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Original Article

Single-incision Laparoscopic Surgery Versus Conventional Laparoscopy for Colorectal Cancer: A Comparison of Oncologic Outcomes

Ching-Hsien Wang[1,2]
Yueh-Ming Lin[1]
Hong-Hwa Chen[1]
Chia-Lo Chang[1]
Ko-Chao Lee[1]
Kai-Lung Tsai[1]
Chien-Chang Lu[1]
[1]*Division of Colorectal Surgery, Department of Surgery, Kaohsiung Chang-Gung Memorial Hospital and Chang-Gung University College of Medicine,*
[2]*Division of Colorectal Surgery, Department of Surgery, Kaohsiung Armed Forces General Hospital, Kaohsiung, Taiwan*

Key Words
Single incision;
Laparoscopy;
Oncologic outcome;
Colorectal cancer

Purpose. To compare the perioperative and oncologic outcomes between conventional laparoscopy (CL) and single-incision laparoscopic surgery (SILS) for colorectal malignancy.
Methods. The medical records of patients who underwent CL and SILS for the treatment of colorectal malignancy between January 2007 and January 2012 were reviewed. The inclusion criteria were stages 1-3 colorectal adenocarcinoma. The demographics, perioperative data, and oncologic outcomes were retrospectively evaluated.
Results. We recruited 161 patients to participate. Eighty-eight patients underwent SILS and 73 underwent CL initially. The two groups did not differ significantly in terms of age, sex, body mass index (BMI), and the American Society of Anesthesiology (ASA) score. The intraoperative and perioperative outcomes were similar, except with regard to the operation time and conversion. Fourteen patients in the SILS group were converted to additional ports, but no conversion to laparotomy occurred in this group. One patient in the CL group was converted to laparotomy. Regarding the oncologic outcomes, the number of harvested lymph nodes in the SILS group was significantly more than that in the CL group ($p = 0.033$).
Conclusions. SILS for colorectal malignancy provided a nearly equivalent efficacy for the operative and oncologic outcomes in comparison to CL. No significant disadvantages such as complications and conversion to laparotomy were found after performing SILS. Thus, SILS may be considered as an alternative to CL.
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Tarasconi, a Brazilian obstetrician/gynecologist, performed an endoscopic salpingectomy in the 1970s. The work, later published in 1981, has been regarded as the first case of laparoscopic organ resection in medical literature.[1] Regarding the application of the laparoscopic technique for the gastrointestinal tract, Kurt Semm performed the first laparoscopic appendectomy in 1981,[2] and the first laparoscopic colectomy

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Correspondence to: Dr. Chien-Chang Lu, Division of Colorectal Surgery, Department of Surgery, Kaohsiung Change-Gung Memorial Hospital, No. 123, Dapi Road, Niaosong District, Kaohsiung 83301, Taiwan. Tel: 886-7-731-7123; Fax: 886-7-731-8762; E-mail: doctor.lu@msa.hinet.net

was performed by Moises Jacobs in 1990.[3] The laparoscopic approach, showing benefits in postoperative outcomes, has been promoted fervently, and it has become an alternative to open surgery for colorectal malignancy ever since. Laparoscopic colectomy (CL) has distinct advantages, including a faster recovery, reduced use of parenteral narcotics and oral analgesics, and shorter length of incision compared to open surgery.[4,5] The new generation of surgeons has made efforts to minimize invasiveness and provide greater cosmesis. Hence single-incision laparoscopic surgery (SILS), natural orifice transluminal endoscopic surgery (NOTES), and minilaparoscopy-assisted natural orifice surgery have been introduced as new techniques for multidisciplinary diseases.[6] The initial use of SILS in the colorectal surgical field was for the resection of benign diseases.[7-10] Under the validity and potential advantage for colorectal benign diseases, SILS was subsequently used for treating colorectal cancer. An increasing number of studies on the comparison between SILS and CL have been reported. But these studies focused on the short-term surgical outcomes.[11] The goal of this study was to compare the perioperative outcomes and the mid-term oncologic prognostic results between SILS and CL.

Materials and Methods

Patient selection

All consecutive patients who were admitted for laparoscopic resection of the colon and rectal malignancy after January 2007 were retrospectively assessed. The medical records of those patients were collected and reviewed. Only those patients who underwent operations by C. L., a colorectal surgeon of Kaohsiung Change-Gung Memorial Hospital, were included. Some patients were excluded since the study focused on mid-term outcomes and disability in a disease-free assessment of patients with TNM Classification of Malignant Tumors (TNM) stage 4. The exclusion criteria were as follows: (1) distal organ metastasis confirmed perioperatively; (2) pathologically confirmed carcinoma in situ; and (3) a postoperative period of < 3 years. A total of 161 patients between January 2007 and January 2012 were enrolled. Among them, 88 patients underwent SILS, and 73 underwent CL. The following perioperative and subsequent follow-up data were collected: age, sex, body mass index (BMI), the American Society of Anesthesiologist (ASA) score, operation types, operation time, conversion to additional ports or open surgery, postoperative time to the first flatus, postoperative length of hospital stay, complications, specimen length, tumor size, resection margin, the number of harvested lymph nodes, the pathologic TNM stage, the prescription of adjuvant chemotherapy, and recurrence and mortality occurring within 3 years.

Surgical technique

SILS group

The patients were placed in the lithotomy or supine position under general anesthesia. An incision of 2.5-3 cm in length was made at the umbilicus or McBurney's point according to the tumor location or the ileostomy creation. Pneumoperitoneum with 12 mmHg of CO_2 was performed after setting a commercial LagiPort™ Kit (Lagis) or a self-made glove-port system, which was introduced in our previous study.[10] A 30°, 10-mm diameter rigid laparoscope was inserted via the trocar or a port beyond the umbilical wound to explore the abdominal cavity. Medical to lateral approaches using conventional or curved laparoscopic instruments and/or LigaSure™ instruments (Valleylab) were used to perform dissections in all the operations. The tilts of the operation tables, helpful in providing adequate operative fields, were performed according to the target location.

During right-side resections, the ileocolic pedicle was identified with grasper traction, and then mesocolic dissection was performed with a laparoscopic monopolar dissector. The ileocolic vessels (and the right colic vessels, if necessary) were ligated with hemoclips and were cut using a LigaSure™ instrument. During extended right hemicolectomies, the assistants introduced grasping forceps to tent the transverse colon, which facilitated middle colic vessels control. After detaching the right colon from the retroperitoneum, terminal ileum, and great omentum, the abdominal incision wound was slightly extended for extracorporeal side-to-side ileocolic anastomosis using 75-mm linear cutters (Johnson & Johnson).

During left-side resections, the inferior mesenteric pedicle was identified and was isolated after mesocolic dissection. The inferior mesenteric vessels were ligated with hemoclips and were cut using a LigaSure™ instrument. After freeing the left side colon and dissecting the mesorectum, transection of the colorectum was performed with an Echelon Flex 60™ Endopath stapler (Johnson & Johnson). The specimen was removed via the slightly extended abdominal incision wound. Then anastomosis was performed intracorporeally using a PROXIMATE-ILS™ intraluminal curved or straight stapler (Johnson & Johnson).

During total colectomies, the procedures for vessel control and colorectal mobilization were the combination of those procedures of right-side and left-side resections. We used a PROXIMATE-ILS™ intraluminal straight stapler (Johnson & Johnson) to perform ileorectal anastomosis.

CL group

The surgical positions, pressure of the pneumoperitoneum, direction of the approaches, rigid laparoscope, laparoscopic tools for mesocolic dissection, vessel control, and colorectal mobilization were nearly the same as those in the SILS group. Nevertheless, the setting of separate trocars over the isolated regions of the abdominal wall was the major difference. First, a minilaparotomy wound was created at the umbilicus for placement of a 12-mm trocar. Other three to four ports were placed following successful pneumoperitoneum. Transection of the colorectum in this group was performed using an Echelon Flex 60™ Endopath stapler (Johnson & Johnson) via the port over McBurney's point. One of the trocar sites, based on the tumor location, was extended to an adequate length to extract the specimen.

In subtotal colectomies for two patients in this group, the procedures and applied laparoscopic tools were similar to the total colectomies performed in the SILS group, except for the setting of the isolated ports and transection of the colorectum via trocars at McBurney's point.

During a transverse colectomy for one patient in the CL group, the middle colic vessels were controlled with hemoclips and a LigaSure™ instrument after mesocolic dissection. Subsequently, extracorporeal side-to-side colocolic anastomosis using 75-mm linear cutters (Johnson & Johnson) was performed.

Statistical analysis

Data were analyzed using the chi-square test for categorical values and the independent-samples t-test for continuous variables. Statistical results were considered significant at $p < 0.05$. Statistical analysis was performed using SPSS, version 20.0 (IBM Corp.).

Results

Patients' characteristics

Between January 2007 and January 2012, 83 men and 78 women were enrolled. Among them, 88 patients underwent primary SILS, and 73 underwent CL initially. Most of the patients in the CL group underwent operations before January 2010, while most operations in the SILS group were performed during the late phase of our study. The two groups did not differ significantly in terms of general characteristics, including age ($p = 0.209$), sex ($p = 0.841$), BMI ($p = 0.195$), and the ASA score ($p = 0.354$). The data of the enrolled patients are listed in Table 1.

Intraoperative and perioperative outcomes

In the SILS group, 18 right hemicolectomies, 3 left hemicolectomies, 64 anterior resections, and 3 total colectomies were performed. In the CL group, 11 right hemicolectomies, 1 transverse colectomy, 1 left hemicolectomy, 58 anterior resections, and 2 subtotal colectomies were performed. There was no difference observed in the distribution of the operation types between the two groups ($p = 0.590$). The mean operation time of the SILS group was shorter compared to the CL group (167 ± 35 min vs. 183 ± 43 min, $p = 0.006$).

Fourteen patients, who were planned to undergo SILS initially, encountered conversion to additional ports, but laparotomy was not required in any of the patients of the SILS group. A patient in the CL group was converted to open surgery due to uncontrolled bleeding. We defined the addition of ports and switch to laparotomy as positive conversion in the SILS group. This was why conversion in the two groups was statistically significant (p = 0.002). Postoperative recovery was similar in both groups (the first passage of flatus: 2.4 ± 0.6 days vs. 2.5 ± 0.6 days, p = 0.251; postoperative hospital stay: 8.6 ± 11.1 days vs. 8.0 ± 4.3 days, p = 0.631). Nine patients developed complications during the study (4 vs. 5, p = 0.526). In the SILS group, two patients had leakage of anastomosis and underwent conservative treatment. Respiratory failure occurred in an 83-year-old male, and he died 107 days postoperatively. In the CL group, 3 patients had leakage of anastomosis. All 3 patients recovered after conservative treatment, but one had local recurrence 4 months postoperatively. The intraoperative and perioperative outcomes are listed in Table 2.

Pathologic and oncologic outcomes

Oncologic resection assessment was performed using the length of the specimens, tumor size, resection margin, and number of harvested lymph nodes. The two groups did not differ significantly in terms of the first three parameters (p = 0.224, 0.278, and 0.057, respectively). The harvested lymph nodes in the SILS group were significantly more than that in the CL group (10.7 ± 7.9 vs. 8.1 ± 7.1, p = 0.033). Distribution of the pathologic stages showed no statistical significance (p = 0.282), and the rates of the prescription of adjuvant chemotherapy in the two groups were similar (39.8% vs. 35.6%, p = 0.588). At the 3-year follow-up, the two groups did not differ significantly with regard to the recurrence rates (11.4% vs. 19.2%, p = 0.166) (Fig. 1). One local recurrence and 9 distal recurrences occurred in the SILS group. The overall survival rates showed statistical equivalence (94.3% vs. 91.8%, p = 0.525) (Fig. 2). One patient in the SILS group died due to trauma, while 2 in the CL group died due to the progression of acute myeloid leukemia and influenza-related complications, individually. The pathologic results and oncologic outcomes are listed in Table 3.

Table 1. Patient demographics

	SILS (n = 88)	CL (n = 73)	p value
Age (years)			0.209
Mean	64 ± 11	66 ± 12	
Range	40-85	34-91	
Gender			0.841
Male	46	37	
Female	42	36	
BMI (kg/m^2)			0.195
Mean	24.07 ± 3.22	24.82 ± 4.12	
Range	17.19-31.58	16-35.92	
ASA score			0.354
2	79	62	
3	9	11	

SILS: single-incision laparoscopic surgery; CL: conventional laparoscopy; BMI: body mass index; ASA: American Statistical Association.

Table 2. Intra and perioperative outcomes

	SILS (n = 88)	CL (n = 73)	p value
Operation type			0.590
RH	18	11	
Transverse colectomy	0	1	
LH	3	1	
AR	64	58	
Subtotal or total colectomy	3	2	
Operation time (min)			0.006
Mean	167 ± 35	183 ± 43	
Range	100-270	100-360	
Conversion			0.002
To additional ports	14	0	
To laparotomy	0	1	
Passage of flatus (days)			0.251
Mean	2.4 ± 0.6	2.5 ± 0.6	
Range	1-4	2-4	
Postoperative hospital stay (days)			0.631
Mean	8.6 ± 11.1	8.0 ± 4.3	
Range	4-107	3-26	
Complication			0.526
Wound problem	1	2	
Anastomosis leakage	2	3	
Respiratory failure	1	0	

SILS: single-incision laparoscopic surgery; CL: conventional laparoscopy; RH: right hemicolectomy; LH: left hemicolectomy; AR: anterior resection.

The operation time in the first 10 cases in SILS right hemicolectomies and anterior resections

The mean operation time of the first 10 cases in SILS right hemicolectomies was longer compared to the cases 11-18 (173 ± 26 min vs. 142 ± 11 min, p = 0.005). In SILS anterior resections, the first 10 cases also got longer mean operation time, compared to the cases 11-20 (197 ± 28 min vs. 162 ± 27 min, p = 0.011). The results are listed in Table 4.

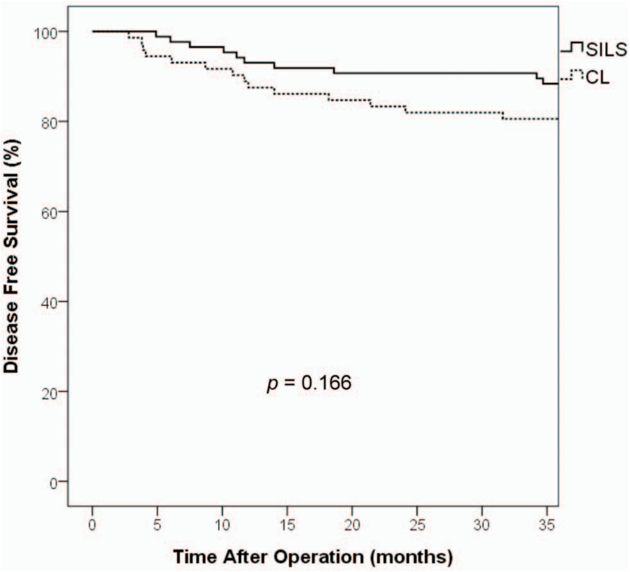

Fig. 1. Disease free survival of 3-year follow-up.

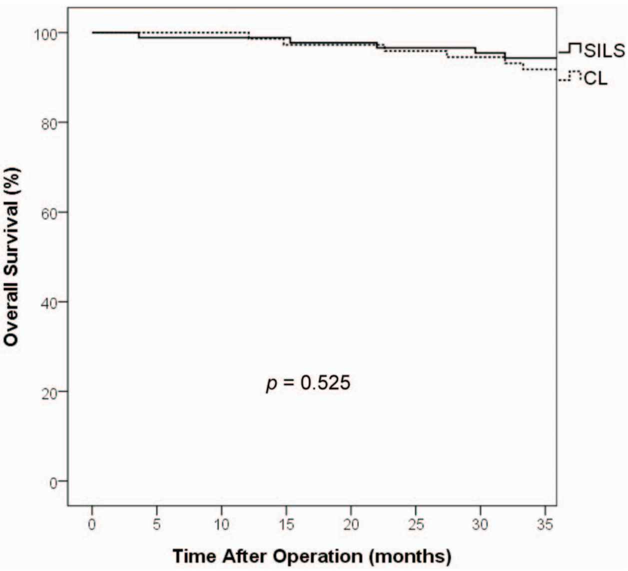

Fig. 2. Overall survival of 3-year follow-up.

Discussion

The safety and feasibility of new surgical techniques in the general surgical field are worthy of dis-

Table 3. Oncologic resection and outcomes

	SILS (n = 88)	CL (n = 73)	p avlue
Specimen length (cm)			0.224
Mean	26.9 ± 15.2	24.4 ± 8.4	
Range	13.0-109.7	10.8-58.0	
Tumor size (cm)			0.278
Mean	3.7 ± 2.0	4.0 ± 1.9	
Range	0.6-12.0	0.6-8.7	
Resection margin (cm)			0.057
Mean	8.7 ± 12.6	5.7 ± 4.2	
Range	1.0-92.0	0.3-24.0	
No. of LN harvested			0.033
Mean	10.7 ± 7.9	8.1 ± 7.1	
Range	0-40	0-32	
Pathologic stage			0.282
I	33	20	
II	31	34	
III	24	19	
Adjuvant chemotherapy			0.588
Yes	35	26	
No	53	47	
3-year disease-free survival			0.166
Free	78	59	
Recurrence	10	14	
3-year overall survival			0.525
Survival	83	67	
Death	5	6	

SILS: single-incision laparoscopic surgery; CL: conventional laparoscopy; LN: lymph nodes.

Table 4. Operation time

	Operation time, mean ± SE (min)	p value
RH		0.005
First 10 cases	173 ± 26	
Cases 11-18	142 ± 11	
AR		0.011
First 10 cases	197 ± 28	
Cases 11-20	162 ± 27	

SE: standard error; RH: right hemicolectomy; AR: anterior resection.

cussion first. Unlike those, the confirmation of the safety and feasibility seems to be not enough in the oncological surgical field. Oncological surgeons need to further investigate the oncologic prognoses as applying new methods for malignancies. In our study, we retrospectively collected the data on recurrence and mortality. We compared the mid-term disease-free survival and overall survival between SILS and CL, which has not been previously discussed in the literature. After analyzing the data of the enrolled patients in our study, there were no statistical differences in the two parameters at the 3-year follow-up. Similar to previous studies, we analyzed the perioperative and pathologic outcomes. There were statistically significant differences in only three parameters: the conversion rates, operation time, and number of harvested lymph nodes. The statistical difference in the conversion rates resulted from a wide definition of conversion. Our mean operation time in the SILS group was shorter than that in the CL group. We simplified the operative procedures of SILS, such as extraction of the specimen via a cutting finger of a self-made glove-port instead of extraction after removal of the whole set of a self-made glove port. Moreover, most patients in the SILS group underwent operations during the late phase of our study. We believe that the accumulation of laparoscopic skills and the reduction of unnecessary procedures were conducive to shortening the operation time. Regarding the increased number of harvested lymph nodes in the SILS group, we present a reason. The original pathologist who was in charge of interpreting colorectal malignancies quit his position in 2011. We assume that the change in pathologists may have caused the statistical difference.

The birth of laparoscopic colectomy marked a milestone in the development of colorectal surgery. It provides a lot of demonstrated benefits under its feasibility and safety during the past two decades. However, setting the transperitoneal ports, which is deemed as minimally invasive, may cause complications such as bleeding, pain, internal organ damage, or hernia.[11,12] The evolution of SILS for colorectal diseases enables ultra-minimal invasiveness during colorectal surgery. In previous literature on the comparison between SILS and CL for colorectal diseases, SILS caused less wound pain, hernia risk, trocar complications, and better cosmesis.[13,14] Less manpower consumption in the preparation process and no need for additional proprietary purchases are what make SILS superior to NOTES, another ultra-minimally invasive endoscopic technique.[14] In their meta-analysis, Zhou et al. found that SILS was associated with less blood loss, less transfusions, a shorter time to flatus, a shorter hospital stay, and smaller incision lengths compared to CL.[15] The use of a multiple access port in SILS did not increase the total operative cost significantly in the study by Lim et al.[13] However, the use of a self-made glove-port system may lower the total cost when performing SILS.

A longer operation time when performing SILS compared to CL has been reported previously.[13,16] Conversely, our mean operation time in the SILS group was shorter. We believe that surgeons can shorten the operation time of SILS after gaining sufficient experience in performing laparoscopic surgeries. Lim et al. stated a similar opinion after comparing the first 10 cases of SILS to the last 10 cases of SILS.[13] The handicaps as performing SILS included the loss of triangulation, hand collisions, instrument crowding, and non-ergonomic operative postures of surgeons.[11,13,16] Regarding the loss of triangulation, the effect of gravity created as tilting operation tables was helpful in conquering the difficulties with traction and countertraction. The use of a transparietal sling suture may also be beneficial.[13] In our experience, the hand collisions and instrument crowding were reduced after passing the learning curve of the SILS. We think the surgeons who are skilled at conventional laparoscopic colectomies can overcome the learning curve after completion of 10 SILS cases. The operation time decreased after 10 case in the previous two studies about the learning curve for right colectomy.[17,18] It accords with the statistical results in our study. The capacity of using SILS for middle and lower rectal cancers seems to be limited. The requirement of additional ports in those cases was more significantly frequent. The creation of the initial SILS incision wound over the scheduled site of a diverting ileostomy was considered as a solution in those with middle rectal cancers.[13] For lower rectal cancers, the combination of SILS and a transanal approach was suggested.[13,19] Another issue that we should consider is the impact on the education for future surgeons. Because of the character of the one-operating-surgeon technique, the spread of SILS may decrease the opportunity of performance.[13,16]

Few studies have compared the surgical outcomes between SILS and CL for colorectal malignancy. Most of those studies have emphasized the short-term surgical outcomes. The study by Chen et al. was the first to compare the two approaches for colon cancers.[11] Yun et al. demonstrated equivalent disease-free survival at 24 months follow-up between SILS and CL for right colon malignancy.[20] A recent study in 2014 analyzed the pathologic outcomes between the two groups in detail, but no recurrence or survival was discussed.[13] In our study, the oncologic prognoses between the two groups were compared.

Potential limitations of our study include the retrospective nature and no further case categorization for middle and lower rectal cancers in order to compare the additional port demands. Lastly, we did not specifically compare resections for rectal malignancies in both groups.

Conclusions

Our study demonstrated a statistically equivalent efficacy for the operative and oncologic outcomes in a comparison between SILS and CL for colorectal malignancy. We believe that SILS is a safe and feasible alternative to CL in the field of colorectal malignancy. Further long-term prospective, randomized, controlled trials are needed.

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原　著

於大腸直腸癌治療使用單孔腹腔鏡手術對上傳統腹腔鏡：惡性腫瘤預後之比較

王景賢[1,2]　林岳民[1]　陳鴻華[1]　張家駱[1]　李克釗[1]　蔡鎧隆[1]　盧建璋[1]

[1]高雄長庚紀念醫院　外科部　大腸直腸肛門外科

[2]國軍高雄總醫院　外科部　大腸直腸外科

目的　在治療大腸直腸惡性腫瘤上，比較單孔腹腔鏡手術及傳統腹腔鏡手術這兩種方法的手術及惡性腫瘤預後。

方法　我們審視介於西元 2007 年 1 月到西元 2012 年 1 月之間所有接受傳統腹腔鏡及單孔腹腔鏡手術的大腸直腸惡性腫瘤病人的病歷。此研究納入的條件包含第一期到第三期的大腸直腸腺癌。我們回溯地評估分析病患的統計特徵、手術及腫瘤預後。

結果　我們納入 161 個病患，包括 88 個接受單孔腹腔鏡手術，73 個接受傳統腹腔鏡手術。此兩組在年紀、性別、身高體重指數、麻醉危險分級並無統計學上差異。在手術的結果，除手術時間及改變手術術式以外，其他的結果都是相似的。接受單孔腹腔鏡手術的病患，有 14 個接受病患於術中增加了額外的套管，但沒有任何 1 個轉變術式為剖腹探查。接受傳統腹腔鏡手術的病患，有 1 個病患轉變術式為剖腹探查。在腫瘤預後方面，接受單孔腹腔鏡手術病患所被拿取的平均淋巴數目是較多的 (p = 0.033)。

結論　和傳統腹腔鏡手術比較起來，使用單孔腹腔鏡手術治療大腸直腸惡性腫瘤在手術及惡性腫瘤相關的成效方面提供相同的效果。執行單孔腹腔鏡手術並沒有顯著地增加併發症或改變為剖腹探查等缺點，可考慮當成傳統腹腔鏡手術的另一種方案。

關鍵詞　單一切口、腹腔鏡、惡性腫瘤相關成效、大腸直腸癌。