



# Initial clinical experience with Single-Port robotic (SP r) left colectomy using the SP surgical system: description of the technique

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## Abstract

**Background** The daVinci Single-Port (SP) robot is a new robotic platform designed to overcome the challenges of Single-Incision Laparoscopic Surgery. The objective of this study is to demonstrate the feasibility and technical aspects of SP robotic (SP r) left colectomy using the SP platform.

**Methods** Under Institutional Review Board approval and registration on ClinicalTrials.gov, we performed SP rLeft colectomy using the daVinci SP surgical system on four patients. The primary end-point of this study was to report and describe the technical feasibility to perform SP rLeft colectomy. The secondary end-points included perioperative metrics and outcomes.

**Results** Four patients underwent successful SP rLeft colectomy for diverticulitis through a single incision (average size: 4.4 cm) without intraoperative complications or conversions. The robot was docked 2.7 times on average (range 2–4). The average docking time was 8.4 min (range: 3–33 min). The mean estimated blood loss was 91 mL (range: 20–250 mL). There were no morbidities or mortalities. Patients were discharged on POD 2 and 3.

**Conclusion** We demonstrated in this initial clinical series the SP rLeft colectomy to be feasible and safe to perform in select patients. The SP robot's single-arm design and flexible instruments have shown to provide excellent visualization and retraction with minimal collisions. We predict that the SP robot will be widely utilized in the field of colorectal surgery as it becomes available to colorectal surgeons. Further experience and larger studies are needed to define the advantages and identify the problems with the SP rLeft colectomy.

**Keywords** Single-port robot · Single-port colectomy · Robotic surgery · Robotic single-incision laparoscopic surgery (rSILS) · Left colectomy

Laparoscopic surgery is now recognized as a standard of care in colorectal surgery. Its multiple benefits have been well established [1–3]. However, its slow adoption rate has pushed the development of a robotic platform to overcome technical challenges of laparoscopy in an attempt to make minimally invasive surgery (MIS) more readily accessible. There has been a steady and continuous increase in the utilization of the robotic platform in recent years across all hospital settings in the USA [4].

As MIS techniques evolved, single-incision laparoscopic surgery (SILS) was introduced in the mid-2000s in an effort to minimize parietal trauma. The first SILS colectomy was performed in 2008 [5], although technical challenges of this technique precluded large-scale adoption. Attempts to reproduce the laparoscopic single-incision surgery using the daVinci Si and Xi robots showed that it was feasible and safe [6]. However, this approach was limited to a few case series due to the technical and logistical challenges surrounding the design of the platform.

To overcome these obstacles, Intuitive Surgical developed a new robotic system dedicated to Single-Incision Surgery in 2018. The Single-Port (SP) daVinci robot was developed with instruments that have wristed articulation and flexible elbows, console-controlled flexible camera and instrument movement, and 3-dimensional optics with a holographic display showing instrument position. This represents a

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The video was accepted and presented at the 2019 SAGES meeting.

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significant advance in the fields of single-port transanal and transabdominal surgery.

In 2018, the SP robot received initial FDA approval for use in urologic surgery and is currently in the process for FDA approval for use in colorectal and general surgery.

We present herein a dynamic manuscript with a video demonstrating the technique of SP robotic (SP r) Left colectomy.

## Methods

### Study protocol

Following Institutional Review Board (IRB) approval and registration on ClinicalTrials.gov, patients were enrolled to undergo single-incision robotic assisted colectomy using the da Vinci SP Surgical System (Intuitive Surgical, Sunnyvale, CA). All procedures were performed by one attending surgeon (J.M.) who was involved in the development of the SP robot and had published his cadaveric experience using it [7].

All patients who were candidates for colectomy were considered for inclusion in the study. Exclusion criteria were emergency surgery, pregnant women and an inability to offer informed consent. The patient demographics collected included patient age, gender, and BMI. Perioperative data analyzed include preoperative and postoperative diagnosis, operative time, need for additional ports and instrumentation, length of stay, and morbidity.

We are presenting the first four patients who were enrolled in the study for a left colectomy for diverticulitis.

The surgery is performed through a 4 cm abdominal wall incision through which a GelPoint access platform (Applied Medical, Rancho Santa Margarita, CA, USA) is placed. The dedicated SP r 25-mm multichannel port is inserted, accommodating a 12 × 10 mm oval articulating three-dimensional robotic camera and three 6-mm double-jointed articulating robotic instruments. One instrument is used for retraction and exposure and two for the dissection. Additional ports are placed in the GelPoint for the bedside assistant (Fig. 1). Since this procedure requires access to multiple quadrants, we typically place two assistant ports in the GelPoint cap, on opposite sides of the SP trocar. Depending on the quadrant we are working on, the assistant ports are used accordingly.

The primary objective was to report and demonstrate the technical feasibility to perform a SP r Left colectomy using the SP robot.

### Operative instrumentation

The da Vinci SP robot is a new robotic platform designed to facilitate single-incision surgery. The system includes



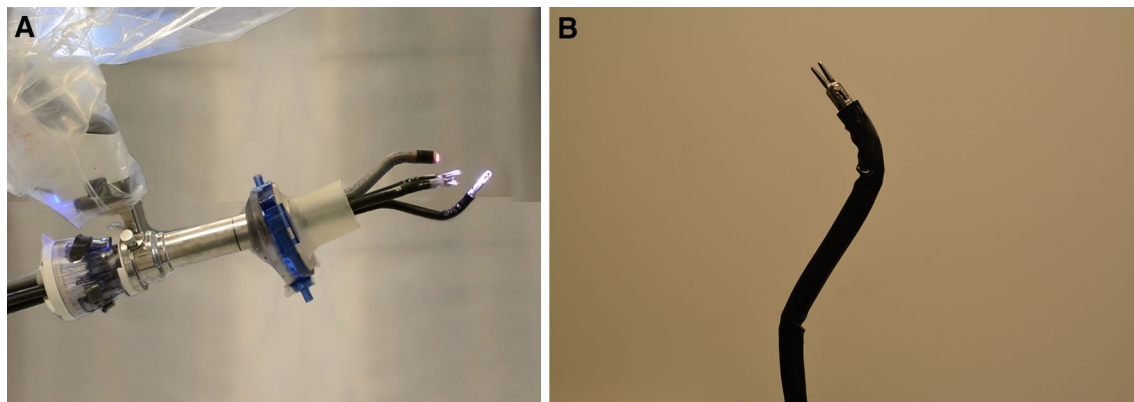
**Fig. 1** Placement of the assistant port and 25-mm multichannel instrument port through the GelPoint access platform

three, multi-jointed, fully wristed, elbowed instruments and the first fully wristed 3-dimensional high-definition camera (Fig. 2A, B). The instruments and the camera are introduced through a single 25 mm port and are properly triangulated around the target anatomy owing to their intracorporeal multi-joints to avoid external instrument collisions that can occur in narrow surgical workspaces (Fig. 3). The system enables flexible port placement and excellent internal and external range of motion through the single “C shaped” arm. The surgeon controls the fully articulating instruments and the camera on the da Vinci SP system via the console, which is the same surgeon console as the da Vinci X and Xi systems except for an additional foot pedal.

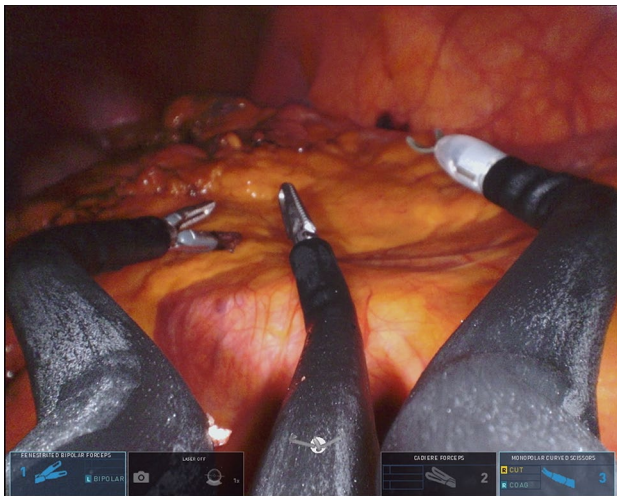
The current SP instruments include a Cadierre forceps, graspers, scissors, and clip applicator. The system currently lacks an energy device, stapler, and suction/irrigation system.

### Operative technique

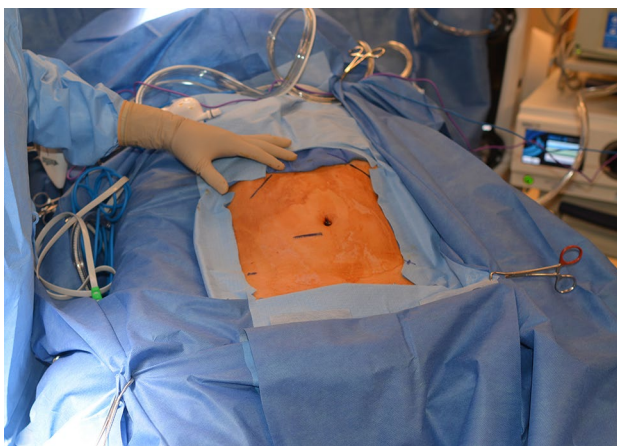
Under general endotracheal anesthesia, the patient is placed in a supine split-leg position with the arms tucked along the body. A 4-cm transverse muscle-splitting incision is made in the right lower quadrant (Fig. 4). The peritoneal cavity is entered and a GelPoint access platform is inserted and secured. Two assistant ports are introduced in the GelPoint. The operating table is then tilted to 5 degrees reverse Trendelenburg and 18 degrees right-side down. The single-port robot is brought in over the patient’s left side and docked (Fig. 5). The gastrocolic ligament is identified and opened with the robotic scissors. The bedside assistant transects the perforating vessels using a vessel sealer device (Ligasure, Medtronic, Minneapolis, MN, USA) introduced through the assistant port. This can also be done with the robotic bipolar and the robotic scissors depending on the vessel size. The



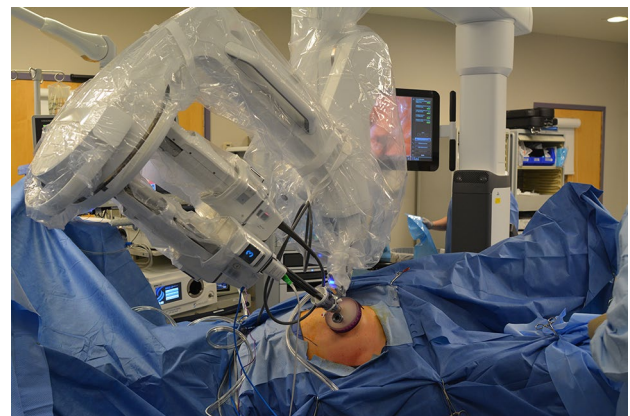
**Fig. 2** **A** Extracorporeal view of the three, multi-jointed instruments and 3-dimensional high-definition camera through the 25-mm instrument port. **B** Demonstration of the multi-jointed, fully wristed, and elbowed needle driver



**Fig. 3** Intracorporeal view of the deployed, multi-jointed instruments

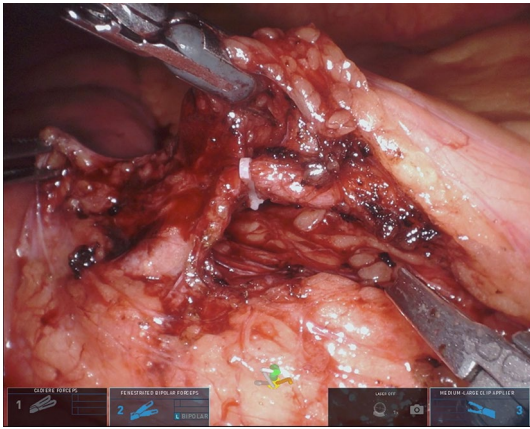


**Fig. 4** 4-cm transverse rectus abdominis incision marked



**Fig. 5** Single-Port robot docked over the patient's left-hand side

lesser sac is entered and the splenic flexure is mobilized in a standard medial-to-lateral supracolic fashion. All instruments are then removed and the robot is undocked. The operating table is then placed in 18 degrees Trendelenburg position, 18 degrees right-side down. The SP r is brought back in and docked. The small bowel is positioned in the right lower quadrant. The retroperitoneum is incised from the sacral promontory to the duodenal-jejunal junction. The hypogastric nerves are identified and swept posteriorly and the left ureter is identified. The inferior mesenteric artery (IMA) is then dissected free (Fig. 6). The IMA is then controlled with vascular clips or the vessel sealing device (Ligasure). The inferior mesenteric vein (IMV) is then identified and transected in a similar fashion. The mesentery is dissected free in a medial-to-lateral fashion. Once this is done the lateral attachments are incised and the left colon is fully mobilized. Attention is then directed to the pelvis: using scissors, the lateral rectal sulcus is incised and the upper presacral space entered while preserving the hypogastric nerves. The upper portion of the rectum is dissected distal to the area of



**Fig. 6** Dissected inferior mesenteric artery (IMA) with one clip applied

back into the abdominal cavity. The robot is docked again. The anvil is mated with the circular stapler and the stapler is fired. Air leak test is then performed. The robot is undocked and the incision is closed in a standard fashion.

## Results

Patients characteristics are summarized in Table 1. The SP rLeft colectomies were successfully completed using the SP robot without the need for additional transabdominal ports. The average estimated blood loss was 91 mL (20–250 mL). This was collected in a canister using a suction irrigator introduced via the assistant port. None of the patients required blood transfusion. The average number of robotic

**Table 1** Patient characteristics

Patient	Gender	Age	ASA	BMI	Preoperative Diagnosis	Postoperative Diagnosis
1	M	53	II	22.3	Diverticulitis	Diverticulitis
2	F	59	II	29.7	Diverticulitis	Diverticulitis
3	F	63	III	20.2	Diverticulitis	Diverticulitis
4	F	56	II	30.9	Diverticulitis	Diverticulitis

**Table 2** Single-Port (SP) robot docking and console times

Patient	Number of dockings	Average Time/Dock (min) [range]	Time/1st Dock (min)	Time/2nd Dock (min)	Time/3rd Dock (min)	Time/4th Dock (min)	Total Console Time (min)
1	2	23 [11–33]	11	33	n/a	n/a	177
2	3	7 [3–10]	8	10	3	n/a	241
3	4	4 [3–7]	7	4	3	4	143
4	2	4 [3–6]	6	3	n/a	n/a	183

**Table 3** Intraoperative metrics

Patient	Additional laparoscopic port(s)	Intraoperative complications	Robotic takedown of splenic flexure	EBL (cc)	Incision length (cm)	Total operative time (min)
1	0	None	Yes	20	4.0	273
2	0	None	Yes	60	4.5	334
3	0	None	Yes	250	4.0	325
4	0	None	Yes	35	5.0	307

inflammation and the mesentery is dissected free circumferentially. The rectum is irrigated and transected with 2 firings of Endo GIA purple load (Medtronic, Minneapolis, MN, USA) introduced via the assistant port. The robot is then undocked and the specimen is exteriorized through the same incision. The specimen is transected after an automatic pursestring is applied. A 28 EEA anvil (Medtronic, Minneapolis, MN, USA) is inserted and secured. This is dropped

dockings per case was 2.7 (2–4). The docking and console times are reported in Table 2. The mean length of the incision was 4.4 cm (4–5 cm). No intraoperative complications occurred (Table 3).

All patients were managed on an ERAS protocol, as is standard for our MIS colectomies, and started on a clear liquid diet immediately postoperatively and were advanced to a

low residue diet on postoperative day one and two (Table 4). The mean hospital stay was 2.7 days (2–3 days).

## Discussion

In this study, we present our initial clinical experience, along with the first video demonstration, of SP rLeft colectomy with description of the technique for a one stage resection of select patients with diverticulitis. The operation is performed in a similar technique to our Xi robotic and laparoscopic left colectomy.

In the setting of a new technology, feasibility is the first query. SILS was first reported more than a decade ago but still lacks large-scale adoption due to its technical difficulties, prolonged operative times and ergonomic challenges [1]. The main problem with this approach is instrument collision. Other challenges stem from poor ergonomics, camera instability, and a two-dimensional view. Attempts to overcome some of these challenges using the daVinci Si or Xi robotic platforms, while successful, were limited to a few case series. The persistent technical challenges resulting from a bulky, multi-armed robot entering via a single incision remain daunting. The rigid robotic arms clash interminably and result in a non-generalizable operation.

The SP r is the first robotic platform specifically designed for single-port surgery. It was designed to overcome most of the abovementioned technical challenges.

After publishing our first clinical experience using the SP robot [8], we demonstrate in this video report the technical aspects of having a dedicated robotic platform for SILS. We hope that this will help surgeons understand this new technology and facilitate their learning curve.

We show in the video the ease of docking of the robot. Indeed, the average docking time was only 8 min, although this could be as quick as 3 min. This is due to a single-arm docking system compared to multi-arm docking in the Si/Xi robot. The docking time will likely become quicker with more experience and familiarity with the system. The most noticeable difference when compared to previous SILS platforms is the absence of instruments clashing owing to the multi-jointed, fully wristed, elbowed instruments. This allows for triangulation around the target anatomy. Yet, the

instruments are strong enough to grasp, hold, and retract inflamed bowel in diverticulitis cases, as shown in the video, even with a BMI of 31 kg/m<sup>2</sup>.

Multi-quadrant surgery is facilitated by a 360-degree rotation of the boom around the robotic port as well as the instruments within the SP cannula. This allows the surgeon to view and operate in different quadrants without the need to necessarily redock the robot. This is especially important in colorectal surgery in general and left colectomies in particular. However, for retraction purposes with gravity, we prefer and demonstrate a dual dock technique to facilitate take down of the splenic flexure. Additionally, a novel holographic navigation system on the console screen, allows the surgeon to keep track of the spatial positioning of the instruments, minimizing further instrument collision. This is a very useful new feature of the SP robot that we feel would represent an advance for the console surgeon in multiport robotic surgery as well.

We present in this study the successful completion of four SP rLeft colectomies. As with adoption of any new technology, the emphasis must be on patient safety and technical feasibility, and in this initial experience in a select group of patients, we were able to perform SP rLeft colectomy safely without morbidity or mortality. There were no conversions and no need for additional incisions or trocar placement. Docking times were short and mastery of the SP robotic system was learned quickly. In this small group, the incision length was smaller than the average incision used with the multiport robot [9]. Patients reported minimal pain and were discharged on POD 2 and 3, which is similar to our hospital stay after laparoscopic or robotic Xi colectomies.

The lack of a SP vessel sealer, stapler, and suction devices represent a significant drawback of the current system. However, this was readily overcome with an assistant port placed in the GelPoint through which the bedside assistant introduced laparoscopic vessel sealer, clip appliers, laparoscopic suction device, and laparoscopic stapler. When the angle of the assistant instrument is not ideal, the entire platform can be adjusted from the console; alternatively, the robotic instruments are versatile and strong enough to direct and help the assistant. In the future, a dedicated robotic vessel sealer, stapler, and suction device will be mandatory for widespread adoption of this technology, and

**Table 4** Hospital course

Patient	Clear diet (POD)	Low residual diet (POD)	Flatus (POD)	Bowel movement (POD)	Discharge (POD)	Postoperative morbidity	Postoperative mortality
1	0	2	2	2	2	None	None
2	0	2	2	2	3	None	None
3	0	1	1	1	3	None	None
4	0	2	2	2	3	None	None

these instruments are currently under development. These devices will additionally reduce the work for the bedside operative assistant. Another limitation is that the integrated table motion (Trumpf) bed is not compatible with the SP robot yet. Hence the need for multiple dockings to reposition the patient.

## Conclusion

We have shown a video of SP rLeft colectomy and demonstrated it to be feasible and safe in select patients. The ease of use of this platform for single-port abdominal surgery contrasts significantly with laparoscopic or robotic Xi/Si SILS. SP r SILS represents a major advancement and will become a valuable tool in our surgical armamentarium. We predict that the SP robot will be widely utilized in the field of colorectal surgery as it becomes available to more surgeons. However, further studies and more experience will be required to completely grasp the advantages and identify any problems with the SP rLeft colectomy.

**Supplementary Information** The online version contains supplementary material available at <https://doi.org/10.1007/s00464-020-08159-2>.

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## Compliance with ethical standards

**Disclosures** Dr. John Marks is a speaker and consultant for Intuitive Surgical, Stryker, Medtronic, and Applied Medical. Drs. Jean Salem,

Samir Agarwal, Henry Schoonyoung, and Mr. Charlie Martin have no conflicts of interest or financial ties to disclose.

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