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ORIGINAL ARTICLE

Single-incision laparoscopic colectomy: outcomes of an emerging minimally invasive technique

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Abstract
Purpose Single-incision laparoscopic colectomy (SILC) is an emerging procedure in the field of minimally invasive colon and rectal surgery. The purpose of this study was to evaluate the safety and feasibility of this procedure.
Methods Between July 2009 and April 2010, SILC was performed for 35 patients presenting with pathology of the colon. Surgical procedures included right hemicolectomy, sigmoid resection, and total colectomy. Demographic data, intraoperative parameters, and short-term postoperative outcomes were assessed.
Results Thirty two of the 35 patients (91.4%) underwent successful completion of SILC while 3 patients required laparoscopic modifications. The mean incision length was 3.4 cm with a range of 2–6 cm. The mean total operative time (OT) for right, left, and total colectomies was 158.8±31.8 min, 127.0±37.1 min, and 216.3±72.6 min, respectively. Overall, the OT was not significantly different between patients with a body mass index (BMI) ≥25 kg/m^2 (147.9±47.9 min) compared to those with a BMI <25 kg/m^2 (123.1± 40.9 min). In the subset of patients with malignant disease, the mean lymph node extraction was 23.5±12.0 and all margins were negative. There were no intraoperative complications, and the overall mean length of hospital stay was 2.9±1.0 days (range 2–6 days). The postoperative morbidity rate was 11.4%.
Conclusions Single-incision laparoscopic colectomy is a safe and feasible procedure for benign and malignant diseases of the colon. This modality can be successfully applied for various colorectal procedures without conversion to open surgery, resulting in a short length of hospital stay and a minimal short-term complication rate.

Keywords Single-incision laparoscopic colectomy · Single-incision laparoscopic surgery · Colectomy · Laparoscopic colectomy · Colon cancer · Minimally invasive surgery

Abbreviations

SR	Sigmoid resection
ASA	American Society of Anesthesiologists
BMI	Body mass index
EBL	Estimated blood loss
HALS	Hand-assisted laparoscopic surgery
IL	Incision length
LNE	Lymph node extraction
LOA	Lysis of adhesions
LOS	Length of stay
OT	Total operative time
RH	Right hemicolectomy
SILC	Single-incision laparoscopic colectomy
TC	Total colectomy

Introduction

Single-incision laparoscopic surgery is a rapidly emerging technique in the field of minimally invasive surgery (MIS). First reported in 1992 [1], this modality has been applied to a variety of surgical procedures including cholecystectomy,

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nephrectomy, adrenalectomy, and gastric banding [2–5]. However, this MIS platform has only recently been applied to colorectal surgery, with the first SILC having been reported in July 2008 [6].

Application of single-incision technique for colorectal procedures has gained mounting enthusiasm over the past 2 years. An increasing number of case reports and small case series have demonstrated the safety and feasibility of this technique for benign and malignant diseases of the colon [6–21], although predominantly for right hemicolectomy (RH). These studies have reported improvement in cosmetic outcome with the potential for lower morbidity associated with the reduced number of utilized ports and a probable decrease in extent of incisional pain. In our previous experience with consecutive SILC RH in unselected patients, we found the technique to be safe and feasible with short length of hospital stay and low short-term complication rate [15, 16]. However, in obese patients, satisfactory outcomes were typically at the expense of prolonged operative time.

The purpose of this study was to assess intraoperative parameters and short-term postoperative outcomes in a large cohort of consecutive patients undergoing SILC for benign and malignant disease. We present our expanded experience, including application of the technique for RH as well as additional procedures of the colon and rectum.

Materials and methods

This study was approved by the institutional review board. Between July 2009 and April 2010, SILC was performed in 35 patients presenting with benign or malignant pathology. Patients were excluded from undergoing SILC if they: (1) were American Society of Anesthesiologists score (ASA) 4 or 5, (2) required an emergency procedure, (3) were unwilling to provide informed consent, or (4) presented with middle or lower rectal disease, large bulky malignant disease, or phlegmon.

Demographic data including patient age, gender, and body mass index (BMI) were tabulated along with ASA score and history of prior abdominal surgery. Intraoperative parameters including umbilical incision length (IL), OT, estimated blood loss (EBL), and intraoperative complications were analyzed. Pathology was reviewed for specimen length, lymph node extraction (LNE), and surgical margins in the subset of patients with malignant disease. Short-term postoperative outcomes including hospital length of stay (LOS) and 30-day complication rate were recorded.

Operative technique

After obtaining informed consent, one of two board-certified colon and rectal surgeons performed the procedures using the SILS™ Port Multiple Instrument Access Port (Covidien, Mansfield, MA) or GelPOINT™ Advanced Access Platform (Applied Medical, Rancho Santa Margarita, CA). A 30°, 5-mm standard laparoscope with a right-angle light cord adaptor and standard non-articulating laparoscopic instruments were utilized for all procedures. Surgical procedures included RH (including ileocolic resection), sigmoid resection (SR), and total colectomy (TC), (see Fig. 1).

A 2.0-2.5-cm vertical incision was made through the center of the umbilicus as the initial maneuver in all cases. The single-incision device was placed, and laparoscopic exploration was performed in part to assess for unforeseen evidence of bulky or fixed disease. The technique for RH has previously been reported [15, 16]. Dissection began with identification and ligation of the base of the ileocolic vascular pedicle once the duodenum was identified. The retroperitoneal plane was then developed in a medial-to-lateral approach. The hepatic flexure was taken down followed by division of the lateral peritoneal reflection and ileocolic attachments. The specimen was then extracted through the single incision for resection and anastomosis.

The technique for SR required positioning the patient in modified lithotomy in Trendelenburg with left side elevated. The surgeon and assistant were positioned on the right side of the patient. The procedure commenced in a medial-to-lateral approach with initial isolation of the inferior mesenteric artery. Once the left ureter was identified, the vessel was ligated and a retroperitoneal plane was established from the sacral promontory to the lateral peritoneal reflection and Gerota's fascia. Division of the inferior mesenteric vein and splenic flexure takedown were performed as needed. The lateral peritoneal attachments along the left and sigmoid colon were then divided, followed by mobilization of the rectosigmoid and pelvic dissection along the avascular presacral plane. The mesentery of the distal resection margin was divided followed by division of the corresponding bowel using the Echelon™ 60 ENDOPATH® stapling device (Ethicon Endo-Surgery, Inc., Cincinnati, OH). The segment of bowel isolated for resection was then extracted through the transumbilical incision, and a primary end-to-end anastomosis was fashioned.

For TC, portions of the procedure involving the right and left colon were performed with similar positioning and technique as described above. For mobilization of the transverse colon and division of the middle colic vessels, the surgeon was positioned between the patient's legs and the assistant was located on the patient's right side. The vessels were ligated in a medial-to-lateral fashion at the level of the ligament of Treitz.

Postoperative recovery pathway

Following completion of their respective procedure, each patient was monitored in the post-anesthesia care unit

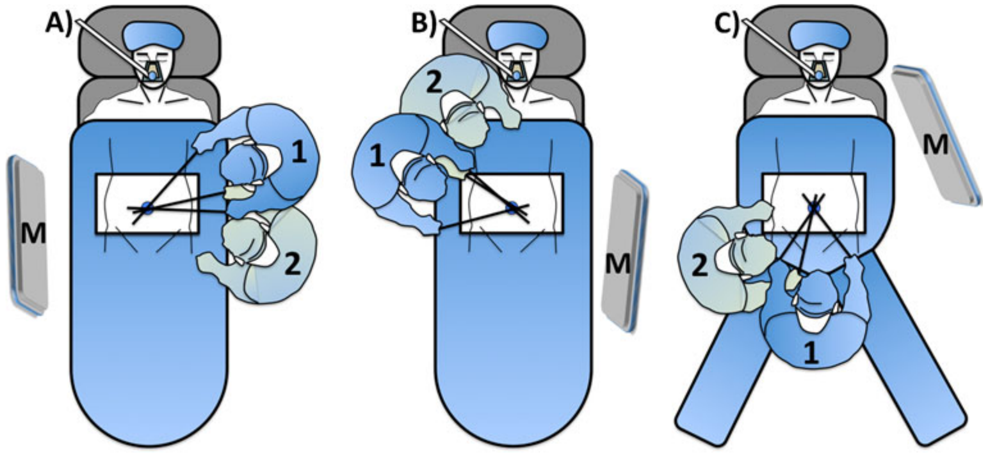

Fig. 1 Surgeon–assistant positioning. **a** Right hemicolectomy. **b** Sigmoid resection. **c** Total colectomy. *1* Surgeon, *2* assistant, *M* monitor

before being transferred to the hospital floor. All patients were placed on an accelerated postoperative recovery pathway, which included early feeding and ambulation, absence of a nasogastric tube, early removal of Foley catheter, and additional quality measures. Patients were discharged following evidence of return of bowel function, including passage of flatus or bowel movements, absence of abdominal strain, and tolerance of oral diet.

Statistical analysis

Intercooled Stata version 9.2 (Stata Corp., College Station, TX) was used for statistical analysis. Comparison of categorical variables was performed using chi-square analysis. Comparison of continuous variables was performed using a two-tailed unpaired Student's *t* test. The significance level was set at alpha=0.05 (with Bonferroni correction for multiple comparisons among procedure type).

Results

A total of 35 patients (17 female and 18 male) were consented for SILC with primary anastomosis (Table 1). Surgical procedures included right hemicolectomy (n=26, 74.3%), sigmoid resection (n=6, 17.1%), and total colectomy (n=3, 8.6%). The mean age was 54.3±10.4 years (range 29-78 years), mean BMI was 28.1±6.3 kg/m^2 (range 17.7-49.0 kg/m^2), and median ASA was 2 (range 1-3). Fifteen patients (42.9%) had a history of prior abdominal surgery and of these, 7 (46.7%) required lysis of adhesions (LOA) during the SILC procedure. Twenty-five patients (71.4%) presented with benign disease [polyps (n=15), diverticulitis (n=6), colonic inertia (n=3), and recurrent cecal volvulus (n=1)]. Ten patients (28.6%) presented with malignant disease [adenocarcinoma (n=8) and carcinoid (n=2)].

Thirty two of the 35 patients (91.4%) underwent successful completion of SILC while 3 patients required laparoscopic modifications, 2 required hand-assisted laparoscopic technique (HALS), and 1 required multi-port laparoscopic technique. No intraoperative complications were encountered, and there were no conversions to open surgery (Table 2). Overall the mean IL was 3.4±1.0 cm (range 2.0-6.0 cm). The IL for SR (3.1±0.4 cm), RH (3.5±1.1 cm), and TC (2.8±0.8 cm) was not significantly different between procedure types. The mean OT for RH, SR, and TC was 127.0±37.1 min, 158.8±31.8 min, and 216.3±72.6 min, respectively. There was no significant difference in OT between those cases that required LOA (129.7±42.1 min) and those that did not (132.3±43.7 min). Overall and by procedure type, the OT was not significantly different between patients with BMI ≥25 kg/m^2 (147.9±47.9 min) compared to those with BMI <25 kg/m^2 (123.1±40.9 min).

In the subset of patients with malignant disease, the mean IL was 4.0±1.2 cm (range 2.5–6.0 cm) and the mean OT was 119.9±43.3 min (range 72–180 min). The mean SL

Table 1 Patient demographics and preoperative parameters (n=35)

Parameters			
Gender	Male, 18 (51.4%)		Female, 17 (48.6%)
Prior abdominal surgery	Yes, 15 (42.9%)		No, 20 (57.1%)
Pathology	Benign, 25 (71.4%)		Malignant, 10 (28.6%)
Parameters	Mean±SD	Median	Range
Age (years)	54.3±10.4	54	29–78
BMI (kg/m^2)	28.1±6.3	27.4	17.7–49
ASA	2.2±0.6	2	1–3

ASA American Society of Anesthesiologists, *BMI* body mass index, *SD* standard deviation

Table 2 Intraoperative parameters

Parameter	n	Mean±SD	Range	p value
Incision length (cm)	35	3.4±1.0	2–6	
Right hemicolectomy	26[a]	3.5±1.1	2.5–6.0	
Anterior resection	6	3.1±0.4	2.5–3.5	NS
Total colectomy	3	2.8±0.8	2.0–3.5	
Malignant cases	10	4.0±1.2	2.5–6.0	<0.013
Benign cases	25	3.1±0.7	2.0–5.0	
OT (min)	35	140.1±46.7	66–300	
Anterior resection	6	158.8±31.8	119–192	
Right hemicolectomy	26	127.0±37.1	66–180	NS
Total colectomy	3	216.3±72.6	170–300	
BMI <25 kg/m^2	11	123.1±40.9	72–180	NS
BMI≥25 kg/m^2	24	147.9±47.9	66–300	
EBL (cm^3)	35	59.1±36.6	20–150	
Conversion to open technique (%)	35	0%		
Complication rate (%)	35	0%		

BMI body mass index, *EBL* estimated blood loss, *NS* not significant, *OT* total operative time, *SD* standard deviation

[a] Includes one ileocecal resection and one ileocolic resection

was 21.5±7.3 cm (range 11.0–34.5 cm), and all surgical margins were negative. The mean LNE was 23.5 with a range of 14–47 (Table 3). Eight of the 10 malignant cases had positive lymph nodes (range 1–9).

The overall mean LOS was 2.9±1.0 days (range 2-6 days). For the 32 patients that underwent successful SILC technique, the mean OT (156.7±36.2 min) and LOS (2.3±0.6 days) were not significantly different from those in which the procedure required conversion to HALS (n=2) or multi-port laparoscopic technique (n=1). By procedure type, the LOS was 2.7±0.8 days for SILC RH, 2.5±0.5 days for SILC SR, and 5.0±1.0 days for SILC TC. Four patients (11.4%) developed short-term postoperative complications consisting of bleeding at the ileorectal anastomosis, intra-abdominal hemorrhage, wound infection, and wound seroma (Table 4). Reoperation was only required for the case involving postoperative hemorrhage. Postoperative mortality was encountered in one patient who underwent a palliative resection for cecal cancer with extensive pulmonary and hepatic metastasis.

Discussion

Numerous devices have been developed and described for single-port access surgery (Table 5) [8, 10, 13, 15, 20, 22–29]. We initially utilized the SILS™ port [15, 16] as this was the only commercially available device at our institution. The port is introduced through a single transumbilical incision, thus reducing the number of sites for potential complications. Nevertheless, certain technical constraints limited its utility. During excessive torquing, the port tended to dislodge in patients with a high BMI or wide abdominal girth, and could not be securely reinserted following extension of the incision for specimen extraction. In addition, the device lacks flexibility for a supplementary trocar when required during the procedure. We have since gained experience with the GelPOINT™ device and found it more advantageous for colorectal procedures. Its high outer profile allows use of four or even five trocars with varying degrees of separation to limit clashing and allowing for ample countertraction when needed. In addition, a built-in wound protector not only prevents direct contact between the specimen and the abdominal wall, but also secures the port in patients with a high BMI or thick abdominal wall.

Table 3 Pathology of malignant cases (n=10 unless otherwise specified)

Parameter	Mean±SD	Median	Range
Specimen length (cm)	21.5±7.3	20.8	11.0–34.5
Lymph node extraction	23.5±12.0	18.5	14–47
Positive lymph nodes (n=8)	3.8±2.4	3.5	1–9

SD standard deviation

Table 4 Postoperative outcomes

Parameter	n	Mean±SD	Range
LOS (days)	35	2.9±1.0	2–6
Anterior resection	6	2.5±0.5	2–3
Right hemicolectomy	26	2.7±0.8	2–5
Total colectomy	3	5.0±1.0	4–6
Parameter	n	Percentage	
Morbidity rate (%)	4[a]	11.4%	
Mortality rate (%)	1	2.9%	
Readmission rate (%)	1	2.9%	

LOS length of stay

[a] Bleeding at anastomosis, wound infection, seroma, and intra-abdominal bleeding

Table 5 Published literature on single-incision laparoscopic colectomy (minimum of five cases)

Authors	No. of Pts	Age (years)	BMI (kg/m^2)	PSH (%)	Diagnosis (*n*)	Port	Procedure	Conversion	OT (min)	LNE	IL (cm)	LOS (days)	M&M
Boni et al.[a] [22]	36	69	NR	36.1	Benign (4), malignant (32)	SILS™ Port (21), Endocone™ (15)	RC	None	145	24	2.6	5	UTI (1), ileus (1)
Gash et al.[b] [23]	20	46	25	40.0	Benign (12), malignant (8)	Olympus TriPort	RH (3), ERH (1), AR (2), LAR/TME (3), ICA (2), colectomy and IRA (4), pan-PC (2), APR (1), RP (2)	2 to CLS	110	NR	2[c]	46 h	Ileus (2), wound infxn (1), anastomotic bleed (1), HTN/ARF (1)
Ramos-Valadez et al.[a] [15]	13	51.2	27.5	46.2	Benign (7), malignant (6)	SILS™ Port	RH	2:1 to HALS, 1 to CLS	131.5	26.7	3.1	2.5	Pulmonary complications (1)
Podolosky et al.[a] [13]	13	NR	NR	NR	Benign (5), malignant (8)	Single TU and multiple fascial incisions	RC (3), LC (1), SC (8), TP (1)	NR	RC 155, LC 179, SC 169, TP 300	RC 12–18[d], LC 14, SC 13–16[d]	1.5[c]	RC 6–7[d], LC 5, SC 5–8[d], TP 5	Wound infxn (1), access site hernia (2)
Vestweber et al.[b] [24]	10	63.5	26.7	50.0	Benign	SILS™ Port	SC	1 to open	120	NA	2.5[c]	Total 9, Postop 7	Subcutaneous hematoma (1)
Wong et al.[b] [25]	10	64	21.5	NR	Benign (2), malignant (8)	SILS™ Port	ERH (1), RH (9)	NR	83	16	5	6	NR
Ishida et al.[b] [26]	9	67	21.2	NR	Malignant	Surgical glove with wound protector	Colectomy	None	140	18	NA	NA	NA
Law et al.[b] [27]	8	78	22.7	NR	Benign (3), malignant (5)	Olympus TriPort	RC (6), LC (1), AR (1)	1 to HALS	175	13.5	3.4[a]	3.5	Ileus (1)
Rieger et al.[a] [20]	7	71	24.3	14.3	Benign (3), malignant (4)	Single TU and multiple fascial incisions	RC (6), LC (1)	None	89	15	3.1	5.4	Bacteremia (1)
Uematsu et al.[b] [28]	7	NR	NR	NR	Malignant	Olympus TriPort	LH (2), RH (5)	None	255	32	3–4[c]	7[e]	None
Chambers et al.[b] [10]	7	44	NR	42.9	Benign (5), malignant (2)	Self-constructed port	Appy (1), RH (1), ERH (1), colectomy with IRA (1), PC (1), AR (1), RP (1)	None	48	NR	2.5[c]	16 h	Secondary bleed from ileorectal anastomosis (1)
Uematsu et al.[b] [8]	5	73	25	0.0	Malignant	Self-constructed port	SC	1 to CLS	185	17	3–4[c]	7[e]	None
Pietrasanta et al.[a] [29]	5	81.6	NR	NR	Malignant	SILS™ Port	RC	2:1 to open, 1 to CLS	191	18	2[c]	9.8	None

AR anterior resection, *Appy* appendectomy, *APR* abdominoperineal resection, *ARF* acute renal failure, *BMI* body mass index, *CLS* conventional laparoscopic surgery, *ERH* extended right hemicolectomy, *HALS* hand-assisted laparoscopic surgery, *HTN* hypertension, *infxn* infection, *ICA* ileocolic anastomosis, *IL* incision length, *IRA* ileorectal anastomosis, *LAR/TME* low anterior resection with total mesorectal excision, *LC* left colectomy, *LH* left hemicolectomy *LNE* lymph node extraction, *LOS* length of stay, *M&M* morbidity and mortality, *NA* not applicable, *NR* not reported, *OT* operative time, *Pan-PC* panproctocolectomy, *PC* proctocolectomy, *Pts* patients, *Postop* postoperative, *PSH* past surgical history, *RC* right colectomy, *RH* right hemicolectomy, *RP* restorative proctocolectomy with J pouch, *SC* sigmoid colectomy, *TP* total proctocolectomy with J pouch, *TU* transumbilical, *UTI* urinary tract infection

[a] Mean data unless otherwise specified

[b] Median data unless otherwise specified

[c] Size of initial incision

[d] Range

[e] Same length of stay for all patients in series

We were able to accomplish the procedure in all cases through the initial 2.0-2.5-cm transumbilical incision. However, approximately one third of the patients (37.1%) required extension by up to 1.0 cm (total IL=3.0–3.5 cm) while approximately one third (28.6%) required extension greater than 1.0 cm (total IL=3.5-6.0 cm) for specimen extraction. The most common reasons for IL extension beyond 1.0 cm included bulky specimen ($n=4$) and alleviation of tension during extracorporeal creation of the anastomosis ($n=1$). Extension of the incision beyond 3.5 cm for specimen extraction occurred more frequently for malignant cases (60%) than for benign cases (16%), $p<0.01$. This reflects the importance of maintaining oncologic principles including tension-free, atraumatic extraction of the specimen. The final length of the incision did not correlate with the procedure type. However, compared to the cases for benign disease, the final incision was significantly larger for cases involving malignant disease (4.0±1.2 cm compared to 3.1±0.7 cm), $p<0.013$. The mean IL for all cases in the current study was 3.4± 1.0 cm, which is comparable to that previously reported (range 2.0-6.0 cm) in the literature (Table 5). In all cases, incision through the folds of umbilicus not only resulted in excellent cosmesis, but also provided an additional 1-2 cm to the incision without affecting the actual length.

We evaluated the OT of the various procedures and compared them to the OT of conventional laparoscopic surgery and HALS reported in larger series. We noted that our mean OT during SILC (140.1 min) was comparable to that reported for conventional laparoscopic colectomy (range 145-150 min) [30, 31] and HALS colectomy (range 120-211 min) [32] in large national studies. Although SILC is a new technique, one may expect similar overall OT compared to other minimally invasive approaches. There was no significant difference in OT when comparing the first ($n=17$) and second ($n=18$) half of cases in this series. We did not find OT to be a hindrance to adoption of the technique. This approach should be considered a modification of existing minimally invasive techniques and thus not be expected to carry its own unique learning curve for surgeons with extensive MIS experience. Indeed, the transition from multi-port to single-incision colectomy technique in this series was readily accomplished without requiring formal hands-on training in inanimate or cadaver labs.

Over 90% of the cases were successfully completed with single-incision technique, and there were no conversions to open surgery. Of the three cases unable to be completed with single-incision technique, one case required lengthening of the incision to facilitate specimen extraction, which resulted in inability to maintain pneumoperitoneum and a GelPort® was introduced for completion of the procedure. HALS was required in a second case for additional mobilization of the transverse colon to facilitate a tension-free ileocolic anastomosis. In the third case, two auxiliary laparoscopic ports were utilized for suture reinforcement of the staple line at the colorectal anastomosis following a positive air insufflation test. There were no significant differences noted in OT, EBL, intraoperative complications, LOS, or postoperative complications when comparing these three cases to the 32 cases completed without modification. Maintaining an MIS platform avoided the negative impacts of open conversion described in the published literature, including significantly longer OT [33], need for transfusion [34], extended LOS [35], and increased postoperative morbidity [36]. Despite addition of a GelPort® device, the final incision length in the two patients requiring HALS technique was 5.0 cm. Attempting to perform SILC procedure does not appear to have a negative impact during conversion, specifically when another MIS modality can successfully salvage the procedure.

Previously, we noted significantly prolonged OT in overweight patients (i.e., BMI≥25 kg/m^2) compared to normal-BMI patients [15], yet this finding was not observed in the current expanded series. This may be due to increased surgeon experience with the technique. Most notably, in overweight patients, we attempt to dissect in the retroperitoneal plane to a farther extent to avoid the “over the top” method in which the adipose tissue makes it difficult to enter the correct planes due to poor visualization and loss of principles of triangulation. In regards to those patients with previous abdominal surgery, there was no significant difference in OT based on whether they underwent laparoscopic LOA during the SILC procedure. This may be due to the excellent access and exposure to LOA with the SILC approach. For instance, through the initial transumbilical incision, we were able to visualize and lyse multiple adhesions at the outset of the case, prior to insertion of the SILC device. Thereafter, we were readily able to lyse the remaining adhesions laparoscopically with excellent exposure.

The pathology results were analyzed to assess the adequacy of the oncologic resection in the subset of patients who presented with malignant disease. The SILC technique did not hinder the ability to extract an adequate number of lymph nodes or maintain adequate tumor-free margins. On the contrary, the median LNE of 18.5 in this series is greater than the minimum recommendation of 12 considered sufficient for proper oncologic staging [37]. In addition, we were able to harvest a comparable number of lymph nodes for our malignant cases as compared to the current SILC literature (Table 5).

Conclusion

Single-incision laparoscopic colectomy is a viable minimally invasive technique for the surgical management of diseases of the colon and rectum. The procedure results in a small single transumbilical incision, short length of hospital stay, and low infection rate. The procedure can be completed without conversion to open surgery, and when required, multi-port or hand-assisted technique can be used to salvage the procedure and maintain patient benefits. Larger multicenter comparative studies with conventional laparoscopic colectomy will be necessary to determine additional benefits and potential limitations as well as long-term clinical outcomes.

References

1. Pelosi MA, Pelosi MA 3rd (1992) Laparoscopic supracervical hysterectomy using a single-umbilical puncture (mini-laparoscopy). J Reprod Med 37:777–784
2. Piskun G, Rajpal S (1999) Transumbilical laparoscopic cholecystectomy utilizes no incisions outside the umbilicus. J Laparoendosc Adv Surg Tech A 9:361–364
3. Ponsky LE, Cherullo EE, Sawyer M, Hartke D (2008) Single access site laparoscopic radical nephrectomy: initial clinical experience. J Endourol 22:663–666
4. Castellucci SA, Curcillo PG, Ginsberg PC, Saba SC, Jaffe JS, Harmon JD (2008) Single port access adrenalectomy. J Endourol 22:1573–1576
5. Teixeira J, McGill K, Koshy N, McGinty J, Todd G (2010) Laparoscopic single-site surgery for placement of adjustable gastric band–a series of 22 cases. Surg Obes Relat Dis 6:41–45
6. Bucher P, Pugin F, Morel P (2008) Single port access laparoscopic right hemicolectomy. Int J Colorectal Dis 23:1013–1016
7. Bucher P, Pugin F, Morel P (2009) Single-port access laparoscopic radical left colectomy in humans. Dis Colon Rectum 52:1797–1801
8. Uematsu D, Akiyama G, Matsuura M, Hotta K (2010) Single-access laparoscopic colectomy with a novel multiport device in sigmoid colectomy for colon cancer. Dis Colon Rectum 53:496–501
9. Remzi FH, Kirat HT, Geisler DP (2009) Laparoscopic single-port colectomy for sigmoid cancer. Tech Coloproctol 14(3):253–255
10. Chambers W, Bicsak M, Lamparelli M, Dixon A (2009) Single-incision laparoscopic surgery (SILS) in complex colorectal surgery: a technique offering potential and not just cosmesis. Colorectal Dis 13(4):393–398
11. Geisler DP, Condon ET, Remzi FH (2009) Single incision laparoscopic total proctocolectomy with ileopouch anal anastomosis. Colorectal Dis 12(9):941–943
12. Merchant AM, Lin E (2009) Single-incision laparoscopic right hemicolectomy for a colon mass. Dis Colon Rectum 52:1021–1024
13. Podolsky ER, Curcillo PG 2nd (2010) Single port access (SPA) surgery–a 24-month experience. J Gastrointest Surg 14:759–767
14. Yamaguchi Y, Minami K, Kawabuchi Y, Emi M, Toge T (2005) Anterior resection of rectal cancer through a one hand-size incision with or without laparoscopy: proposal of one hand-size incision surgery (OHaSIS). J Surg Res 129:136–141
15. Ramos-Valadez DI, Patel CB, Ragupathi M, Bartley Pickron T, Haas EM (2010) Single-incision laparoscopic right hemicolectomy: safety and feasibility in a series of consecutive cases. Surg Endosc 24:2613–2616
16. Patel CB, Ramos-Valadez DI, Ragupathi M, Haas EM (2010) Single incision laparoscopic-assisted right hemicolectomy technique: application for a mass of the ascending colon (with video). Surg Laparosc Endosc Percutan Tech 20(5):e146–e149
17. Brunner W, Schirnhofer J, Waldstein-Wartenberg N, Frass R, Weiss H (2009) Single incision laparoscopic sigmoid colon resections without visible scar: a novel technique. Colorectal Dis 12(1):66–70
18. Leroy J, Cahill RA, Asakuma M, Dallemagne B, Marescaux J (2009) Single-access laparoscopic sigmoidectomy as definitive surgical management of prior diverticulitis in a human patient. Arch Surg 144:173–179, discussion 179
19. Remzi FH, Kirat HT, Kaouk JH, Geisler DP (2008) Single-port laparoscopy in colorectal surgery. Colorectal Dis 10:823–826
20. Rieger NA, Lam FF (2009) Single-incision laparoscopically assisted colectomy using standard laparoscopic instrumentation. Surg Endosc 24:888–890
21. Wexner SD, Cohen SM (1995) Port site metastases after laparoscopic colorectal surgery for cure of malignancy. Br J Surg 82:295–298
22. Boni L, Dionigi G, Cassinotti E, Di Giuseppe M, Diurni M, Rausei S, Cantore F, Dionigi R (2010) Single incision laparoscopic right colectomy. Surg Endosc 24:3233–32336
23. Gash KJ, Goede AC, Chambers W, Greenslade GL, Dixon AR (2010) Laparoendoscopic single-site surgery is feasible in complex colorectal resections and could enable day case colectomy. Surg Endosc 25(3):835–840
24. Vestweber B, Alfes A, Paul C, Haaf F, Vestweber KH (2010) Single-incision laparoscopic surgery: a promising approach to sigmoidectomy for diverticular disease. Surg Endosc 24:3225–3228
25. Wong MT, Ng KH, Ho KS, Eu KW (2010) Single-incision laparoscopic surgery for right hemicolectomy: our initial experience with 10 cases. Tech Coloproctol 14:225–228
26. Ishida H, Okada N, Ishibashi K, Ohsawa T, Kumamoto K, Haga N (2010) Single-incision laparoscopic-assisted surgery for colon cancer via a periumbilical approach using a surgical glove: initial experience with 9 cases. Int J Surg 9(2):150–154
27. Law WL, Fan JK, Poon JT (2010) Single-incision laparoscopic colectomy: early experience. Dis Colon Rectum 53:284–288
28. Uematsu D, Akiyama G, Magishi A, Nakamura J, Hotta K (2010) Single-access laparoscopic left and right hemicolectomy combined with extracorporeal magnetic retraction. Dis Colon Rectum 53:944–948
29. Pietrasanta D, Romano N, Prosperi V, Lorenzetti L, Basili G, Goletti O (2010) Single-incision laparoscopic right colectomy for cancer: a single-centre preliminary experience. Updates Surg 62:111–115
30. The Clinical Outcomes of Surgical Therapy Study Group (2004) A comparison of laparoscopically assisted and open colectomy for colon cancer. N Engl J Med 350:2050–2059
31. Veldkamp R, Kuhry E, Hop WC, Jeekel J, Kazemier G, Bonjer HJ, Haglind E, Pahlman L, Cuesta MA, Msika S, Morino M, Lacy AM (2005) Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. Lancet Oncol 6:477–484
32. Aalbers AG, Biere SS, van Berge Henegouwen MI, Bemelman WA (2008) Hand-assisted or laparoscopic-assisted approach in colorectal surgery: a systematic review and meta-analysis. Surg Endosc 22:1769–1780
33. Rottoli M, Bona S, Rosati R, Elmore U, Bianchi PP, Spinelli A, Bartolucci C, Montorsi M (2009) Laparoscopic rectal resection for cancer: effects of conversion on short-term outcome and survival. Ann Surg Oncol 16:1279–1286
34. Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AM, Heath RM, Brown JM (2005) Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. Lancet 365:1718–1726
35. Gonzalez R, Smith CD, Mason E, Duncan T, Wilson R, Miller J, Ramshaw BJ (2006) Consequences of conversion in laparoscopic colorectal surgery. Dis Colon Rectum 49:197–204
36. Tan PY, Stephens JH, Rieger NA, Hewett PJ (2008) Laparoscopically assisted colectomy: a study of risk factors and predictors of open conversion. Surg Endosc 22:1708–1714
37. Nelson H, Petrelli N, Carlin A, Couture J, Fleshman J, Guillem J, Miedema B, Ota D, Sargent D (2001) Guidelines 2000 for colon and rectal cancer surgery. J Natl Cancer Inst 93:583–596