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Hye Jung Cho and Woo Ram Kim *

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Article

Early Single Center Experience of DaVinci® Single-Port (SP) Robotic Surgery in Colorectal Patients

Hye Jung Cho and Woo Ram Kim *

Division of Colorectal Surgery, Department of Surgery, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Republic of Korea; 211 Eonju-ro, Gangnam-gu, Seoul 06273, Republic of Korea
* Correspondence: wrkim81@yuhs.ac; Tel.: +82-2-2019-3378

Abstract: Background: DaVinci® Single-Port (SP) robotic surgery offers several benefits compared to traditional multiport laparoscopic or robotic surgeries. One of the main advantages is that it allows for a minimally invasive approach, resulting in a single, smaller incision and reduced trauma to the patient's body leading to less postoperative pain, faster recovery, and reduced risk of complications. The cosmesis of a single port with minimal visible scarring is also an attractive aspect to the patients; however, many surgeons use an additional port for energy device, stapler use, and drain insertion. Pure single port surgery with one incision is still rare. Here we share our experience of first 10 cases using SP robotic platform in colorectal surgery. **Methods**: From May 2023 to December 2023, colorectal patients who underwent SP-robotic surgery were analyzed. Placement of the incision was umbilicus for 8 patients, and right lower quadrant for 2 patients through which ileostomy maturation was performed. Data including perioperative parameters and postoperative outcomes were analyzed with a median follow-up of 4.6months (range 0.6-7.4months). **Results:** A total number of 10 colorectal patients underwent DaVinci® Single-Port robotic colorectal surgery at our institution during this period. Demographics of the patients showed 4 males (40%) and 6 females (60%) with a median age of 63.5years (range 50-75years). Median body mass index (BMI) was 22.89kg/m^2 (range 19.92-26.84kg/m^2), and 9 patients were diagnosed with colorectal cancer and 1 patient was diagnosed with rectal gastrointestinal tumor. One patient underwent anterior resection and cholecystectomy simultaneously. Mean operation time was 222min (range 142-316min), and mean wound size was 3.25cm (range 2.5-4.5cm). Nine patients underwent surgery with single incision through which single port trocar was inserted, and one patient had one additional port for drain insertion. Mean hospital stay was 6 days (range 4-8 days) with 1 postoperative complication of bleeding requiring transfusion, but there was no re-admission within 30 days. **Conclusions**: Overall, our experience with single-port robotic colorectal surgery has been promising. With only one patient with additional port for drain insertion, all nine patients underwent SP-robotic surgery with single incision for colon as well as rectal surgeries. Compared to an average postoperative length of stay of 6.5-8 days in laparoscopic colorectal surgeries reported in literature, SP-robotic surgery showed faster recovery of 6 days highlighting its benefits in patient recovery and satisfaction.

Keywords colorectal neoplasm; robotic surgery; single-port

Introduction

Minimally invasive surgery (MIS) has been at the center of surgical field since the 1980s. Over the past four decades, surgical innovations have taken an enormous stride into the robotic platform. Among these advancements, DaVinci® Single-Port Robotic Surgery (SPRS, Intuitive Surgical, Sunnyvale, CA) is at its utmost cutting edge system designed to enhance the performance of complex surgeries with minimal invasiveness. In addition to the benefits of ergonomics provided by the robotic system, SPRS provides additional benefits of cosmesis, reduced postoperative pain requiring analgesics, and reduced costs. [1–3] With its clinical debut in 2018, the SPRS platform has been mainly used in urology, gynecology, and general surgery, such as cholecystectomy and adrenalectomy.[4] However, its application in colorectal surgery was stagnant.

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With its first report in 2020 by Marks *et al*, SPRS for colectomy has gained momentum in many colorectal surgeons.[5] Comparative studies between SPRS and single-incision laparoscopic surgery (SILS) have reported similar operation time, complication rates, and pathological outcomes confirming its safe and feasible use.[6,7] The hesitant application of SPRS in colorectal surgery pertain to rectal surgery due to the absence of stapling device and angulation. As the SPRS is currently approved for clinical use in United States, South Korea, and Japan, the authors appreciate the importance of sharing our experience and shedding light on ways to overcome some of the difficulties surrounding the SPRS.

Materials and Methods

Patient Selection

Data from patients, who underwent colorectal surgery using the DaVinci Single-Port (SP) robotic platform between May 2023 and December 2023 at the Gangnam Severance Hospital, Yonsei University College of Medicine (Seoul, Korea), were reviewed. A total number of 10 patients were analyzed.

Surgical Procedures

For right-sided colectomy, patient lied in a supine position. Transumbilical incision was made through which a 4-chamber SP glove port (MEDITECH INFRAMED, Seoul, Korea) was inserted. For left-sided colectomy, patient lied in a lithotomy position. Likewise, transumbilical incision was made for the glove port; however, for two ultra-low anterior resections, circular incision was made at right lower quadrant at the position of ileostomy maturation. Incisions can be visualized in Figures 1 and 2. The SP robotic arms were positioned and docked from the ipsilateral side of the lesion.

Figure 1. Port placement for ultra-low anterior resection

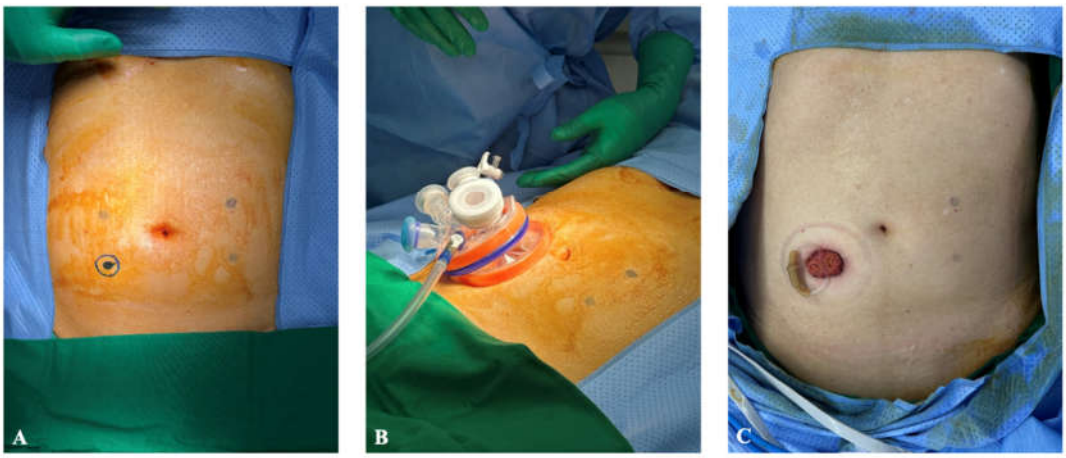

Figure 1. Port placement for ultra-low anterior resection. (A) Circular incision at right lower quadrant. (B) 4-chamber glove port inserted. (C) Loop ileostomy maturation at right lower quadrant incision site.

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Figure 2. Port placement for colectomy using transumbilical incision

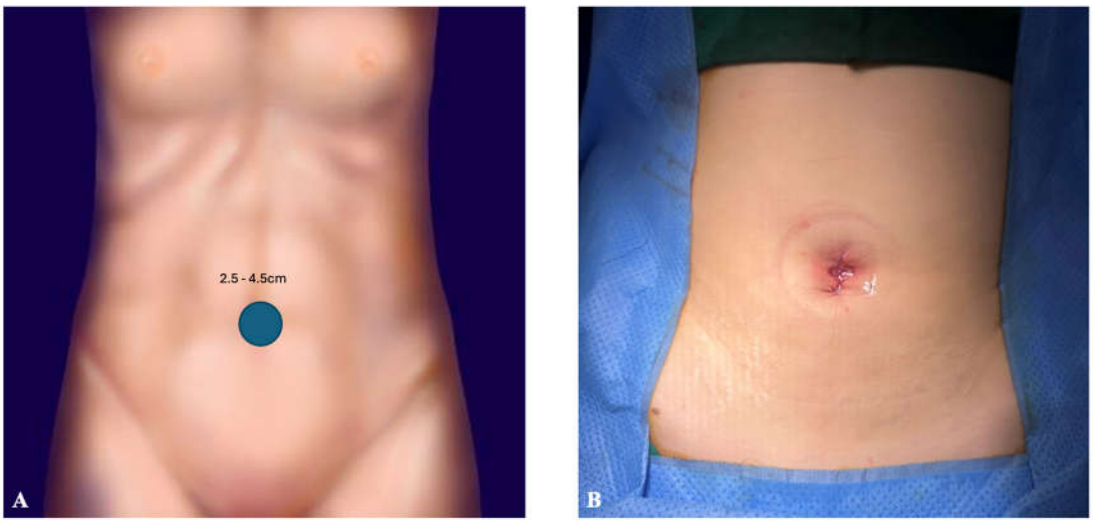

Figure 2. Port placement for colectomy using transumbilical incision. (A) Transumbilical incision (range 2.5-4.5cm) for glove port insertion. (B) Immediate postoperative transumbilical wound.

There was one case of additional port inserted at right lower quadrant for low anterior resection. Laparoscopic stapler (Signia™, Medtronic, Minneapolis. USA) was inserted for distal margin resection and drain insertion. The other 9 cases were performed with a single incision.

For fascia closure, barbed suture (Stratafix™, Ethicon Inc., USA) was used with an absorbable, synthetic, barbed suture (3-0 vicryl*, Ethicon Inc., USA) and skin adhesive (Liquiband®, Advanced Medical Solutions Ltd., USA).

Measurement of Clinical Variables

Demographics of the patients including age, sex, American Society of Anesthesiologists (ASA) classification, and body mass index (BMI) were collected. Clinical data included the diagnosis of the patient for which surgery was performed, operation date, and discharge date were reviewed. Length of hospital stay (days) was defined as day of surgery to discharge date. Intraoperative results, such as operation time (min), wound size (cm), blood loss (mL), transfusion status, ileostomy status, wound location, as well as drain insertion status were analyzed. Patients graded the pain level using a numeric pain rating scale (NPRS, 1-10) daily and NPRS on postoperative day 1 and 3 were reviewed. The length of intravenous (IV) pain medication was also collected. After discharge, pathologic data was reviewed at outpatient clinic including tumor size, TNM stage, lymphovascular (LVI) and perineural invasion (PNI) status, and adjuvant chemotherapy status. Postoperative complication graded according to Clavien-Dindo classification was assessed. Median follow-up was 6.6months (range 2.6-9.4months).

Statistical Analysis

All analyses were performed using R version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria, https://www.r-project.org/). Data including perioperative parameters and postoperative outcomes were analyzed. Continuous variables were analyzed using t-test and are presented as means, medians, and standard deviations with a range. Categorical variables were analyzed using chi-square test or Fisher's exact test presented as frequencies.

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Results

Data from 10 patients (4 male [40%], 6 female [60%]; mean [± SD] age, 62.9 ± 9.6 years) were analyzed. Mean BMI was 22.87 ± 2.5, and ASA status varied (ASA 1, 1 (10%); ASA 2, 4 (40%); ASA 3, 5 (50%)). The diagnosis of the patients was divided into 9 (90%) colorectal cancer and 1 (10%) rectal gastrointestinal tumor. Surgical procedure was carried out according to the location of the lesion, arranging from two right hemicolectomies, five anterior resections, one low anterior resection, and two ultra-low anterior resections. One patient had double primary cancers at descending and sigmoid colon for which anterior resection was performed, and one patient underwent cholecystectomy in addition to anterior resection for primary sigmoid colon cancer. The baseline demographics of the patients are shown in Table 1.

Table 1. Baseline characteristics of included patients.

Patient No.	Age (years)	Sex	BMI (kg/m²)	Diagnosis
1	67	M	23.65	Rectosigmoid junction cancer
2	60	F	21.10	Sigmoid colon cancer
3	69	F	22.38	Ascending colon cancer
4	50	F	20.23	Rectal cancer
5	71	F	26.84	Rectal cancer
6	56	M	23.92	Descending + sigmoid colon cancer
7	52	F	20.63	Splenic flexure cancer
8	75	M	19.92	Ascending colon cancer
9	75	M	26.60	Rectal GIST
10	43	F	23.40	Sigmoid colon cancer + cholecystitis

GIST, Gastrointestinal stromal tumor; BMI, Body mass index.

Mean operation time was 222.4 ± 66.1min (range 142-316min) with a mean blood loss of 148 ± 126.2ml (range 50-400ml). Two patients for whom ultra-low anterior resection were performed, single port incision was made at the right lower quadrant. Ileostomy was maturated for both patients at the end of the surgery through the single port site. (Figure 1C) Transumbilical incision was made for the rest of the 8 patients, and the mean wound size was measured at 3.25 ± 0.6cm (range 2.5-4.5cm). (Figure 2) No intraoperative blood transfusion was given. The average tumor size was 3.15 ± 1.9cm (range 1.2-6.9). Four patients underwent adjuvant chemotherapy, and the pathologic stage of the patients are shown in Table 2.

Table 2. Perioperative and histologic outcome.

Patient No.	Operation time (min)	Blood loss (ml)	Wound incision	Wound size (cm)	Tumor size (cm)	Pathologic stage	Adjuvant chemotherapy status
1	220	50	Umbilical	4.5	5.5	IIIB	Yes
2	151	50	Umbilical	4	1.2	I	No
3	262	100	Umbilical	3.5	6.9	IIA	Yes
4	312	350	Right lower quadrant	3	3.7	I	No
5	275	100	Umbilical	3.5	1.4	IIIA	Yes
6	142	100	Umbilical	2.5	2.4	I	No
7	190	50	Umbilical	2.5	1.8	I	No
8	207	100	Umbilical	3	3.1	IIA	Yes
9	316	400	Right lower quadrant	3	4.1	-	No
10	149	180	Umbilical	3	1.4	0	No

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Median NPRS on postoperative day 1 and 3 were 3 (range 2-3) on both days. No patients required IV pain medication after 2 days. Mean hospital stay was 6 ± 1.2days (range 4-8days), and no readmission within 30 days was noted. One patient had grade II complication for which blood transfusion was required for low hemoglobin level (6.9g/dL). The patient was discharged on postoperative day 5 without any sequelae. The results abovementioned are shown in Table 3.

Table 3. Postoperative outcome.

Patient No.	Pain score, POD#1 (NPRS)	Pain score, POD#3 (NPRS)	IV pain medication (days)	Hospital stay (days)	Postoperative complication (Clavien-Dindo classification)
1	2	3	0	6	
2	3	3	0	7	
3	3	2	0	5	
4	3	3	1	5	II, postoperative anemia
5	7	3	1	8	
6	5	3	2	4	
7	3	2	2	6	
8	3	2	2	5	
9	3	2	0	7	
10	2	3	2	7	

NPRS, numeric pain rating scale; IV, intravenous.

Discussion

Our exploration into the application of the SPRS system for colorectal procedures has illuminated several critical insights. The system's integration into colorectal surgery represents a significant advancement in MIS, echoing the broader shift towards robotics in the surgical field. The utilization of SPRS in colorectal surgery, while initially hesitant, has seen a burgeoning interest following reports of its successful application in colectomy.

The ergonomics of the robotic platform is an undisputable advantage compared to the laparoscopic platform.[8] Through this benefit, Eisenberg *et al* reported a significantly shorter suturing time in the robot system than the standard laparo-endoscopic single-site surgery (P<0.0001).[9] The risk of bypassing drain insertion, especially for low anterior resection may hold some risk. However, intracorporeal reinforce suture of the anastomosis using the robotic system can reduce the possible occurrence of anastomosis leakage. A recent systematic review and meta-analysis by Wang *et al* demonstrated a lower incidence of anastomosis leakage (RR 0.41, 95% CI 0.25-0.66) in patients with reinforcing sutures with a leakage rate of 4.4% compared to the 11.9% for whom no reinforce suture was performed.[10]

Our data align with the existing literature that compares SPRS with single-incision laparoscopic surgery (SILS), showing comparable operation times [6,7]. Our mean operation time of 222.4min is longer than that reported by Change *et al* (185min) but shorter than the comparative analysis performed by Keller *et al* (296min). We reported one case of grade II Clavien-Dindo complication of postoperative anemia (Hg 6.9g/dL) requiring transfusion. However, the initial hemoglobin level of the patient was low (8.5g/dL) with hematocrit of 28.1% (normal range 37-47%). The patient was discharged without any sequelae on postoperative day 5. There were no readmissions within 30 days.

The mean wound size of 3.25cm was comparable to all other studies regarding SPRS colectomy. Lim et al reported a transumbilical incision length of 4-6 cm, and Bae *et al* reported 5.0cm.[11,12] Initial experience by Marks *et al* reported an incision length of 4.0 and 4.5cm in SPRS.[5] Our transumbilical wound incision length of 3.25cm is one of the shortest incision length yet to report, emphasizing the cosmetic benefit of SPRS.

The comparative analysis of length of hospital stays, postoperative pain levels, and the limited need for IV pain medication post-surgery attests to the SP system's advantage in enhancing patient

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recovery experiences. Mean length of hospital stay was 6 days comparable to the 2-9 days reported by a recent systemic review of SPRS for colonic disease.[13] Forty percent (4/10) patients did not require any IV analgesic after the day of operation. Two patients required IV pain control up to postoperative day 1, and the rest (40%) up to postoperative day 2. These findings coincide with the overarching goals of MIS to reduce hospitalization duration and expedite patient recovery, pivotal in the current healthcare landscape focused on patient-centered outcomes and cost-efficiency. The median follow-up of 6.6 months, although limited, provides an initial glance at the postoperative trajectory, with outcomes suggesting a positive recovery profile.

The SP system has some drawbacks. Due to the absence of SP-synced stapler, additional trocar is often inserted for such use. The resection of the distal margin in upper to middle rectal cancer using the laparoscopic stapling device using the same single port trocar site may be difficult due to the angle of the device and the narrow space of the pelvic cavity. Many of the studies reporting single-incision robotic colectomies often use an additional port for such reason.[11,14,15] In our study, two patients had drain insertions. First patient was our first colectomy using the SP robotic platform, and the drain was inserted through the umbilical incision site. The second patient was diagnosed with rectal cancer for whom low anterior resection was performed. An additional port was inserted at right lower quadrant through which the assistant used laparoscopic stapler for distal margin resection, and drain was inserted through the additional port at the end of the surgery. Although the recent rise in the use of Enhanced Recovery After Surgery (ERAS) protocol strongly recommends no drainage of the peritoneal cavity and pelvis after colorectal surgery, the role of early detection of anastomosis leakage hinders many surgeons from relinquishing the procedure.[16] In order to compensate for such burden, for patients with upper to middle rectal cancer for whom low anterior resection is required, a drain may be inserted through the additional port. Based on our experience, we suggest that optimal indications for a true SPRS may include early-stage colorectal cancers located from the cecum to the rectosigmoid junction. This range facilitates the use of a stapler for resection through the single-port site. Furthermore, for cases of low rectal cancer where a diverting ileostomy is necessary, an incision in the right lower quadrant may represent an additional appropriate indication for SPRS.

The most remarkable benefit of SPRS is the ability to perform multi-quadrant operation with a single incision. To our knowledge, other than a case report shared by Juo *et al*, no other attempts have been reported on performing subtotal or total colectomy using a single incision.[17] Patients with inflammatory bowel disease (IBD), such as ulcerative colitis requiring total proctocolectomy may benefit from a single incision, and the advancement of IBD surgery is open for advancement with the SPRS once doors open with FDA approval in the US as well as adoption of SPRS in Europe this year.[18]

Despite these promising results, our study had several limitations, the first of which was the inherent constraints of its retrospective design. The relatively small sample size may also constrain the generalizability of the findings. Up to date, all reported findings regarding colectomy using SPRS are from case studies. Future research should aim to expand on these preliminary insights through multicenter trials and larger patient cohorts, exploring long-term outcomes and further delineating the criteria for patient selection to optimize benefits.

Conclusions

Overall, our experience with single-port robotic colorectal surgery has been promising. With only one patient with additional port for drain insertion, all nine patients underwent SP-robotic surgery with single incision for colon as well as rectal surgeries. Compared to an average postoperative length of stay of 6.5-8 days in laparoscopic colorectal surgeries reported in literature, SP-robotic surgery showed faster recovery of 6 days highlighting its benefits in patient recovery and satisfaction.

Ethical Standards: This study was approved by the Institutional Review Board and Ethics Committees of Yonsei Severance Hospital (IRB No. 3-2023-0449) and was conducted according to the

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principles of the Declaration of Helsinki. A written informed consent was not required for this retrospective study.

Conflict of Interest: The authors declare no actual or potential conflicts of interest.

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Statement of Authors' Contributions to Manuscript: Hye Jung Cho (HJC) and Woo Ram Kim (WRK) have contributed to the design, data collection, methodology, analysis, as well as writing and reviewing of the manuscript. All authors (HJC and WRK) have read and approved the manuscript.

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