Single-Incision Laparoscopic Colon and Rectal Surgery

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Abstract

Keywords

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- laparoscopic colectomy
- minimally invasive colorectal surgery

Single-incision laparoscopic surgery (SILS) was introduced to further the enhanced outcomes of multiport laparoscopy. Multiple studies have demonstrated the safety and feasibility of SILS for both benign and malignant colorectal disease. SILS provides the potential for improved cosmesis, postoperative outcomes, and patient quality of life. However, widespread use has been limited by technical demands and lack of an evidence and competency-based curriculum.

Over the last two decades, the most significant progress in colorectal surgery has come from the expanding use of laparoscopy. Laparoscopic colectomy has been proven to improve patient outcomes, including earlier return of bowel function, less postoperative pain, shorter operative times and length of stay, lower complication and readmission rates, and lower costs compared with open colectomy.^{1–15}

Single-incision laparoscopic surgery (SILS) is a newer innovation proposed to further the outcomes of multiport laparoscopy. SILS was first reported in 1999 for cholecystectomy, and then applied to colorectal resection in 2008 by Remzi and Bucher.^{16–18} Studies have proven that single-incision laparoscopic surgery (SILS) is safe and feasible for both benign and malignant colorectal disease.^{19–29} SILS has demonstrated similar outcomes to traditional laparoscopy.^{28,30} Furthermore, using a single umbilical single port with multiple incorporated working channels, SILS has reduced the number of incisions and tissue trauma required for surgery, reduced perioperative pain and narcotic use, improved cosmesis, and lowered the rate of port site-related complications.^{30–33}

Despite evidence supporting the use and proven benefits, SILS has not been widely adopted. The technology has ergo-

nomic demands and requires additional time, costs, and skills from multiport laparoscopy, especially in early cases.^{34–38} The results described in the published literature are achieved by skilled laparoscopic surgeons beyond the learning curve performing the procedures, and the technology is currently only advocated for surgeons experienced and adept with laparoscopy and minimally invasive techniques.^{26,28,39,40}

We aim to describe the current state of SILS in colorectal disease, the available technology and techniques, and evaluate the benefits and limitations in the published literature.

Technical Considerations

Access Platforms

Use of single-incision laparoscopic technology requires consideration of the access device, camera, and instruments. Several commercially produced access ports are available in the market, as well as a “homemade” glove port. All the access devices are similar in allowing the surgeon to introduce two or more surgical instruments and a camera into the operative field through a solitary incision, eliminating multiple ports and reducing abdominal wall trauma. Compared with

previous techniques requiring multiple fascial incisions for intra-abdominal access, the single port helps avoid “Swiss cheese” fascial defects and their associated risk of increased postoperative pain and hernias.^{30–32} The commercially available access devices are packaged with all essential trocars and are compatible with all currently available laparoscopic instruments. There are subtle differences, advantages, and disadvantages to each port.

The SILS Port (Covidien, Mansfield, MA) uses a pliable foam port introduced through a 2 to 4 cm skin and fascial incision. Trocars are placed before insertion, and a Kelly or curved hemostat is used to guide the port into the abdominal cavity. The pliable foam creates a seal with the skin once introduced through the incision, maintains adequate pneumoperitoneum, and offers enhanced mobility. The surgeon can also interchange 5-mm and 12-mm ports, and readily remove and reinsert the port as needed. However, the surgeon is limited to three trocars for the instrument and camera, and exchanging trocars or excessive torque can result in intermittent loss of pneumoperitoneum. The port is of a fixed length, so it tends to dislodge if the incision is extended and use limited in patients that are obese or have a thick abdominal wall. In addition, the device has no wound protector for specimen extraction and extracorporeal work.

The GelPOINT platform (Applied Medical, Rancho Santa Margarita, CA) uses a design and structure similar to the GelPort hand-assist platform (Applied Medical) specifically for SILS. Through a 2 to 7 cm incision, a sleeve similar to a wound protector is inserted into the peritoneum and rolled down to create a secure seal. Trocars (5–12 mm) are introduced into the GelSeal cap before the cover is secured to the sleeve. The trocar positions are at the surgeon’s discretion, but usually triangulated, and can be repositioned or exchanged without affecting pneumoperitoneum. The GelPOINT also has a smoke evacuator side port, which can aid visualization. The port offers a wider external profile and low internal profile, which may be advantageous to accommodate various abdominal wall sizes, cases involving multiple quadrants, and bulky or inflammatory disease. In addition, the wound protector offers protection during specimen extraction from tumor seeding in malignant cases and maintains moisture, which may reduce superficial wound infections.^{41,42} Despite its benefits, the GelPOINT does not eliminate instrument clashing, has a larger profile on the abdominal wall, may lose pneumoperitoneum with extreme torque, and trocars may slip into the abdomen.

The TriPort15, TriPort+, and QuadPort+ (Olympus Medical, Center Valley, PA) are newer generations of the original R-port systems that offer several of the advantages of both the SILS Port and GelPOINT access devices. Through a 1 to 3 cm incision (TriPort) or a 1.5 to 5 cm incision (QuadPort), the devices are inserted via blunt dissection using the provided introducer and distal ring attached. The distal ring and excess protector sleeve are then removed, the ring is tightened to the abdominal wall, and the abdominal cavity is insufflated. The TriPort15 provides three channels for introduction of two instruments and the camera into the operative field, while the TriPort+ and QuadPort+ use three and four instrument

channels, respectively, in addition to the camera. These access devices all offer a lower external profile than the dome-shaped GelPOINT. The device is adjustable to abdominal wall thickness and the cap can be removed, allowing the sleeve to serve as a wound protector. Furthermore, each port forms a strong seal once inserted through the abdominal wall, preventing loss of pneumoperitoneum even with extreme torque. Nonetheless, insertion and assembling of this device line can be cumbersome. The design can complicate extracorporealization and specimen extraction, and the gel is prone to damage and leaks.

In the glove port technique, a surgical glove port is fashioned as a simple and cost-effective alternative to commercially available access devices.^{43–46} With this approach, a size 6, sterile, nonlatex glove is affixed to the outer ring of a small wound protector, which is then introduced through a 2 to 3 cm fascial incision. The glove’s fingers are used for instrument and camera access.²⁹ This approach is simple, inexpensive, and easily reproducible. Furthermore, the flexible character of the finger extensions reduces the trocar conflict routinely experienced during SILS. However, there is a poor seal, with resulting loss of pneumoperitoneum, and lack of rigidity provided from the finger trocars compared with commercially available devices.

Instrumentation and Camera

Several factors influence the surgeon’s instrument choice, including which access port they use, their personal experience, and the instrument cost. Laparoscopic instruments created specifically for SILS are generally 5 mm and available in standard (34–35 cm) and extra-long (44–45 cm) shaft lengths. The instruments come in straight, curved, and flexible configurations. Fixed straight instruments offer the advantage of rigidity, can transmit applied force evenly, and provide tactile feedback. However, in SILS, there is a loss of triangulation with straight instruments. Working with straight instruments in a parallel, confined space leads to a “sword-fighting” effect between the working ports and the camera. With experience, surgeons can stagger the instruments into the access device and switch hands to avoid clashing instruments. Curved instruments were introduced specifically to address the “sword-fighting” issues. While they avoid internal interference, there can be external hand collisions as the instruments move toward each other and the target space internally. Furthermore, the curved instruments cannot be passed through conventional, straight trocars. Flexible or articulating instruments were designed to overcome the lack of triangulation with straight instruments in SILS. The flexible instruments articulate at the tip, rotating 360 degrees around the axis of the instrument, increasing freedom of motion and internal triangulation around the region of interest. However, there is a loss of rigidity and tactile feedback with the flexible tools. In addition, the handles are bulky and add difficulty to the external ergonomics of SILS. Still, several series have reported advantages using flexible instruments.^{47–49} Even with specialized single port instruments, standard laparoscopic tools may be effectively used when performing SILS.

Laparoscopes for SILS include 5 and 10 mm widths, with 0, 30, and a flexible 100-degree tips (ENDOYE, Olympus Medical, Center Valley, PA). Using the 5 mm camera leaves a 10 to 12 mm port free for the endoscopic stapler or other larger instruments. Flexible scopes eliminate the need to exchange a 0 degree for angled scope during the procedure. The flexible tip scopes allow a view in all directions that can be fixed at any angle. With all SILS laparoscopes, parallel alignment of the instrumentation and camera can often restrict movement and result in frequent collisions or “sword fighting.” The articulating scopes can eliminate the clashing of parallel instruments while maintaining a head-on directional view.

In general, an experienced assistant and camera driver are essential for SILS, as the flexible tip camera has its own learning curve. In all SILS cases, forced movements can cause inadvertent tissue trauma or injury to nearby critical structures; drawing the camera back toward the port can help decrease this conflict and optimize visualization. Bariatric length instruments may also be beneficial to reduce the clashing between the surgeon's hands and the assistant's camera. Use of a posterior cable connection is also recommended to allow rotation without interfering with the instruments and to reduce external conflicts.

Incision and Locations

Proper port placement facilitates the optimal single-incision operation. Most SILS procedures enter the peritoneum via a vertical midline incision at the umbilicus. The umbilical stump is detached from the fascia, allowing intraperitoneal access through the natural umbilical hernia defect. The fascial incision can be lengthened further without extension of the overlying skin. As there are no muscles or vascular structures along the linea alba, the risk of iatrogenic injury and postoperative pain is minimized. The umbilical access also creates a “hidden” incision, maintaining a “scarless” procedure. Although an umbilical incision may be beneficial for single quadrant procedures, its value may be limited for procedures within the pelvis. A Pfannenstiel incision may be favorable in these or complex cases involving multiple abdominal quadrants. If a stoma is planned, the predetermined ostomy site may be used as the entry and extraction point, also resulting in “scarless” surgery.^{20,50–52}

Current State of Single-Incision Laparoscopic Colorectal Surgery

Published literature recommends SILS only in carefully selected patients by experienced laparoscopic surgeons.⁵³ Early contraindications included patients with multiple comorbidities, emergent procedures, middle or low rectal lesions, large bulky malignant disease, or phlegmon.⁵⁴ Obesity has been a relative contraindication; while published studies demonstrate feasibility and efficacy for SILS in obese patients, surgeon preference has excluded obese patients from the platform.^{54–56}

SILS has been proven safe and feasible for the treatment of benign and malignant colorectal disease.^{19,22–24,26,27} The current literature shows comparable results between SILS,

multiport, and hand-assisted laparoscopic colorectal surgery with regard to operative time, estimated blood loss, intraoperative complications, length of stay, conversion rate, and readmission rate.³⁰ In several studies, SILS has also shown a significantly shorter length of stay than multiport laparoscopy.^{22,30} SILS has additional demonstrated benefits over other laparoscopic platforms, including the cosmetic benefit of a single incision, reduced postoperative pain and narcotic use, and lower rate of port site-related complications.^{30–33,57} The rate of port-specific complications may be improved; however, long-term outcome data are needed.

Our Experience

Between 2009 and 2013, we performed over 400 SILS colorectal resections. In all cases, we used a 5-mm 30-degree camera and nonarticulating instruments. In our unselected case series, the mean patient age was 58.0 years (standard deviation, SD 14.5) and the mean body mass index (BMI) was 26.8 kg/m² (SD 4.8). The majority of patients (55.2%) had previous abdominal surgery. The indications for operations were 65% benign and 35% malignant disease. The median operative time was 157 minutes (range, 37–422 minutes). Conversion from SILS was required in 24 cases (5.9%); of these cases, the procedure was safely completed laparoscopically with the insertion of additional ports in 17 cases, while 7 required conversion to an open procedure. For the malignant disease cohort ($n = 131$), all patients had sufficient lymph nodes extracted and negative margins. The mean hospital length of stay was 4.0 ± 2.9 days (median 3, range: 2–31 days). The postoperative complication, readmission, and reoperative rates were 10.8 ($n = 44$), 4.7 ($n = 19$), and 1.7% ($n = 7$), respectively. The 30-day mortality rate was 0%. Given our favorable experience, we support the expansion of SILS and more investigation into further applications.

Future Directions

Applications of the SILS platforms are continuing to evolve. One example is transanal minimally invasive surgery (TAMIS).⁵⁸ First described in 2010, TAMIS combines single-port laparoscopic surgery with transanal endoscopic microsurgery (TEM) for transanal excision of middle and upper rectal lesions.^{58–61} The procedure is both diagnostic and therapeutic for select patients. TAMIS continues to expand with robotic technology, which allows improved precision and more advanced indications of transanal access surgery.^{62,63} The robotic platform is another evolving application of SILS. Merging the single-incision benefits of reduced parietal trauma and better cosmesis with the ergonomic advantages of the robotic system is proposed to advance SILS.^{64,65} The Da Vinci Single-Site robotic surgery platform (Intuitive Surgical Inc., Sunnyvale, CA) has been developed with promising early results in Europe, and is eagerly anticipated in the United States.^{66,67}

Despite increasing utilization of SILS, several issues need to be addressed to aid its widespread adaption. First, SILS involves a unique skill set and ergonomic demands distinct

from multiport laparoscopy.^{38,68} Thus, an additional learning curve is involved.^{23,36} A standardized teaching curriculum would ensure appropriate training of future single-incision surgeons. The current technology is also limiting SILS implementation. The problems in exposure and parallel alignment often result in "crowding" of the instruments and the camera.³⁵ Development of enhanced laparoscopes with three-dimensional optics advanced instruments and increased operator experience would address these limitations. Finally, cost is always a major focus when implementing new technology. Most reports show a minor increase in cost for SILS over multiport laparoscopic surgery.^{26,37} However, higher initial costs become comparable with increased experience, comparable operative times, and length of stay.⁶⁹ Future reductions in operative time or length of stay may enhance the cost-effectiveness of SILS.

Conclusion

SILS is safe and feasible for a wide variety of procedures regardless of age, BMI, diagnosis, or previous abdominal procedures. Quality patient outcomes, including short length of stay, low conversion, complication, and readmission rates, are achieved similar to multiport laparoscopic surgery with added potential benefits of improved cosmesis, perioperative pain, and quality of life. Future studies on the learning curve and a comparative cost analysis may further demonstrate the merits of this approach.

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