing experience, selected cases with an acute diverticular disease (Hinchey II and III) were also deemed suitable for the single-incision access technique. LMS was performed in elective as well as in emergency cases if patients were deemed suitable for laparoscopic access. Patients with free perforated diverticular disease and fecal peritonitis were treated by conventional open surgery. Patients with oncologic diseases were scheduled for any of the three available techniques, depending on the clinical judgment.

Table 3: Histological characteristics of the two different laparoscopic access groups.

	SLS (n = 47)	LMS (n = 31)
Carcinoma	3 (6%)	3 (10%)
Adenoma	0	3 (10%)
Recurrent diverticular disease	27 (58%)	10 (32%)
Complicated diverticular disease	11 (23%)	13 (42%)
Hinchey I/II	7 (15%)	8 (26%)
Hinchey III	4 (8%)	5 (16%)
Hinchey IV	0	0
Obstructive bowel disease including cul-du-sac	6 (13%)	0
Ischemia	0	1 (3%)
Crohn's disease	0	1 (3%)

Comparison of the intraoperative outcomes

Five cases (9.6%) had to be converted to open surgery due to intestinal adhesions after previous abdominal surgery in the SLS group. No relevant blood loss occurred in this group, and no blood transfusion was required, either intraoperatively or postoperatively. In one case, a protective loop ileostomy was applied. The operating time for the SLS ranged from 65 to 280 min (median, 125 min).

In 9 cases in the LMS group (22.5%), conversion to open surgery was necessary due to intestinal adhesions after previous abdominal surgery in the majority of the cases and severe inflammatory adhesion in one case of emergency surgery. No blood transfusion was administered intraoperatively. The LMS operating time ranged from 55 to 210 min (median, 135 min).

To ensure an intention-to-treat analysis, the patients who underwent conversion to open surgery were not excluded from their originally assigned treatment group in any of our analyses.

The details on operation time are listed in Table 4 and Figure 1.

Table 4: Comparison of operative outcomes.

	SLS (n = 47)	LMS (n = 31)	p-Value
Operation time (min)	124 (65–280)	135 (55–210)	0.440
Postoperative hospital stay (days)	7 (4–30)	9 (6–39)	0.005[a]
NRS, day 1	2 (0–7)	3 (1–10)	0.032[a]
NRS, day 5	0 (0–4)	1 (0–8)	0.042
Pain medication			
Day 1			
PDC (%)	16 (34%)	7 (23%)	
NSAR (%)	94	97	
NSAR dosage (g/day)	5 (0–8)	5 (0–5)	
Opium use (%)	53	68	
Opium dosage (mg/day)	7.5 (0–60)	15 (0–45)	
Day 5			
NSAR (%)	58	77	
NSAR dosage (g/day)	4.5 (0–5)	4.5 (0–6.2)	
Opium use (%)	6.4	19.4	
Opium dosage (mg/day)	0 (0–22.5)	0 (0–15)	

Distributions are presented as median (range) for continuous data and percentages (%) for binary data; p-values from Wilcoxon two-sample test for continuous data. [a]Significant after adjustment of the global significance level, p = 0.05, by Bonferroni-Holm method.

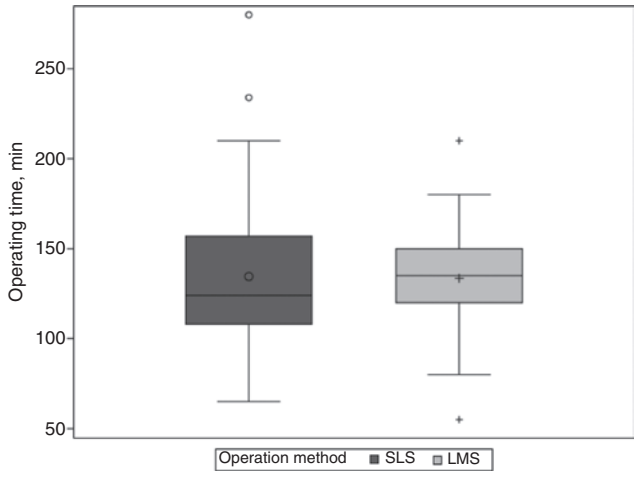

Figure 1: Box plots of the operating time for the two laparoscopic techniques: single-incision laparoscopic surgery (SLS) and laparoscopic multitrocar surgery (LMS).
The box depicts the quartiles (bottom and top) and the median of the operative time in each group, thus containing 50% of the data. Extreme values are highlighted by extra dots above or below the whiskers.

Postoperative course

Three patients in the LMS group received blood transfusion during their hospital stay. Two patients required 5 and 2 blood transfusion units, respectively, 1 and 2 days after surgery. In both cases, a laparoscopic revision due to bleeding was indicated, as stated in the morbidity results. One patient required 1 blood unit within 5 days of surgery. In this case, no operative intervention was necessary.

Postoperative pain scale and pain medication

In the SLS group, the NRS results on day 1 ranged from 0 to 7 (median, 2). In 16 cases (34%), a PDC was applied. Twenty-five patients required morphine-based medication (53%) within the first day after operation. Of these 25 patients, 7 had received simultaneous PDC (28%). On day 5, the pain score ranged from 0 to 4 (median, 0). Three patients still required morphine-based medication (6%). Nineteen patients (40%) required no medication for pain relief.

In the LMS group, the NRS results on day 1 ranged from 1 to 10 (median, 3). A PDC was applied in 7 cases (23%). Within the first 24 h, 21 patients (68%) required morphine-based medication. Five patients (71%) with a PDC required simultaneous morphine application as well. On day 5 after surgery, the median NRS pain score was 1 (range, 0–8). Six patients (19%) required no pain medication, whereas 6 patients (19%) still required morphine-based pain medication.

The postoperative pain score on day 1 was significantly lower in the SLS group compared to the LMS group (p = 0.032), and the same was true on day 5. The latter difference was not statistically significant after adjustment with the Bonferroni-Holm method (Figure 2).

The requirement for pain-relieving medication within the first 24 h after operation in terms of the need for and dosage of morphine-based medication was slightly lower in the SLS group. On day 5 after surgery, the need for opioid-based drugs was slightly lower in the SLS group than in the LMS group.

Details on the results from the NRS as well as the need for pain-relieving medication are given in Table 4 and Figure 3.

Postoperative morbidity and mortality

In the SLS group, postoperative complications were observed in 13 cases (27%). They ranged from grade 1

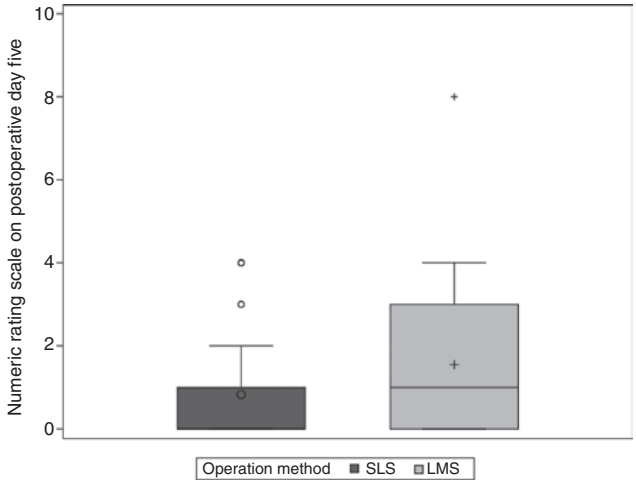

Figure 2: Box plot of the average numeric pain scale between the two surgical techniques.

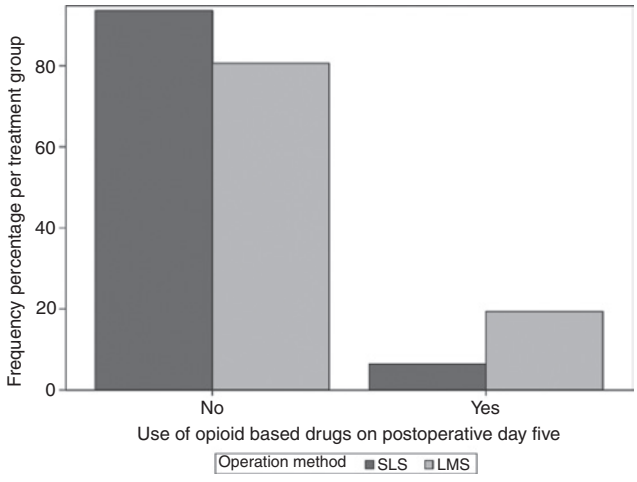

Figure 3: Diagram showing the opioid-based pain-relieving drug requirement on day 5 for the two different surgical techniques.

to grade 4 according to the Clavien-Dindo classification [16]. The majority of cases (9/13; 19%) were minor complications. In 6 cases (13%), a grade 1 complication was observed: 5 cases of superficial wound infection and 1 case of prolonged bowel atonia. In 3 cases (9%), a grade 2 complication was treated with oral antibiotics: two urine infections and one pneumonia. One wound infection required vacuum dressing (grade 3a complication) and in one case, a bleeding complication required re-laparoscopy (grade 3b complication, 4%). In 2 cases, an anastomotic leakage was discovered and required re-laparoscopy as well as intensive care treatment (grade 4a complication, 4%). No grade 4b complication and no mortality were observed.

In the LMS group, a complication was observed in 9 cases (29%). Two cases of a superficial wound infection (grade 1, 6%) and three cases of grade 2 complications (one urine infection, one ileus requiring electrolyte substitution and one pneumonia requiring oral antibiotics, 9%) were observed. In three patients, a reoperation under general anesthesia was required – two cases of postoperative bleeding and one ascites of unknown origin (grade 3b, 9%). One anastomotic leakage was observed and required re-laparoscopy as well as intensive care treatment (grade 4a) (3%). No grade 4b° complication or mortality was observed in this subgroup.

No difference was observed between the two laparoscopic groups concerning postoperative morbidity and mortality ($p = 0.785$). The complications and their distributions are detailed in Table 5 and Figure 4.

Table 5: Postoperative morbidity and mortality according to the Clavien-Dindo classification.

Clavien Dindo classification grades	SLS (n = 47)	LMS (n = 31)
None	34 (72%)	22 (71%)
I°	6 (13%)	2 (6)
II° (medication required as antibiotics)	3 (6%)	3 (10%)
IIIa° (intervention)	1 (2%)	0
IIIb° (intervention requiring anesthesia)	1 (2%)	3 (9%)
IVa° (sepsis)	2 (4%)	1 (3%)
IVb° (multiorgan failure)	None	None
V° (death)	None	None
Summary of complications	13 (27%)	9 (29%)

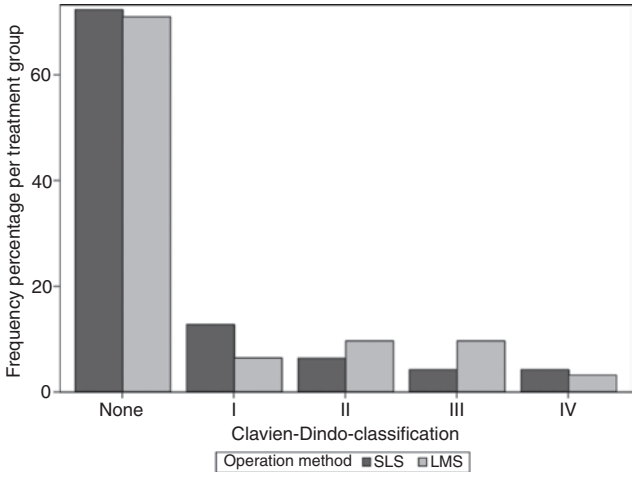

Figure 4: Distribution of postoperative morbidity for the two different laparoscopic approaches according to the Clavien-Dindo classification.

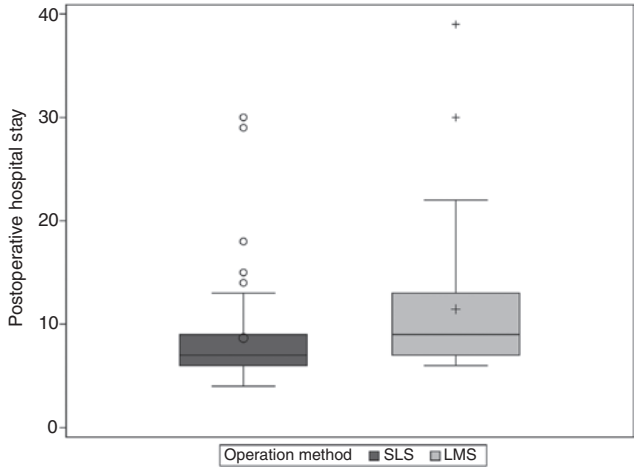

Figure 5: Box plot of the postoperative hospital stay for the two different surgical techniques.

Postoperative hospital stay

Postoperative hospital stay in the SLS group ranged from 4 to 30 days (median, 7 days). In the LMS group, it ranged from 6 to 39 days (median, 9 days). This difference was statistically significant ($p = 0.005$). The difference in the postoperative hospital stay is easily visible in Figure 5.

Discussion

Laparoscopic techniques and minimization of incisional trauma in colorectal surgery have developed rapidly within the last years. Single-incision laparoscopic surgery has been established as a minimally invasive platform, which developed from the natural orifice surgical approach. As an advantage, the SLS is performed with standard straight laparoscopic instruments if the newly developed access platforms are used. In 2008, the technique was first applied for colorectal surgery, and since then, various studies have addressed the feasibility and safety of the technique [13–15]. SLS also has been shown to be oncologically technically feasible and comparable to LMS [20–22].

In the present work, we describe the establishment and short-term outcome of a consecutive series of single-incision laparoscopic colorectal resections. Operation time did not differ between the groups in our study, which agrees with previously published data [23, 24]. Surprisingly, in the SLS group, a tendency toward a shorter operating time compared with the LMS group was observed. This fact is remarkable since the presented data were generated during the time period when the method was being established. We were expecting a learning curve with resulting prolonged operating time. The short operating time may have been due to the fact that all operations in both groups were performed by surgeons trained in colorectal laparoscopic surgery. Obviously, no time-consuming learning curve for performing SLS is necessary, which corresponds to previously reported data [25]. It seems that SLS can be easily established as an operation technique if training on laparoscopic skills is provided.

The conversion rate was also lower for the SLS group – five cases versus nine cases in the LMS group. Nevertheless, the number of conversions to open surgery is slightly higher compared to the published literature [26]. This was due to the fact that previous abdominal surgery was not considered a general contraindication for laparoscopic access [27, 28]. Furthermore, the series included elective cases as well as emergency cases. In these patients, a rather circumspect and conservative approach was defined. This means that conversion was accepted if the surgeon felt the slightest aspect of impaired patient safety. No bleeding complication occurred during the operative procedure, which highlights our careful approach.

The distribution of patient characteristics was comparable between the two groups. The histological findings differed due to the different diagnoses of the patients. Only left-sided colorectal resections were included in the SLS group because the technical aspect of the trocar placement was deemed unsuitable for right-sided colon resection. The LMS technique was suitable for both left- and right-sided colon resections.

In the postoperative course, we found no significant differences with respect to morbidity or mortality between the groups. The major complications consisted of two grade 3 and two grade 4 cases in the SLS group and three grade 3 and one grade 4 case in the LMS group. Only two cases of anastomotic leakage were observed in the whole study, both in the SLS group. These results are within the range of published literature, with a very low rate of anastomotic leakage. The number of minor complications, which had no further impact on the patient outcome or clinical results, appears rather high. This is due to the fact that even a superficial wound infection and prolonged bowel atonia were consequently documented, as intended by the Clavien-Dindo classification. These complications had no impact on the postoperative course and did not prolong the discharge of the patients.

The postoperative hospital stay was significantly shorter in the SLS group. Postoperative pain on days 1 and 5 after surgery was higher in the LMS group. On day 1, it was even statistically significant after adjustment with

the Bonferroni-Holm method, which agrees with the data published in a recent meta-analysis [14].

One criticism of SLS is the potential generation of higher costs due to the use of the SLS port and longer operation time. The price of the SLS gel port is approximately €350, much higher than the price of single- or multi-use trocars. We find the expensive costs of the SLS technique to be an important aspect in the evaluation of this method.

We did not find any significant differences between SLS and LMS for most of our investigated outcomes. We also found SLS to be technically feasible without a time-consuming learning curve for an experienced laparoscopic colorectal surgeon. With regard to short-time postoperative course, SLS may be even slightly advantageous because it yielded less pain and a slightly shorter postoperative hospital stay. The intraoperative costs, however, were remarkably higher in SLS than LMS.

One limitation of our study was that the comparison was applied retrospectively. The patient inclusion in this study occurred consecutively in both groups, but the decision on the performed surgical operation method was not randomly assigned. Rather, it was chosen as deemed suitable for the individual patient. These drawbacks cannot be eliminated and might bias the presented results. This study presents the results of our first experience with SLS and should not be interpreted as confirmatory results.

In conclusion, we find no clear clinical advantages of SLS versus LMS. The detected differences for lesser pain on day 1 and a shorter hospital stay did not affect long-term clinical outcome. Hence, they do not have enough weigh to favor the new technique. Advantages in terms of fewer incisional hernias and significant advantages in the postoperative course have not been determined so far and are rather unlikely to add further evidence in favor of one technique [14]. SLS is a feasible method without significantly more adverse events during surgery within our study population. This new surgical approach adds a new technical option in laparoscopic colorectal surgery, which can be applied by an experienced laparoscopic colorectal surgeon without a time-consuming learning curve. However, we were not able to identify substantial advantages of SLS.

Author Statement

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Author Contributions

Bernd Schneider: data curation; formal analysis; methodology; writing – original draft. Anne Catharina Brockhaus: formal analysis; investigation; software; supervision; validation; writing – review & editing. Marcos Gelos: conceptualization; data curation; formal analysis; methodology; validation; writing – original draft; writing – review & editing. Claudia Rudroff: conceptualization; data curation; investigation; methodology; project administration; supervision; validation; visualization; writing – original draft; writing – review & editing.

References

[1] Vennix S, Pelzers L, Bouvy N, Beets GL, Pierie JP, Wiggers T, et al. Laparoscopic versus open total mesorectal excision for rectal cancer. Cochrane Database Systematic Rev 2014;15:CD005200.
[2] Kuhry E, Schwenk WF, Gaupset R, Romild U, Bonjer HJ. Long-term results of laparoscopic colorectal cancer resection. Cochrane Database Systematic Rev 2008;16:CD003432.
[3] Jayne DG, Thorpe HC, Copeland J, Quirke P, Brown JM, Guillou PJ. Five-year follow-up of the Medical Research Council CLASICC trial of laparoscopically assisted versus open surgery for colorectal cancer. Br J Surg 2010;97:1638–40.
[4] Piskun G, Rajpal S. Transumbilical laparoscopic cholecystectomy utilizes no incisions outside the umbilicus. J Laparoendoscopic Adv Surg Tech A 1999;9:361–4.
[5] Bucher P, Pugin F, Morel P. Single port access laparoscopic right hemicolectomy. Int J Colorectal Dis 2008;23:1013–6.
[6] Remzi FH, Kirat HT, Kaouk JH, Geisler DP. Single-port laparoscopy in colorectal surgery. Colorectal Dis 2008;10:823–6.
[7] Chen WT, Chang SC, Chiang HC, Lo WY, Jeng LB, Wu C, et al. Single-incision laparoscopic versus conventional laparoscopic right hemicolectomy: a comparison of short-term surgical results. Surg Endosc 2011;25:1887–92.
[8] Rijcken E, Mennigen R, Argyris I, Senninger N, Bruewer M. Single-incision laparoscopic surgery for ileocolic resection in Crohn's disease. Dis Colon Rectum 2012;55:140–6.
[9] 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;54:183–6.
[10] Huscher CG, Mingoli A, Sgarzini G, Mereu A, Binda B, Brachini G, et al. Standard laparoscopic versus single-incision laparoscopic colectomy for cancer: early results of a randomized prospective study. Am J Surg 2012;204:115–20.
[11] Makino T, Milsom JW, Lee SW. Single-incision laparoscopic surgeries for colorectal diseases: early experiences of a novel surgical method. Minim Invasive Surg 2012;2012:783074.

[12] Makino T, Milsom JW, Lee SW. Feasibility and safety of single-incision laparoscopic colectomy: a systematic review. Ann Surg 2012;255:667–76.
[13] Vestweber B, Vestweber KH, Paul C, Rink AD. Single-port laparoscopic resection for diverticular disease: experiences with more than 300 consecutive patients. Surg Endosc 2016;30:50–8.
[14] Brockhaus AC, Sauerland S, Saad S. Single-incision versus standard multi-incision laparoscopic colectomy in patients with malignant or benign colonic disease: a systematic review, meta-analysis and assessment of the evidence. BMC Surg 2016;16:71.
[15] Keller DS, Flores-Gonzalez JR, Ibarra S, Haas EM. Review of 500 single incision laparoscopic colorectal surgery cases – lessons learned. World J Gastroenterol 2016;22:659–67.
[16] 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;240:205–13.
[17] Huskisson EC. Measurement of pain. J Rheumatol 1982;9:768–79.
[18] Aickin M, Gensler H. Adjusting for multiple testing when reporting research results: the Bonferroni vs Holm methods. Am J Public Health 1996;86:726–72.
[19] Hinchey EJ, Schaal PG, Richards GK. Treatment of perforated diverticular disease of the colon. Adv Surg 1978;12:85–109.
[20] Marks JH, Montenegro GA, Shields MV, Frenkel JL, Marks GJ. Single-port laparoscopic colorectal surgery shows equivalent or better outcomes to standard laparoscopic surgery: results of a 190-patient, 7-criterion case-match study. Surg Endosc 2015;29:1492–9.
[21] Yun JA, Yun SH, Park YA, Huh JW, Cho YB, Kim HC, et al. Oncologic outcomes of single-incision laparoscopic surgery compared with conventional laparoscopy for colon cancer. Ann Surg 2016;263:973–8.
[22] Kim CW, Cho MS, Baek SJ, Hur H, Min BS, Kang J, et al. Oncologic outcomes of single-incision versus conventional laparoscopic anterior resection for sigmoid colon cancer: a propensity-score matching analysis. Ann Surg Oncol 2015;22:924–30.
[23] Ramos-Valadez DI, Ragupathi M, Nieto J, Patel CB, Miller S, Pickron TB, et al. Single-incision versus conventional laparoscopic sigmoid colectomy: a case-matched series. Surg Endosc 2012;26:96–102.
[24] Vasilakis V, Clark CE, Liasis L, Papaconstantinou HT. Non-cosmetic benefits of single-incision laparoscopic sigmoid colectomy for diverticular disease: a case-matched comparison with multiport laparoscopic technique. J Surg Res 2013;180:201–7.
[25] Kim CW, Kim WR, Kim HY, Kang J, Hur H, Min BS, et al. Learning curve for single-incision laparoscopic anterior resection for sigmoid colon cancer. J Am Coll Surg 2015;221:397–403.
[26] Allaix MA, Furnée EJB, Mistrangelo M, Arezzo A, Morino M. Conversion of laparoscopic colorectal resection for cancer: What is the impact on short-term outcomes and survival? World J Gastroenterol 2016;22:8304–13.
[27] Jabir MA, Brady JT, Wen Y, Dosokey EMG, Choi D, Stein SL, et al. Attempting a laparoscopic approach in patients undergoing left-sided colorectal surgery who have had a previous laparoromy: is it feasible? J Gastrointest Surg 2018;22:316–20.
[28] Haksal M, Ozdenkaya Y, Atici AE, Okkabaz N, Aksakal N, Erdemir A, et al. Safety and feasibility of laparoscopic sigmoid colon and rectal cancer surgery in patients with previous vertical abdominal laparotomy. Int J Surg 2015;21:97–102.

Supplemental Material: The article (https://doi.org/10.1515/iss-2017-0048) offers reviewer assessments as supplementary material.

Reviewer Assessment

Bernd Schneider, Anne Catharina Brockhaus, Marcos Gelos and Claudia Rudroff*

The single-incision laparoscopic surgery technique has questionable advantages in colorectal surgery

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***Corresponding author: Claudia Rudroff,** MD, Department of General and Visceral Surgery, Evangelische Klinik Koeln-Weyertal, Weyertal 76, D-50931 Cologne, Germany, Phone: +49-221-4792212, E-mail: clro@gmx.de

Reviewers' Comments to Original Submission

Reviewer 1: Thomas Carus

Dec 01, 2017

Reviewer Recommendation Term:	Revise with Major Modifications
Overall Reviewer Manuscript Rating:	20

Custom Review Questions	**Response**
Is the subject area appropriate for you?	3
Does the title clearly reflect the paper's content?	3
Does the abstract clearly reflect the paper's content?	3
Do the keywords clearly reflect the paper's content?	4
Does the introduction present the problem clearly?	4
Are the results/conclusions justified?	4
How comprehensive and up-to-date is the subject matter presented?	3
How adequate is the data presentation?	3
Are units and terminology used correctly?	5 - High/Yes
Is the number of cases adequate?	5 - High/Yes
Are the experimental methods/clinical studies adequate?	5 - High/Yes
Is the length appropriate in relation to the content?	3
Does the reader get new insights from the article?	1 - Low/No
Please rate the practical significance.	1 - Low/No
Please rate the accuracy of methods.	4
Please rate the statistical evaluation and quality control.	4
Please rate the appropriateness of the figures and tables.	3
Please rate the appropriateness of the references.	4
Please evaluate the writing style and use of language.	4
Please judge the overall scientific quality of the manuscript.	3
Are you willing to review the revision of this manuscript?	Yes

Comments to Authors:

This single center study shows a retrospective analysis of single port versus multiport left colonic resections. It is well known, that there are no significant differences between these two groups, and has been published several times. In this study significant differences were found for “postoperative hospital stay” and for “postoperative pain” on day 1.
There was a very high complication rate in both groups with 28 % (SLS) and 29 % (LMS). This is much higher than in literature and should be seriously discussed.
The conversion rate is also very high in both groups, especially in the LMS Group (SLS = 9,6 %, LMS = 22,5 %). This was caused by “intestinal adhesions”. In literature you can find conversion rates for SLS with 6 % and for LMS much lower. What are the reasons for the high conversion rates? Had these patients prior abdominal surgeries? This should be clarified and discussed.

The main problem is seen in a missing real “discussion” - comparing the own results with the published literature to bring some new aspects for the reader.

The discussion should be written respecting these aspects.

One correction: in Figure 4 are german descriptions - they should be in english.

Reviewer 2: anonymous

Dec 26, 2017

Reviewer Recommendation Term:	Revise with Major Modifications
Overall Reviewer Manuscript Rating:	60

Custom Review Questions	**Response**
Is the subject area appropriate for you?	4
Does the title clearly reflect the paper’s content?	1 - Low/No
Does the abstract clearly reflect the paper’s content?	3
Do the keywords clearly reflect the paper’s content?	3
Does the introduction present the problem clearly?	3
Are the results/conclusions justified?	3
How comprehensive and up-to-date is the subject matter presented?	3
How adequate is the data presentation?	3
Are units and terminology used correctly?	3
Is the number of cases adequate?	3
Are the experimental methods/clinical studies adequate?	4
Is the length appropriate in relation to the content?	3
Does the reader get new insights from the article?	3
Please rate the practical significance.	3
Please rate the accuracy of methods.	3
Please rate the statistical evaluation and quality control.	4
Please rate the appropriateness of the figures and tables.	4
Please rate the appropriateness of the references.	4
Please evaluate the writing style and use of language.	3
Please judge the overall scientific quality of the manuscript.	3
Are you willing to review the revision of this manuscript?	Yes

Comments to Authors:

In the latest systematic review comparing single-incision versus multi-incision laparoscopic colectomy in patients with malignant or benign colonic disease Brockhaus et al. in 2016 could only include two randomized controlled trials with a total of 82 colorectal cancer cases. There was insufficient evidence to clarify whether SILC leads to less local complications or lower mortality. Length of stay was significantly shorter in the SILC group. One of the two studies found postoperative pain intensity to be lower at the first day. The authors concluded, that the currently available study results are too sparce to detect or rule out relevant differences between SILC and multi-incision laparoscopic colectomy. The quality of the current evidence is low, and the additional analysis of non-randomized studies does not solve the problem. As the authors of the present non-randomized study clearly pointed out, that the SILC cases have been operated by experienced multi-port laparoscopic colorectal surgeons in the learning curve of SILC, which also explains the relevant differences in the patient populations, they should focus their manuscript more on this aspect. For the comparison of SILC versus multi-incision laparoscopic colectomy patient selection bias is to profound. Therefore, the conclusion, that SILC is comparable to multi-port laparoscopic colorectal surgery, can hardly be supported by the study. The discussion should lead to the main message, that experienced laparoscopic colorectal surgeons can introduce SILC by patient selection with comparable or even better results.

Authors' Response to Reviewer Comments

Jan 22, 2018

Dear Professor Jaehne,
Dear collegues,

Thank you for revising our manuscript on single-incision surgery for colorectal disease. We are grateful for the valuable comments of the two reviewers, which we answer as follows:

Reviewer #1:
RE: "complication rate": The complication rate according to the Clavien-Dindo classification includes minor complications, such as superficial wound infection, seroma and urinary infection. These minor complications have no or at most a marginal effect on the general outcome of the patients. As we thoroughly documented each slight wound alteration as a small dehiscence, the overall complication rate was comparatively high. This was due to the high rate of grade 1 (no further intervention necessary) and grade 2 complications (requiring medications such as oral antibiotics).
In contrast, major complications (grade 3 and grade 4) definitely have an impact on patient outcome. The rate of major complications was substantially lower. We modified our manuscript accordingly.

RE: "conversion rate": We had and still have an attitude favoring conversion if we have doubts about whether the laparoscopic operation can safely continue. In our series, we operated on both elective cases and emergency cases. Conversion in this series occurred only due to severe adhesions after prior abdominal operations.
Taking the advice of the reviewer into account, we adjusted the manuscript accordingly, as highlighted in red. The translated "Figure 4" is included in our revised manuscript.

Reviewer #2:
We are very thankful for the detailed comments of Reviewer #2. The patient characteristics were similar between the two laparoscopic techniques. We assume that the reviewer meant to address the difference in the indication for surgery. Since the right colon is not suitable to be addressed by single-access laparoscopic surgery, only left-sided colorectal resections were included within this group. Nevertheless, we thought it was suitable to analyze all consecutive laparoscopic procedures according to the respective technique. The difference in the performed procedure with comparable optional clinical course and outcome seems suitable.

We completely agree with Reviewer #2 that a conclusion of equality of the two groups cannot be made, since we did not perform any non-inferiority testing. We deleted or revised the sentences that might have given that impression.

As Reviewer #2 suggested, we modified the Discussion to emphasize that this technique is easy to learn for each experienced surgeon but that no substantial advantages are to be found in our data.

Finally, our “figure 4” is actually “figure 5” ! We corrected the graph and the title.

We hope our changes, that are highlighted in the text, meet your expectations and look forward to hear from you.

Yours sincerely
Corresponding Author

Reviewers’ Comments to Revision

Reviewer 1: Thomas Carus

Jan 24, 2018

Reviewer Recommendation Term:	Accept
Overall Reviewer Manuscript Rating:	90

Custom Review Questions	**Response**
Is the subject area appropriate for you?	5 - High/Yes
Does the title clearly reflect the paper’s content?	5 - High/Yes
Does the abstract clearly reflect the paper’s content?	5 - High/Yes
Do the keywords clearly reflect the paper’s content?	5 - High/Yes
Does the introduction present the problem clearly?	5 - High/Yes
Are the results/conclusions justified?	5 - High/Yes
How comprehensive and up-to-date is the subject matter presented?	5 - High/Yes
How adequate is the data presentation?	5 - High/Yes
Are units and terminology used correctly?	5 - High/Yes
Is the number of cases adequate?	5 - High/Yes
Are the experimental methods/clinical studies adequate?	5 - High/Yes
Is the length appropriate in relation to the content?	5 - High/Yes
Does the reader get new insights from the article?	4
Please rate the practical significance.	4
Please rate the accuracy of methods.	4
Please rate the statistical evaluation and quality control.	5 - High/Yes
Please rate the appropriateness of the figures and tables.	5 - High/Yes
Please rate the appropriateness of the references.	5 - High/Yes
Please evaluate the writing style and use of language.	5 - High/Yes
Please judge the overall scientific quality of the manuscript.	5 - High/Yes
Are you willing to review the revision of this manuscript?	Yes

Comments to Authors:
Thank you for the excellent corrections - it should be published without further changes.

Reviewer 2: anonymous

Jan 27, 2018

Reviewer Recommendation Term:	Accept
Overall Reviewer Manuscript Rating:	60

Custom Review Questions	**Response**
Is the subject area appropriate for you?	3
Does the title clearly reflect the paper's content?	4
Does the abstract clearly reflect the paper's content?	4
Do the keywords clearly reflect the paper's content?	4
Does the introduction present the problem clearly?	4
Are the results/conclusions justified?	4
How comprehensive and up-to-date is the subject matter presented?	4
How adequate is the data presentation?	4
Are units and terminology used correctly?	4
Is the number of cases adequate?	4
Are the experimental methods/clinical studies adequate?	3
Is the length appropriate in relation to the content?	4
Does the reader get new insights from the article?	3
Please rate the practical significance.	3
Please rate the accuracy of methods.	3
Please rate the statistical evaluation and quality control.	3
Please rate the appropriateness of the figures and tables.	4
Please rate the appropriateness of the references.	4
Please evaluate the writing style and use of language.	3
Please judge the overall scientific quality of the manuscript.	3
Are you willing to review the revision of this manuscript?	Yes

Comments to Authors:
After major revision the paper can now be accepted for publication.