ORIGINAL CONTRIBUTION

Single-Port Access Laparoscopic Surgery for Rectal Cancer: Initial Experience With 10 Cases

Orhan Bulut, M.D. • Claus B. Nielsen, M.D. • Niels Jespersen, M.D.

Department of Surgical Gastroenterology, Hvidovre Hospital, University of Copenhagen, Copenhagen, Denmark

BACKGROUND: Single-port access laparoscopic surgery is emerging as a method to improve the morbidity and cosmetic benefits of conventional laparoscopic surgery and minimize the surgical trauma. However, the feasibility of this procedure in rectal surgery has not yet been determined.

OBJECTIVE: This study aimed to evaluate our initial experience using single-port access in laparoscopic rectal surgery.

DESIGN: This investigation was designed as a prospective clinical study.

SETTINGS: The study took place in a university hospital.

PATIENTS: Ten patients with nonmetastatic rectal cancer underwent rectal resections.

MAIN OUTCOME MEASURES: The main outcome measures are perioperative data including intraoperative and postoperative complications, pathological outcome, length of stay, and short-term follow-up.

RESULTS: The median age of the patients was 67 (range, 49–83) and the median body mass index was 23.5 kg/m^2 (range, 20–25 kg/m^2). Six patients had previously had abdominal surgery. The operations were 6 low anterior resections (4 receiving diverting ileostomy), 2 anterior resections, 1 Hartmann procedure, and 1 abdominoperineal resection. The median operative time was 229 minutes (range, 185–318), and blood loss ranged from 0 to 100 mL. In 2 cases, it was necessary to add an extra 5-mm port to deal with intraoperative complications. The median hospital stay was 7 days (range, 4–14). There were no anastomotic leaks and no mortality. All of the resection margins were clear, and the circumferential resection margin was a median of 11 mm (range, 2.5–25). The median number of lymph nodes examined was 14 (range, 3–20).

LIMITATIONS: This study's limitations include the lack of registration of postoperative pain, immunological parameters, and long-term clinical and oncological outcome. The small sample size makes it difficult to ascertain complication and conversion rates.

CONCLUSIONS: Single-port access laparoscopic surgery for rectal cancer can be performed safely in slim patients with a small tumor. This technique can be an alternative option for selected patients in the hands of skilled laparoscopic surgeons. Prospective comparative studies are needed to determine the role for this technique approach in the future.

KEY WORDS: Single-incision laparoscopic surgery; Single-port access; Laparoscopy; Rectal cancer; Low anterior resection; Laparoscopic colorectal surgery.

Laparoscopic procedures have assumed a central role in the management of benign and malignant colorectal diseases as a result of a recent paradigm shift toward minimally invasive surgery. The reasons include faster recovery times with reduced hospital stay, fewer wound-related complications, better cosmesis, and oncological outcomes identical to the open traditional procedures.[1–3] Although the conventional laparoscopic approach (CLS) is less traumatic than open surgery, it still continues to be associated with tissue trauma because of the size and the number of ports, each at least 1 to 2 cm in length.[4,5] Each incision carries potential morbidity risks of bleeding, visceral organ damage, pain, and the formation of incisional hernia. Moreover, the small incisions performed for trocar placement may result in multiple scar formation and compromised cosmetic outcome.[6] Single-port access (SPA) or single-incision laparoscopic surgery

Financial Disclosures: None reported.

Correspondence: Orhan Bulut, M.D., Department of Surgical Gastroenterology, Hvidovre Hospital, Copenhagen University, Kettegaards allé 30 DK-2650 Hvidovre, Denmark. E-mail: Orhan.Bulut@hvh.regionh.dk

Dis Colon Rectum 2011; 54: 803–809
DOI: 10.1007/DCR.0b013e3182147b4d

(SILS) has been developed as a new alternative to conventional laparoscopy. The SPA technique uses a solitary incision with a specialized multilumen (3–4) port and curved or articulated instruments. This surgical innovation obviates the need for triangulation, a fundamental requirement of conventional laparoscopy, thus minimizing the number of ports. SPA surgery is emerging as a method to help decrease morbidity, optimize the cosmetic benefits of CLS, and minimize the surgical trauma. Early clinical series with various procedures have demonstrated not only the feasibility, but also the safety of the SPA surgery.[7–9] Recently, there has been an increasing trend toward the application of SPA surgery in complex abdominal operations.[10] Although there have been published accounts of SPA laparoscopic colon resections and some cases of proctocolectomy and total colectomy,[11–20] the literature regarding SPA laparoscopic surgery for rectal cancer is currently very limited.[21,22] The aim of the present study was to describe the proposed surgical technique and to report our initial experience of rectal surgery performed with SPA in the treatment of nonmetastatic rectal cancer.

MATERIALS AND METHODS

Patient Selection

Between January 2010 and August 2010, all patients referred to our institution for surgical treatment of rectal cancer were evaluated as potential candidates for SPA laparoscopic surgery. This study was initiated after approval from the departmental review board was obtained. Pathological examination, endoscopy, CT, liver ultrasound, and chest x-ray, MRI were performed preoperatively for diagnosis and staging in all patients with rectal cancer according to the national guidelines. Each patient was reviewed and discussed at our multidisciplinary colorectal cancer meetings both before and after the operation. The lower limit of tumor was accepted as 15 cm from the anal verge as measured by a rigid rectoscope. Rectal cancer suitable for SPA surgery was defined as a biopsy-proven adenocarcinoma without metastasis. Previous intestinal surgery or evidence of tumor infiltration of adjacent organs and T_4 staging at preoperative CT or MRI, obstructive cancers, midrectal tumors located from 5 to 8 cm from the anal verge, and tumors measuring more than 4 cm at their cross section at MRI were considered contraindications to SPA. Additional selection criteria were BMI $\leq$ 25 and absence of health conditions precluding a laparoscopic procedure. Informed written consent was obtained from all patients following discussion of risks and potential benefits with the operating surgeon. Patients were also counseled that additional incisions and/or conversion to open surgery might be necessary as warranted during the operation. No patients received neoadjuvant chemoradiation therapy. Stoma sites were marked preoperatively. A phosphate enema was given as bowel preparation before surgery. Patient characteristics, tumor size, and location in rectum, as well as perioperative data, pathology results, complications, length of stay, readmissions, and follow-up were recorded prospectively.

Surgical Technique

After the induction of anesthesia, the patient was placed into a Lloyd-Davis position. A right or left lower quadrant possible stoma site or umbilical site, depending on the operative procedure and the location of rectal tumor, was used to access the abdomen. An open skin and fascial incision of 2.5 cm was used to access the abdominal cavity. The abdomen was entered under direct vision and the SILS (Covidien, Norwalk, CT) port was placed. The abdomen was insufflated with CO_2 to a pressure of 12 mmHg. A 5-mm straight laparoscope with a 0° optic was used to image the abdominal cavity. A 5-mm Harmonic ACE (Ethicon Endo-surgery, Cincinnati, OH) and a 5-mm curved endoscopic grasper were introduced via 2 other 5-mm ports. The camera operator was located on the right side of the patient together with the surgeon in all patients operated on with transumbilical access and/or chosen stoma site in the right side of abdomen. The surgeon stood on the left side of the patient when the chosen stoma and extraction site was located in the left lower quadrant. The patient was then placed in a steep Trendelenburg position and the operating table was rotated toward the right side. Subsequently, the sigmoid colon was suspended toward the abdominal wall with transparietel sutures through the mesentery (Fig. 1A). Mesocolic dissection and inferior mesenteric pedicle isolation were achieved with the medial approach (Fig. 1B), and the superior rectal artery was divided just below the inferior mesenteric artery after application of 5-mm clips (Endo Clip III 5 mm, Covidien, Norwalk, CT) (Fig. 1C) The left ureter was then recognized and subsequently (Fig. 1D), with the patient placed supine and rotated left side up, medial-to-lateral dissection was continued cranially up until the left colon was mobilized. The splenic flexure was not routinely taken down. The patient was returned to the Trendelenburg position, and the small bowel was reflected cranially after the completion of mobilization of the left colon. The grasper and previously inserted transabdominal sutures were used to elevate the rectosigmoid colon out of the pelvis and away from the retroperitoneum and sacral promontory to enable entry into the presacral space. The posterior aspect of the mesorectum was easily identified, and the mesorectal plane was dissected with a harmonic scalpel, preserving the hypogastric nerves (Fig. 1E). Dissection was continued down to the presacral space in this avascular plane toward the pelvic floor. Elevation of the upper rectum by transabdominal sutures facilitated further posterior dissection along the back of mesorectum to the pelvic floor. The anterior dissection between the rectum and the posterior vaginal wall (in females) and the seminal vesicles and prostate (in men)

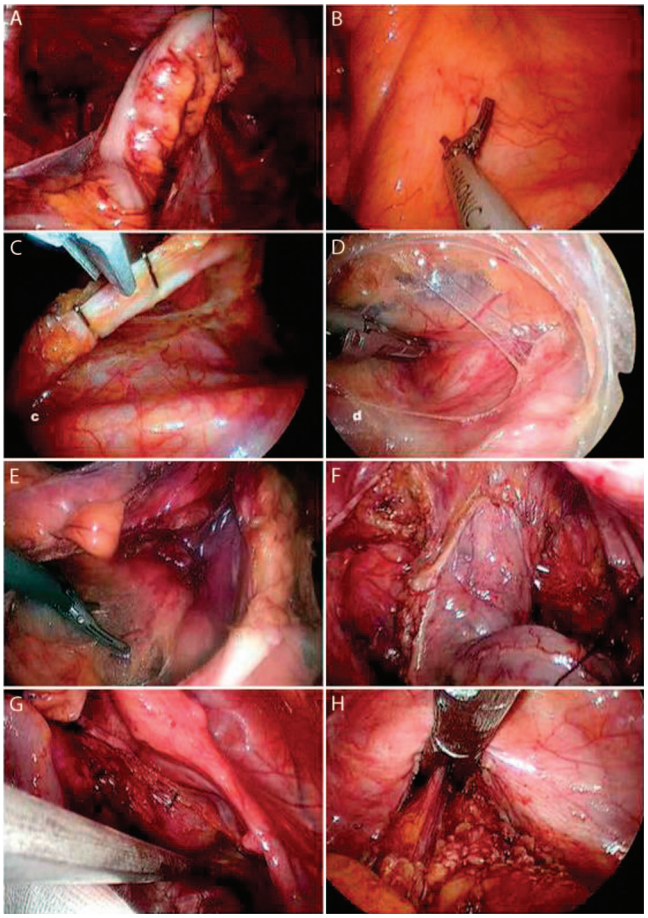

FIGURE 1. A, Suspension through transparietal sutures of the rectosigmoid colon. B, Beginning of mesocolic dissection. C, Clipping of superior rectal artery. D, Identification of left ureter. E, Dissection of the presacral areolar tissue. F, Pelvic view after completion of presacral and anterior dissection. G, Marking of distal resection margin with clip. H, Transsection of the rectum with EndoGIA.

was performed by decreasing the tension of the transabdominal sutures and retracting the peritoneal fold anterior to the rectum. Dissection proceeded laterally on both sides of rectum until circumferential mobilization of lower rectum was accomplished (Fig. 1F). Digital examination was performed to verify the distance between the tumor's inferior margin and the line of resection, and the adequacy of the distal margin was marked with a clip (Fig. 1G). One 5-mm port was changed with a 10-mm port. A blue 45-mm EndoGIA roticulator stapler (Covidien Ltd., Norwalk, CT) was fired twice from this port to divide the lower rectum safely (Fig. 1H). The abdomen was then deflated, and a wound protector (Alexis O, Applied Medical Rancho Santo Margarita, CA) was placed at the aperture of SILS port. The specimen was extracted through the SILS aperture and resected. Extracorporeal preparation of the proximal colon was completed with placement of the anvil of a 29-mm circular stapler in position to perform a side-to-end or end-to-end colorectal anastomosis.

FIGURE 2. Abdominal view on postoperative day 1.

After pneumoperitoneum reestablishment, a conventional intracorporeal colorectal anastomosis was made with transanal insertion of a circular stapler (Proximate ILS circular stapler, Ethicon Endo-surgery, Cincinnati, OH) under direct vision. Testing for anastomosis was performed by insufflating air into the rectum while the pelvic cavity was filled with water. The fascia was closed with PDS sutures continuously and the skin was closed with interrupted 3/0 nylon sutures. In the cases needing a proximal diverting ileostomy, the diversion loop ilostomy was brought out through the SILS aperture approximately 20 cm proximal to the ileocecal valve. The ileostomy was created ad modum Turnbull fashion with use of 3/0 vicryl sutures (Fig. 2). No drains were used. Intra-abdominal smoke formation was drained via the insertion of an intravenous cannula working as a separate venting channel at the suprapubic site.

RESULTS

During the study period, a total of 10 patients with rectal carcinoma met our entry criteria (2 men and 8 women). The median age of the patients was 67 (range, 49–83) and the median body mass index was 23.5 kg/m^2 (range, 20–24

TABLE 1. Patient characteristics and perioperative data

Case No.	Sex	Age (y)	Body mass index (kg/m^2)	Distance of tumor from AV	ASA class	Previous open abdominal surgery	Operation	Location of incision	Operation time (min)	Estimated blood loss (mL)
1	F	64	20	10	2	—	LAR with ileostomy	RLQ	244	0
2	F	83	24	10	2	Hysterectomy	LAR with ileostomy	RLQ	305	100
3	F	78	23	12	2	—	LAR	TU	255	50
4	F	70	23	11	3	Hysterectomy, appendectomy, and operation for liver cysts	Hartmann procedure	LLQ	233	0
5	F	54	22	9	2	Open cholecystectomy	LAR with ileostomy	RLQ	222	100
6	F	49	24	15	1	Appendectomy	AR	TU	185	0
7	M	62	24	12	1	—	LAR	TU	225	0
8	F	67	24	14	1	—	AR	TU	210	50
9	M	80	24	4	2	Appendectomy	APR	LLQ	318	0
10	F	67	21	9	2	Hysterectomy	LAR with ileostomy	RLQ	205	0

F = female; M = male; AV = anal verge; ASA = American Society of Anesthesiologists; AR = anterior resection; LAR = low anterior resection; APR = abdominoperineal resection; RLQ = right lower quadrant; LLQ = left lower quadrant; TU = transumbilical.

kg/m^2). Most of the patients had an upper rectal cancer and the median distance of tumor from the anal verge was 10.5 cm (range, 4–15). Six patients had previously had abdominal surgery. We performed 6 low anterior resections (4 received diverting ileostomy), 2 anterior resections, 1 Hartmann procedure, and 1 abdominoperineal resection (APR). We used the umbilicus for both the SPA site and the specimen extraction in 4 patients. Furthermore, in the other 4 patients who underwent low anterior resection, no additional abdominal access was used, and the marked diverting ileostomy site was used both for SPA placement and subsequently extraction. In the case of Hartmann procedure, the SPA site in the left lower quadrant was used for port placement and, subsequently, extraction of the specimen and formation of an end sigmoidostomy. The patient who underwent APR also had the SPA incision located at the stoma site in the left lower quadrant, but the specimen was removed via the perineal incision. In all but 2 cases, a medial-to-lateral approach was used, with initial identification and clipping of the superior rectal artery at the base of the inferior mesenteric pedicle. In 2 patients, who underwent APR or Hartmann procedure, conventional lateral-to-medial dissection was used. All procedures were successfully accomplished without conversion to multiport laparoscopy or open procedure. An additional laparoscopic 5-mm port was inserted in 2 patients, the first port for suturing an anterior anastomotic defect after a positive air-leak test in a female patient, who underwent LAR with diverting ileostomy, and the other port to control of bleeding from the pelvic area during the abdominal phase of an APR. The median operation time was 229 minutes (range, 185–318) and estimated blood loss was low (range, 0–100 mL). Other patient characteristics and perioperative data are shown in detail in Table 1.

The median tumor size was 3.5cm (range, 1.5–4 cm), and there were no positive surgical margins in any case as shown in Table 2. The circumferential resection margin was a median of 11 mm (range, 2.5–25) and the distal

TABLE 2. Pathological and surgical results of patients

Case No.	LN (n)	Length of specimen (cm)	Tumor size (cm)	CRM (mm)	DRM (mm)	MRF	T stage	N stage	Surgical morbidity	Hospital stay (days)	Readmission (days)
1	3	10	1.5	10	25	NC	2	0	—	7	2
2	13	15	4	10	10	NC	3	1	—	7	—
3	12	15	4	20	30	C	3	2	—	4	—
4	13	19	2.5	15	20	C	3	1	—	6	—
5	20	12	4	25	5	C	3	1	—	7	—
6	16	11	3	12	30	C	3	1	—	4	—
7	12	14	3	15	35	NC	3	0	Compartment syndrome	8	—
8	15	11	2	5	20	C	2	1	—	4	—
9	19	32	4	6	35	NC	2	0	Pelvic fluid collection	14	2
10	18	14	4	2.5	20	C	3	0	—	7	—

LN = lymph node; CRM = circumferential resection margin; DRM = distal resection margin; MRF = mesorectal fasciae; NC = nearly complete; C = complete.

resection margin was a median of 22.5 mm (range, 5–35) measured at the pathological examination. The number of harvested lymph nodes was a median of 14 (range, 3–20). The TNM status was stage I for 2 patients and stage II and stage III for 6 patients. The pathological examination showed a complete mesorectum in 6 patients and a nearly complete mesorectum in 4 patients. There were 2 postoperative complications. One patient developed a pelvic fluid collection after APR. It was treated with transperineal percutaneous drainage. Another patient, known to have peripheral ischemia, developed compartment syndrome in his leg, and underwent urgent fasciotomy on the first postoperative day. There were no anastomotic leaks and no mortality. The median length of hospital stay was 7 days (range, 4–14 days). Two patients were readmitted in the postoperative period. One was hospitalized because of electrolyte and fluid imbalance and responded immediately to conservative treatment. The other patient required drainage of a pelvic fluid collection as stated previously. The median follow-up was 4.5 months (range, 2–7 months). During this period, 1 patient, with previous low anterior resection and diverting ileostomy, underwent ileostomy closure. All patients recovered uneventfully and they were well at their latest outpatient review.

DISCUSSION

Conventional laparoscopic colorectal surgery requires a number of ports and an incision at least 4 to 6 cm in length. Recent advances in minimally invasive surgery have resulted in an increasing tendency toward either limiting the number of abdominal incisions (as in SPA) or eliminating them completely (as in natural orifice transluminal endoscopic surgery (NOTES)). The NOTES technique is performed through a solitary natural orifice such as the stomach, vagina, or rectum. The potential benefits of NOTES include absence of visible scarring, reduction in pain, shorter recovery time, and elimination of hernia formation. Although NOTES is being considered to be the next stage of surgical development, it still is in the early stages of development and requires extensive specialized instruments and much more intensive training.[23] In addition, additional ports are often needed if endoscopic staplers are being used, and there has been some concern about the morbidity associated with the extraction sites.[24] These limitations have resulted in a remarkable increase in SPA procedures over past years. The SPA technique seems to be more practical and more acceptable for immediate clinical use. Early clinical series demonstrated the feasibility and the safety of this technique in general surgery and urology after the first reports appeared in the literature for appendectomy and cholecystectomy in 1997.[25,26] Two early case reports described right hemicolectomy with use of laparoscopic instruments and transparietel stitches with oncologically safe results.[11,12] Leroy et al[27] have reported a laparoscopic sigmoidectomy using reticulating graspers and extracorporeal magnets for adequate exposure. Since 2008, several series including left colectomy, high anterior resection, and total proctocolectomy have been published.[14–20,28] Recently, innovative surgical technology such as articulating instrumentation and novel multilumen ports have made SPA surgery feasible and safe in complex abdominal and pelvic surgery.[21,28,29]

Patient selection is crucial, and our patients were slim with a BMI $\leq$25. A previous nonintestinal abdominal operation, such as appendectomy or hysterectomy, is not a main contraindication for the operation. However, dissection of adherence formation creating a suitable working space in the lower abdomen or pelvis prolongs the operation time. Most of our patients were women with small tumors. The relative lack of visceral fat and the wide pelvis in females, combined with the small rectal tumors, facilitated the SPA laparoscopic dissection in the deep pelvis. A transumbilical SPA incision was chosen for upper rectal tumors. A SPA incision at the protective ileostomy site was chosen for the lesions close to the mid rectum. One of the challenges in laparoscopic rectal surgery is localization of the tumor. Without tactile sensation, it can be difficult to determine adequacy of distal rectal dissection and to be sure that the endoscopic stapler is applied at the appropriate level distal to the tumor. For this reason, the level of anastomosis will be close to the anal verge, even in some patients with an upper rectal tumor. We routinely perform a diversion ileostomy in patients needing anastomosis within 5 cm of the anal verge. We had a low threshold for insertion of additional ports as required by the findings, such as the air-test leak after anastomosis formation and bleeding from the pelvis in 2 cases. The insertion of additional ports should also be done when facing technical difficulties. Although the initial chosen length for SPA incision was approximately 2 to 2.5 cm, we extended the incision according to tumor size to allow the specimen to be intact when extracted. The operation time in some of our cases was relatively long because of the time-consuming dissection of intra-abdominal adherences, and a learning curve on the procedure must be considered. Estimated blood loss was close to 0 in 6 patients and ranged between 50 and 100 mL in 4 of 10 cases, which is comparable to conventional laparoscopic rectal procedures. Six patients in our series had stomas and they needed to learn stoma care before leaving the hospital, which contributed to a relatively longer length of stay. However, the median 7-day hospital stay is similar to previous studies on laparoscopic rectal surgery.[30–32] The 2 prolonged hospital stays in this series of 8 and 14 days were due to complications as stated previously.

Our initial experience has shown that SPA rectal surgery for cancer of the high and low rectum can be accomplished with an acceptable operating time and without additional morbidity. The majority of midrectal tumors

located in a bony narrow pelvis is still a challenge, not only in SPA but also in CLS. Therefore, we have decided not to include midrectal tumors, in which laparoscopic rectal dissection performed with the SPA approach probably is associated with technical difficulties at the present. The SPA technique has 2 major drawbacks. The first drawback is the difficulty of creating triangulation. The second one is that hands and trocars interfere with each other either inside or outside the abdominal cavity. Inserting the laparoscopic instruments from a single port prevents triangulation when using standard laparoscopic instruments. Triangulation from a single port can only be achieved by use of articulated or curved instruments and reasonable placing of transparietal suspension sutures. To ensure adequate and timely traction, and possibly to maneuver the rectum during the pelvis dissection and stapling procedure, transparietal sutures are applied through the abdominal wall. This is done by sewing through the abdominal wall, making a loop all the way around the rectum/mesorectum (half-hitch) and fixations of the suture with clips to both sides of mesorectum, and finishing by sewing up through the abdominal wall again. The traction on one end of the sutures creates triangulation, which will facilitate a better exposure and margin clearance. In addition, tilting of the operating table to reverse the Trendelenburg position and toward the right side of patient helps to facilitate the exposure of the operative field and dissection.

Concerning oncological results, data from high-quality randomized clinical trials are scarce at the current time, although several series have been published with excellent outcomes.[32–34] Assessment of a technical procedure by evaluating blood loss, assessing the operative time, and analyzing the pathology findings determines some quality measures regarding oncological outcome. In the present series, there were no cases of tumor involvement of the distal and circumferential resection margins. These parameters are especially important for the oncological prognosis. However, there is no prognostic difference between patients with a complete mesorectum compared those with a nearly complete mesorectum, whereas patients with an incomplete mesorectum have a significantly higher risk of local recurrence compared with patients with a complete mesorectum.[35] Technical difficulties in rectal mobilization because of instrumentation have probably resulted in some tears and shallow breaks into the mesorectum, which made grading of mesorectal fasciae nearly complete in 4 cases in this series. Obtaining more lymph nodes may benefit patients because it allows for more accurate cancer staging and appropriate use of adjuvant chemotherapy. A minimum number of 12 lymph nodes has been endorsed as a consensus standard of performance in colorectal resections.[36] Many factors affect the number of lymph nodes examined, including the extent of surgical resection, patient age, tumor location, pathologist, surgeon, and the method of specimen preparation. The median lymph node extraction of 14 obtained in these cases matches the other laparoscopic series and population-based studies.[30–32,37] The median specimen length measured in fixed formalin was 14 cm (range, 10–32).

Although the present series has shown the safety and feasibility of performing the SPA procedure for oncological resection in rectal surgery, our study has several limitations, including lack of registration of postoperative pain, immunological parameters, and long-term clinical and oncological outcome. The small sample size makes it difficult to ascertain complication and conversion rates. The performance of SPA surgery, especially for complex procedures such as rectal surgery, is challenging; also, in the hands of a skilled laparoscopic colorectal surgeon, a significant learning curve is anticipated.

At present, the thick bulky mesorectum seen in patients with higher BMIs or the dense inflammatory perirectal or perisigmoidal reaction seen in some cases is a contraindication to SPA laparoscopic rectal surgery.

CONCLUSIONS

Our initial results showed that SPA surgery for rectal tumors can be performed safely in slim patients with no bulky tumor by using one incision, either through the patient's umbilicus or through a chosen stoma site that may become the diversion ileostomy or end-sigmoidostomy aperture. The SPA surgery has a potential of reducing postoperative pain. The decrease in incision number may decrease the development of wound infection or hernias, prevent the formation of intra-abdominal adhesions, and improve cosmetic results. However, the potential benefits or disadvantages of SPA laparoscopic procedures require further evaluation. Prospective comparative studies between SPA and conventional laparoscopic colorectal surgery are needed to clearly determine its short- and long-term outcome.

ACKNOWLEDGMENT

The authors are indebted to Steffen Bülow, M.D., Dr.Med.Sci., for his review of this article.

REFERENCES

1. Schwenk W, Haase O, Neudecker J, Muller JM. Short term benefits for laparoscopic colorectal resection. *Cochrane Database Syst Rev*. 2008;CD003145.
2. Bonjer HJ, Hop WC, Nelson H, et al. Laparoscopically assisted vs open colectomy for colon cancer: a meta-analysis. *Arch Surg*. 2007;142:298–303.
3. Braga M, Vignali A, Zuliani W, Frasson M, Di Serio C, Di Carlo V. Laparoscopic versus open colorectal surgery: cost-benefit analysis in a single-center randomized trial. *Ann Surg*. 2005;242:890–896.

4. Lowry PS, Moon TD, D'Alessandro A, Nakada SY. Symptomatic port-site hernia associated with a non-bladed trocar after laparoscopic live-donor nephrectomy. *J Endourol.* 2003;17:493–494.
5. Marcovici I. Significant abdominal wall hematoma from an umbilical port insertion. *JSLS.* 2001;5:293–295.
6. Dunker MS, Stiggelbout AM, van Hogezand RA, Ringers J, Griffioen G, Bemelman WA. Cosmesis and body image after laparoscopically-assisted and open ileocolic resection for Crohn's disease. *Surg Endosc.* 1998;12:1334–1340.
7. Ateş O, Hakgüder G, Olguner M, Akgür F. Single-port laparoscopic appendectomy conducted intracorporeally with the aid of a transabdominal sling suture. *J Pediatr Surg.* 2007;42:1071–1074.
8. Raman JD, Bagrodia A, Cadeddu JA. Single-incision, umbilical laparoscopic versus conventional laparoscopic nephrectomy: a comparison of perioperative outcomes and short-term measures of convalescence. *Eur Urol.* 2009;55:1198–1204.
9. Podolsky ER, Curcillo PG 2nd. Single port access (SPA) surgery—a 24-month experience. *J Gastrointest Surg.* 2010;14:759–767.
10. Ahmed K, Wang TT, Patel VM, et al. The role of single-incision laparoscopic surgery in abdominal and pelvic surgery: a systematic review [published online ahead of print July 10, 2010]. *Surg Endosc.* doi: 10.1007/s00464-010-1208-6.
11. Bucher P, Pugin F, Morel P. Single port access laparoscopic right hemicolectomy. *Int J Colorectal Dis.* 2008;23:1013–1016.
12. Remzi FH, Kirat HT, Kaouk JH, Geisler DP. Single-port laparoscopy in colorectal surgery. *Colorectal Dis.* 2008;10:823–826.
13. Bucher P, Pugin F, Morel P. Single-port access laparoscopic radical left colectomy in humans. *Dis Colon Rectum.* 2009;52:1797–1801.
14. Geisler DP, Condon ET, Remzi FH. Single incision laparoscopic total proctocolectomy with ileopouch anal anastomosis. *Colorectal Dis.* 2010;12:941–943.
15. Remzi FH, Kirat HT, Geisler DP. Laparoscopic single-port colectomy for sigmoid cancer. *Tech Coloproctol.* 2010;14:253–255.
16. Brunner W, Schirnhofer J, Waldstein-Wartenberg N, Frass R, Weiss H. Single incision laparoscopic sigmoid colon resections without visible scar: a novel technique. *Colorectal Dis.* 2010;12:66–70.
17. Law WL, Fan JK, Poon JT. Single-incision laparoscopic colectomy: early experience. *Dis Colon Rectum.* 2010;53:284–288.
18. Cahill RA, Lindsey I, Jones O, Guy R, Mortensen N, Cunningham C. Single-port laparoscopic total colectomy for medically uncontrolled colitis. *Dis Colon Rectum.* 2010;53:1143–1147.
19. Wong MT, Ng KH, Ho KS, Eu KW. Single-incision laparoscopic surgery for right hemicolectomy: our initial experience with 10 cases. *Tech Coloproctol.* 2010;14:225–228.
20. Ramos-Valadez DI, Patel CB, Ragupathi M, Bartley Pickron T, Haas EM. Single-incision laparoscopic right hemicolectomy: safety and feasibility in a series of consecutive cases. *Surg Endosc.* 2010;24:2613–2616.
21. Bulut O, Nielsen CB. Single-incision laparoscopic low anterior resection for rectal cancer. *Int J Colorectal Dis.* 2010;25:1261–1263.
22. Bulut O, Nielsen CB. Laparoscopic rectum resection with salpingo-oophorectomy via a single incision [published online ahead of print January 3, 2011]. *Ugeskr Læger.*
23. Flora ED, Wilson TG, Martin IJ, O'Rourke NA, Maddern GJ. A review of natural orifice translumenal endoscopic surgery (NOTES) for intra-abdominal surgery: experimental models, techniques, and applicability to the clinical setting. *Ann Surg.* 2008;247:583–602.
24. Clayman RV, Box GN, Abrahams JB, et al. Rapid communication: transvaginal single-port NOTES nephrectomy: initial laboratory experience. *J Endourol.* 2007;21:640–644.
25. Navarra G, Pozza E, Occhionorelli S, Carcoforo P, Donini I. One-wound laparoscopic cholecystectomy. *Br J Surg.* 1997;84:695.
26. Esposito C. One-trocar appendectomy in pediatric surgery. *Surg Endosc.* 1998;12:177–178.
27. Leroy J, Cahill RA, Peretta S, Marescaux J. Single port sigmoidectomy in an experimental model with survival. *Surg Innov.* 2008;15:260–265.
28. Chambers W, Bicsak M, Lamparelli M, Dixon A. Single-incision laparoscopic surgery (SILS) in complex colorectal surgery: a technique offering potential and not just cosmesis [published online ahead of print December 14, 2009]. *Colorectal Dis.* doi: 10.1111/j.1463-1318.2009.02158.x.
29. Co CS, Cheung HY, Yau KK, Chung CC, Li M. Combined single-port and endoluminal technique for laparoscopic anterior resection. *Surg Laparosc Endosc Percutan Tech.* 2010;20:253–256.
30. Guillou PJ, Quirke P, Thorpe H, et al. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MCR CLASICC trial): multicentre, randomised controlled trial. *Lancet.* 2005;364:1718–1726.
31. Park JS, Kang SB, Kim DW, Lee KH, Kim YH. Laparoscopic versus open resection without splenic flexure mobilization for the treatment of rectum and sigmoid cancer: a study from a single institution that selectively used splenic flexure mobilization. *Surg Laparosc Endosc Percutan Tech.* 2009;19:62–68.
32. Kang SB, Park JW, Jeong SY, et al. Open versus laparoscopic surgery for mid or low rectal cancer after neoadjuvant chemoradiotherapy (COREAN trial): short-term outcomes of an open-label randomised controlled trial. *Lancet Oncol.* 2010;11:637–645.
33. Dulucq JL, Wintringer P, Stabilini C, Mahajna A. Laparoscopic rectal resection with anal sphincter preservation for rectal cancer: long-term outcome. *Surg Endosc.* 2005;19:1468–1474.
34. Leung KL, Kwok SP, Lam SC, et al. Laparoscopic resection of rectosigmoid carcinoma: prospective randomised trial. *Lancet.* 2004;363:1187–1192.
35. Nagtegaal ID, van de Velde CJ, van der Worp E, et al. Macroscopic evaluation of rectal cancer resection specimen: clinical significance of the pathologist in quality control. *J Clin Oncol.* 2002;20:1729–1734.
36. Nelson H, Petrelli N, Carlin A, et al. Guidelines 2000 for colon and rectal cancer surgery. *J Natl Cancer Inst.* 2001;93:583–596.
37. Baxter NN, Virnig DJ, Rothenberger DA, Morris AM, Jessurun J, Virnig BA. Lymph node evaluation in colorectal cancer patients: a population-based study. *J Natl Cancer Inst.* 2005;97:219–225.