Transumbilical Single-Port Laparoscopic Surgery for Colorectal Cancers: Experience of 258 Consecutive Cases with Rational Manipulation of Instrument for Safety and Benefit

Sho Hirabayashi1,2, Kenji Hibi1, Yoshihiro Hotta1, Ryohei Fukumoto1, Takuya Watanabe1, Junichi Sakamoto1, Yasuhiro Kodera2

1) Department of Gastroenterological Surgery, Tokai Central Hospital
2) Department of Digestive Surgery, Nagoya University Graduate School of Medicine

Abstract

Background: Single port laparoscopic surgery has been rapidly developing worldwide, with the potential for replacing conventional laparoscopic surgery.

Objective: Identification and evaluation of the safety, benefits and disadvantages of single port laparoscopic procedures through presentation of our experience.

Design: Retrospective review of surgical procedures and outcomes for two-hundred-fifty-eight consecutive cases of single port laparoscopic surgery for colorectal cancers, between September 2009 and March 2015.

Main Outcomes: Descriptive analysis of patients' background characteristics (age, sex and cancer location), operative details (type, duration, intra-operative bleeding volume, intra-operative complication, conversion to open surgery), and post-operative follow-up (complications within 30 days).

Results: Cases included ileocaecal resection (n=36), right hemicolectomy (n=54), transverse colectomy (n=21), left hemicolectomy (n=25), sigmoidectomy (n=33), high anterior resection (n=68), low anterior resection (n=24), and abdominoperineal resection (n=1). Patient group included 137 men, 121 women, with a median age of 71 years (range, 26-94). Operative details included a median duration of 234.5min (range, 90-541) and a median blood loss was 70ml (range, 0-2560). The median follow-up period was 253 days (range, 13-703), with 21 reported complications in 17 patients.

Conclusions: Single-port transumbilical laparoscopic surgery is feasible and safe provided that the surgery is performed by experienced surgeons, compared to multiport laparoscopic procedures for colorectal cancers.

Key Words: Colorectal cancer, transumbilical, single-port, laparoscopic surgery

(Received December 15, 2015; Accepted January 6, 2016)
required in these cases. However, studies have reported comparable outcomes of SPLS to CLS and ordinary open surgeries in cases of colorectal cancer, in terms of margins of resection of affected tissues and extent of harvesting of lymph nodes, as well as in terms of short-term\textsuperscript{12,13} and long-term\textsuperscript{14-16} oncological effectiveness of procedures. Similarly, comparative studies have provided evidence on the safety and feasibility of SPLS for colorectal cancer surgery\textsuperscript{4,17}, without compromising the quality of surgical resections or the effectiveness of the oncological management\textsuperscript{18-22}.

Patient satisfaction is a distinctive advantage of SPLS due to its cosmetic superiority over both ordinary open surgery and CLS. SPLS also reduces the likelihood for surgical wound-related complications, compared to CLS, by decreasing the number and size of required incision, which are closely related to the incidence of iatrogenic injuries to the bowel, associated vessels, and other intra-abdominal structures, as well as lowering the risk for trocar (incisional) site hernia\textsuperscript{23}. A meta-analysis provided level I evidence of the significant reduction in wound complication with SPLS, compared to CLS\textsuperscript{24}.

As SPLS becomes more widely adopted, comparison of the incidence of procedure-related complications has also become a more important consideration in the overall discussion of risk-benefit between patients and surgeons. Therefore, the aim of our study was to identify and evaluate the safety, benefits and disadvantages of SPLS through a retrospective review of consecutive cases of laparoscopic surgery for colorectal cancers, performed by a single surgeon (K.H.) with expertise in CLS and SPLS techniques and procedures, at two of our clinical institutions in Japan.

Materials and Methods

Prospective subjects were patients with colorectal cancer, eligible for curative resection of the malignant tumor, who underwent a SPLS procedure at Showa University Fujigaoka Hospital and Tokai Central Hospital, between 2009 and 2015. Patients were provided with detailed explanation of the SPLS procedure, and informed consent was received from all patients before surgery. Cases were screened to identify patients who were 20 years or older and who had histologically confirmed colorectal cancers, as well as to exclude patients with intestinal obstruction. All SPLS procedures were performed under the surveillance and instruction of one surgeon, recognized as an expert in endoscopic colorectal surgery.

Statistical Considerations

All the data were retrospectively collected, entered, and evaluated using descriptive analyzes in Microsoft Office Excel 2013.

Ethical Considerations

Written informed consent for the SPLS procedures was obtained from all patients prior to surgery. All of the procedures were in accordance with the Helsinki Declaration (1964 amended in 2008) of the World Medical Association, Ethical Guidelines for Clinical Studies (2005), Ethical Guidelines for Epidemiological Studies (2005) and other human laws. This project was approved by the Ethics Review Board at Showa University and by the Institutional Review Board of the Tokai Central Hospital.

Operative Techniques

Under general anesthesia, patients were placed in a supine lying position. A vertical skin incision, 3 to 4 cm in length, was made through the umbilicus, and the fascia was exposed and incised up to 5 cm. The SPLS access port was inserted through the transumbilical incision, and three packaged, 5mm, surgical trocars were introduced through the port, using a parallel method, to access the colonic or rectal lesion. The intra-abdominal techniques for SPLS have been described in detail elsewhere\textsuperscript{25,26}.

SPLS procedures

In our data set, SPLS was initially performed using the EndoRelief\textsuperscript{20} system (Hope Densei Co., Ltd., Kamagaya, Chiba, Japan). Three years into the study period, the EndoGrab\textsuperscript{2} system (Virtual Ports, Ltd., Caesarea, Israel) became available and was adopted as it facilitated secure retraction of organs through the transumbilical lumen. From that point, all SPLS procedures were performed through a single port at the umbilical site.

Analyzed factors

The following relevant information was extracted from the charts and recorded: patient characteristics (age, sex and cancer location), operative details (type of surgery performed, operative time, amount of bleeding during the surgery, intra-operative complication, conversion to an open procedure), and post-operative complications within 30 days of the procedure (nature, management, outcome). Identified complications were classified by degree of severity, according to the Clavien-Dindo scale\textsuperscript{27}. Conversion to an ordinary open procedure was defined as lengthening of the port incision by more than what was originally planned for in the SPLS.

Results

Patient Characteristics

Over a period of 67 months, a total of 262 resections for colorectal cancers were performed in 258 patients, 178 cases at the Showa University Fujigaoka Hospital, from September 2009 to March 2013, and 80 cases at
the Department of Surgery, Tokai Central Hospital, from April 2013 to March 2015. The median age of patients in the study group was 71 years (range, 26 to 94 years), with 137 men and 121 women (Table 1).

### Intraoperative courses

Evaluated intra-operative variables are listed in Table 2. The median duration of the SPLS procedures was 234.5 min (range, 90 to 541 min). The operating time varied depending on the location and size of the tumor, as well as on the operative procedures implemented. Of the 262 resections in the 258 operative cases, standard lymph node dissection was indicated and performed in 232 resections (88.6%). The median blood loss during surgery was 70 ml (range, 0 to 2560 ml), with significant intraoperative bleeding observed in 2 cases of sigmoidectomy and transverse colectomy. The conversion rate from SPLS to an open procedure was 2.7% (i.e., 7 of the 258 cases). No patients were identified with a positive air-leak test.

### Postoperative Follow-up

The median length of post-operative follow-up was 253 days. Post-operative complications are described in Table 3. Post-operative complications arose in 17 patients, with 11 of these (i.e., 64.7%) fully recovering with conservative or endoscopic management, while the remaining 6 patients required reoperation for exploratory laparotomy and drainage. Two incisional hernias were reported, and there was one case of anastomotic stenosis. There were no reported cases of cancer seeding and of consequent port site recurrence, with the SPLS procedure. There was no incidence of post-operative death (i.e., mortality rate of 0%).

---

**Table 1** Demographic and clinical characteristics of the patients

| Age, (range) | 71*, (26-94) |
|-------------|--------------|
| Sex         |              |
| Male        | 137          |
| Female      | 121          |
| Tumor location |          |
| Caecum      | 31           |
| Ascending colon | 54         |
| Transverse colon | 28      |
| Descending colon | 23     |
| Sigmoid colon | 49         |
| Rectum      | 80           |
| Operation   |              |
| Ileocaecal resection | 36     |
| Right hemicolecotomy | 54 |
| Transverse colectomy | 21 |
| Left hemicolecotomy | 25 |
| Sigmoidectomy | 33      |
| High anterior resection | 68 |
| Low anterior resection | 24   |
| Abdominoperineal resection | 1 |

*Value is median.

**Table 2** Operative results and outcomes of the patients

| Operating time (minutes)* | 234.5 (90-541) |
| Operative blood loss (ml)* | 70 (0-2560) |
| Conversion (n, %) | 7, 2.7% |
| Additional ports (n, %) | 2, 0.8% |
| Lymph node dissection (n, %) | D3 232, 88.6% |
| | D2 10, 3.8% |
| | D1 20, 7.6% |
| Intraoperative complications | 8, 3.1% |
| Massive bleeding | 2 |
| Ascending colonic injury | 1 |
| Urethral injury | 1 |
| Ureteric injury | 1 |
| Pancreatic injury | 1 |
| Small intestinal injury | 1 |
| Duodenum injury | 1 |

*Values are median (range)

**Table 3** Postoperative complications after SPLS

| Type of complications | # of cases | Primary operation | Management | Clavien-Dindo scale | Outcome |
|-----------------------|------------|-------------------|------------|---------------------|---------|
| Paralytic ileus       | 4          | Right colectomy (2) | conservative | II                  | recovered |
| Anastomotic dehiscence| 3          | Low anterior resection | ileocaecal resection | conservative | II       | recovered |
| Neurogenic bladder    | 2          | High anterior resection | conservative | II                  | recovered |
| Anastomotic stenosis  | 1          | Transverse colectomy | resection, colostomy | IIIb               | recovered |
| Atrial fibrillation tachycardia | 1 | Right colectomy | conservative | II | recovered |
| Fascia separation     | 1          | High anterior resection | re-suture | IIIa               | recovered |
| Colitis               | 1          | Right colectomy | conservative | II       | recovered |
| Central Venous catheter infection | 1 | High anterior resection | conservative | II       | recovered |
| Superficial surgical site infection | 1 | High anterior resection | conservative | I       | recovered |
| Sudden deafness       | 1          | Low anterior resection | conservative | II       | recovered |
| MRSA sepsis           | 1          | Low anterior resection | conservative | II       | recovered |
| IMA embolization      | 1          | Low anterior resection | colostomy | IIIb              | recovered |
| Hyponatremia          | 1          | High anterior resection | conservative | II       | recovered |
| Duodenum ulcer        | 1          | High anterior resection | conservative | IIIa               | recovered |
| Small intestine injury| 1          | Ileocaecal resection | suture | IIIb              | recovered |
Discussion

A single incision site is used in SPLS to fulfill various functions. The incision provides: an access port for the instruments entering into the abdominal cavity, an outlet for extraction of the resected specimen, and a pathway for drainage. The umbilicus is the preferred site of incision for abdominal SPLS procedures for several reasons. The umbilicus is the thinnest part of the abdominal wall and has no major blood vessels or nerves in the vicinity. It is also centrally located and, in most of cases, can provide a shortcut to various intra-abdominal organs in all quadrants of the abdomen. The umbilicus also has the added advantage of being a ‘naturally readymade’ scar which can effectively mask the surgical scar of the SPLS. Use of a single incision is not only cosmetically appealing, which can significantly increase patient satisfaction, but also decreases wound pain and lowers the risk for wound-related complications, such as abdominal wall bleeding, port-site hernia, and iatrogenic damage and injury to internal organs.

After sufficient experience in the use of conventional laparoscopic surgery (CLS), proficiency of well-trained surgeons has enabled the development of SPLS and, currently, the procedure has become one of the standards for abdominal surgery. While promising, the clinical benefits of SPLS over CLS have yet to be confirmed by an authentic clinical trial. In fact, while several comparative studies have described a number of potential advantages of SPLS, including reduction in post-operative pain and faster post-surgical recovery[3-7,28-30], two randomized controlled trials failed to confirm clinical benefits of SPLS over CLS.[31,32] A recent systematic review and meta-analysis on the use of SPLS specifically for colorectal disease reported a post-operative complication rate of 17.78%.[33]

Our goal in this study was to evaluate whether SPLS is really a ‘feasible’ and ‘exploitable’ option for colorectal cancer patients, both in terms of intra-operative and post-operative outcomes, without compromising best available treatment for resectable cancers. In our case series of surgeries, intra-operative blood loss during SPLS was comparable to reported volume loss during CLS procedures. The identified incidence rate for post-operative complications of 6.59% in our case series (i.e., 17 of 258 patients) was markedly lower than the 17.78% incidence reported by Luján et al.[33] The most plausible explanation for this discrepancy in the rate of post-operative complication is that all procedures in our retrospective case series were performed by a single, well experienced surgeon, or under the instruction and surveillance of this particular senior surgical consultant. The importance of surgeon expertise is underscored in the randomized controlled trial conducted by Sano et al.[34] evaluating outcomes of surgical procedures and techniques for localized, advanced, gastric cancer. They reported a 10-fold increase in operative mortality when D2 lymph node dissection was performed by an inexperienced surgeon compared to well-trained, expert surgeons.

Current evidence for the use of SPLS in the management of colorectal cancer is based on clinical reports, a limited number of systematic reviews and meta-analyses, and one randomized controlled trial. Therefore, multi-center randomized controlled trials are needed. Based on current evidence, recommendation for or against SPLS must be guarded. Our clinical case series provides level III evidence that SPLS could be a safe and convenient ‘state of the art’ procedure for abdominal surgery in the future. Our case series study also provides evidence of the importance of surgeons’ expertise and, therefore, the requirement for training.

Acknowledgement
This work is supported, in part, by a grant from the non-profit organization, Epidemiological & Clinical Research Information Network (ECRIN).

References

1) Pelosi MA. Laparoscopic supracervical hysterectomy using a single-umbilical puncture (mini-laparoscopy). (1992) J Reprod Med ; 37: 777-784 [PMID: 1453397].
2) Ateş O, Hakgüder G, Olguner M, Akgür FM. Single-port laparoscopic appendectomy conducted intracorporeally with the aid of transabdominal sling suture. (2007) J Pediatr Surg ; 42: 1071-1074 [PMID: 17560223 DOI: 10.1016/j.jpedsurg.2007.01.065].
3) Podolsky ER, Rottman SJ, Poblete H, King SA, Curcillo PG. Single port access (SPA) cholecystectomy: a completely transumbilical approach. (2009) J Laparoendosc Adv Surg Tech A ; 19: 219-222 [PMID: 19260790 DOI: 10.1089/lap.2008.0275].
4) Bucher P, Pugin F, Morel P. Single port access laparoscopic right hemoctectomy. (2008) Int J Colorectal Dis ; 23: 1013-1016 [PMID: 18607608 DOI: 10.1007/s00384-008-0519-8].
5) Remzi FH, Kirat HT, Kauk JH, Geisler DP. Single-port laparoscopy in colorectal surgery. (2008) Colorectal Dis ; 10: 823-826 [PMID: 18684153 DOI: 10.1111/j.1463-1318.2008.01660.x].
6) Brunner W, Schirnhofer J, Waldstein-Wartenberg N, Frass R, Weiss H. Single incision laparoscopic sigmoid colon resections without visible scar: a novel technique. (2010) Colorectal Dis ; 12: 66-70 [PMID: 19508527 DOI: 10.1111/j.1463-1318.2009.01894.x].
7) Bucher P, Pugin F, Morel P. Transumbilical single incision laparoscopic sigmoidectomy for benign disease. (2010) Colorectal Dis ; 12: 61-65 [PMID: 19320667 DOI: 10.1111/j.1463-1318.2009.01825.x].
8) Co CS, Cheung HY, Yau KK, Chung CC, Li M. Combined single-port and endoluminal technique for laparoscopic anterior resection. (2010) Surg Laparosc Endosc Percutan Tech. Aug;20(4):253-6. doi: 10.1097/SLE.0b013e3181e21833.
9) Cahill RA, Lindsey I, Jones O, Guy R, Mortensen N, Cunningham C. Single-port laparoscopic total colectomy for medically uncontrolled colitis. (2010) Dis Colon Rectum ; 53: 1143-1147 [PMID: 20628277 DOI: 10.1007/DCCR.0b013e3181dd06f2].
10) Napolitano L, Waku M, De Nicola P, Di Bartolomeo N, Cotellese R, D’Aulerio A, Innocenti P. Laparoscopic colectomy in colon cancer. A single-center clinical experience. (2007) G Chir ; 28: 126-133 [PMID: 17475112].
11) Murty H, Hillewaere S, Appelants B, Houben B. Single incision right hemoctectomy for malignancy: a feasible technique with standard laparoscopic instrumentation. (2012) Colorectal Dis ; 14: e764-e770 [PMID: 22776288 DOI: 10.1111/j.1463-1318.2012.03175.x].
12) Veldkamp R, Kuhry E, Hop WC, Jeekel J, Haglind E et al. Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. (2005) Lancet Oncol ; 6: 477-484.
13) Kaiser AM, Kang JC, Chan LS, Vukasin P, Beart RW Jr. Laparoscopic-assisted vs. open colectomy for colon cancer: a prospective randomized trial. (2004) J Laparoendosc Adv Surg Tech A ; 14: 329-334.
14) Jayne DG, Guillou PJ, Thorpe H, Quirke P, Copeland J, Smith AM et al.; UK MRC CLASICC Trial Group. Randomized trial of laparoscopic-assisted resection of colorectal carcinoma: 3-year results of the UK MRC CLASICC Trial Group. (2007) J Clin Oncol ; 25: 3061-3068.
15) 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. (2010) Br J Surg ; 97: 1638-1645.
16) Buunen M, Veldkamp R, Hop WC, Kuhry E, Haglind E et al.; Colon Cancer Laparoscopic or Open Resection Study Group. Survival after laparoscopic surgery versus open surgery for colon cancer: long-term outcome of a randomised clinical trial. (2009) Lancet Oncol ; 10: 44-52.
17) Kim SJ, Ryu GO, Choi BJ, Kim JG, Lee KJ, Lee SC, Oh ST. The short-term outcomes of conventional and single-port laparoscopic surgery for colorectal cancer. (2011) Ann Surg ; 254: 933-940 [PMID: 22107740 DOI: 10.1097/SLA.0b013e318238726b].
18) Papaconstantinou HT, Thomas JS. Single-incision laparoscopic colectomy for cancer: assessment of oncologic resection and short-term outcomes in a case-matched comparison with standard laparoscopy. (2011) Surgery ; 150: 820-827 [PMID: 22000196 DOI: 10.1016/j.surg.2011.07.060].
19) Huscher CG, Mingoli A, Spargini G, Mereu A, Binda B, Brachini G, Trombetta S. Standard laparoscopic versus single-incision laparoscopic colectomy for cancer: early results of a randomized prospective study. (2012) Am J Surg ; 204: 115-120 [PMID: 22178484 DOI: 10.1016/j.amjsurg.2011.09.005].
20) Fung AK, Aly EH. Systematic review of single-incision laparoscopic colonic surgery. (2012) Br J Surg ; 99: 1353-1364 [PMID: 22961513 DOI: 10.1002/bjs.8834].
21) Fuji S, Watanabe K, Ota M, Watanabe J, Ichikawa Y, Yamagishi S, Tatsumi K, Suwa H, Kunisaki C, Taguri M, Morita S, Endo I. Single-incision laparoscopic surgery using colon-lifting technique for colorectal cancer: a matched case control comparison with standard multiport laparoscopic surgery in terms of short-term results and access instrument cost. (2012) Surg Endosc ; 26: 1403-1411 [PMID: 22101420 DOI: 10.1007/s00464-011-2047-9].
22) Yang TX, Chua TC. Single-incision laparoscopic colectomy versus conventional multiport laparoscopic colectomy: a meta-analysis of comparative studies. (2013) Int J Colorectal Dis ; 28: 89-101 [PMID: 22828958 DOI: 10.1007/s00384-012-1537-0].
23) Shabanzadeh DM, Sorensen LT. Laparoscopic surgery compared with open surgery decreases surgical site infection in obese patients: a systematic review and meta-analysis. (2012) Ann Surg ; 256: 934-945 [PMID: 23108128 DOI: 10.1097/SLA.0b013e318269a46b].