Single-Incision Robotic Cholecystectomy

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Introduction

Despite the excellent results of traditional laparoscopic cholecystectomy, there have been numerous attempts to decrease the parietal trauma of the typical 4-port technique. Reducing the number of trocars used and reducing the port size have both been used to reduce the parietal peritoneal trauma. Single-incision laparoscopic cholecystectomy (SILC) has been shown to be feasible [1–7], but the technique is challenging because of reduced ability to triangulate with linear instruments, limited visualization, and internal and external collisions [8]. Despite the demonstrated safety of SILC, these limitations have decreased the wide spread adoption of SILC. Robotic single-incision instrumentation has been able to address many of these limitations.

Since its introduction over a decade ago, the popularity of robotic surgery has increased, especially in the specialties of urology and gynecology. The most robust and studied platform for single-site surgery is the da Vinci Si Surgical System (Intuitive Surgical Inc. Sunnyvale, CA). Although other platforms exist in various stages of development, none are currently approved for use in the United States. The da Vinci single-site technology for cholecystectomy overcomes many of the limitations of SILC, including triangulation, ergonomics, quality of vision, and range of motion [9]. If studies with more than 50 cases are analyzed from a PubMed search for SIRC the average docking times ranged from 5 to 15 min and average total

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Table 19.1 Single-incision robotic cholecystectomy outcomes

	N	Robotic docking time (min)	Console time (min)	Total time (min)	Major complication (bile leak, bleeding)
Pietrabissa et al. (2012)					
SIRC	100	15	31	71	None
Gonzalez et al. (2013)					
SIRC	166	NA	NA	63	1.8%
SILC	166	–	–	37	1.8%
SILC (SPIDER)	166	–	–	53	1.2%
Angus et al. (2014)					
SIRC	55	11	29	62	None
Morel et al. (2014)					
SIRC	82	7	51	91	2.4%
Vidovszky et al. (2014)					
SIRC	95	5	39	84	1.1%
Escobar-Dominguez et al. (2015)					
SIRC	192	NA	NA	58–73	None
Gonzalez et al. (2015)					
SIRC	465	NA	21	52	0.8%
Chung et al. (2015)					
SIRC	70	12	53	106	None
LC	70	–	–	112	None
Svoboda et al. (2015)					
SIRC	200	NA	NA	65	None
Kubat et al. (2016)					
SIRC	150	NA	NA	83	0.7%

Data from PubMed search for SIRC studies with greater than 50 patients
SIRC, single-incision robotic cholecystectomy; *LC,* conventional laparoscopic cholecystectomy; *SILC,* single-incision laparoscopic cholecystectomy; *SPIDER,* single-port instrument delivery extended research (TransEnterix, Inc.); *NA,* not available

operative ranged from 63 to 106 min. The rate of bile injury, bile leak, or bleeding ranged from 0 to 1.8% (Table 19.1).

Indications

The indications for SIRC are similar to those of traditional laparoscopic cholecystectomy. These include symptomatic cholelithiasis, cholecystitis, acalculous cholecystitis, symptomatic gallbladder polyps or polyps greater than 10 mm, porcelain gallbladder, and biliary dyskinesia [10]. Certain relative contraindications for SILC include patients with severe acute cholecystitis, BMI $\geq$ 35 kg/m^2, previous upper abdominal surgery, suspected bile duct stones and intrahepatic duct stones, suspected malignancy, and ASA class $\geq$ 3 [11–13]. Some of these contraindications

have been alleviated by the da Vinci Si single-site cholecystectomy platform because of improved triangulation and surgeon experience with the platform. SIRC is increasingly being performed in patients with higher BMI, cholecystitis, and previous upper abdominal surgery, all with good results [14].

Robotic Components and Operating Room Team

There are three major components to the da Vinci Surgical System. Two components are not sterile and located away from the table: Surgeon Console (SC) and Vision Cart (VC). The patient-side cart (PSC) component is covered with sterile drapes and docked at the operating room table. The SC gives the surgeon control of the instrumentation and visualization of the operative field. The VC contains supporting hardware and software such as the optical light source, electrosurgical unit, and optical integration. The PSC has four articulated mechanical arms, which control the instruments that are docked to the ports. Efficient use of the robotic system is best utilized with dedicated personnel. As previously discussed in Chapter 14, our structure consists of a robotic nurse manager, equipment specialist, circulating nurse, and scrub nurse. The nurse manager coordinates equipment and personnel several days in advance, the equipment specialist will set up the robotic subcomponents, and the circulating nurse is responsible for patient care and any additional equipment during the operation. The bedside scrub nurse must be proficient at instrument exchanges and basic bedside problem solving. This structure has been successful in achieving a mean SIRC docking time of 4.9 ± 2.8 min [14].

Room Setup and Patient Positioning

The patient is positioned supine on the operating table with the right arm tucked and left arm at 90°. The surgeon and assistant initially start on the patient's left or right side according to surgeon preference. The instrument table and scrub nurse are positioned near the feet. The PSC robotic component will always be over the patient's right shoulder, and the position of the electronics cart and surgeon console can be altered depending on room limitations. Typically the SC is to the patient's left and the VC is to the patient's left or right.

Once the single-site port has been deployed and the abdomen insufflated to 12–15 mmHg, the PSC is driven at 45° and placed slightly over the patient's right shoulder. Prior to docking of the robot, the patient is placed in 10°–15° of reverse Trendelenburg and rotated to the left 10°–15°. Once the docking is completed, the surgeon can transition to the console and the assistant can transition to the patient's left side with the scrub nurse remaining near the patient's feet on the left or right. The position of the patient relative to the anesthesia machine may have to be adjusted in order for the robotic patient-side cart to be positioned over the patient's right shoulder without interfering with the anesthesia machine or endotracheal tube (Fig. 19.1).

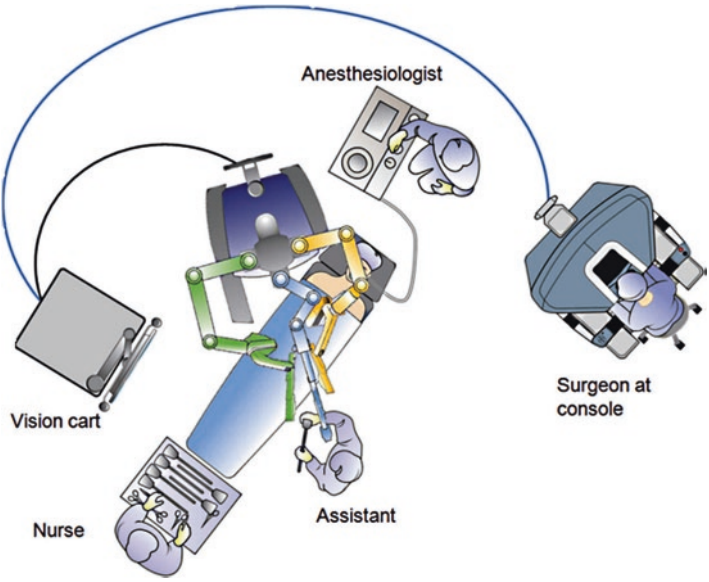

Fig. 19.1 Single-incision robotic cholecystectomy room setup

Technical Pearls

- Consider positioning the patient 30°–45° relative to the anesthesia machine.
- Patient positioning can be altered once the robot is docked if using the da Vinci Xi but not with the da Vinci Si robotic surgical system.

Port Placement and Robotic Docking

A 2.5 cm skin incision is made around the umbilicus. The incision can lie vertical or horizontal depending on the surgeon's preference. Placing the incision in the most prominent skin fold at the umbilicus may provide an improved cosmetic result. Next, the underlying fascia is elevated and opened 2.5 cm horizontally, and the peritoneum is elevated and entered with sharp dissection. Retractors are used to stretch the opening large enough to allow port placement. The da Vinci single-site port (Intuitive Surgical Inc., Sunnyvale, CA) has five openings: one for the robotic 8 mm camera, one for insufflation, two for the robotic arms, and one for the assistant's standard laparoscopic grasper (Fig. 19.2). The silicon port is folded, clamped with an atraumatic clamp at its lower rim, and lubricated with water to facilitate its introduction. Care is taken to not crush the insufflation tubing during clamping. The silicone port is inserted into the abdominal cavity under direct vision by following the curve of the clamps while providing retraction at the incision with Army–Navy retractors. Once deployed, the orientation of the port is confirmed by making sure to align the arrow with the anatomical target and the carbon dioxide insufflation is begun (Fig. 19.3).

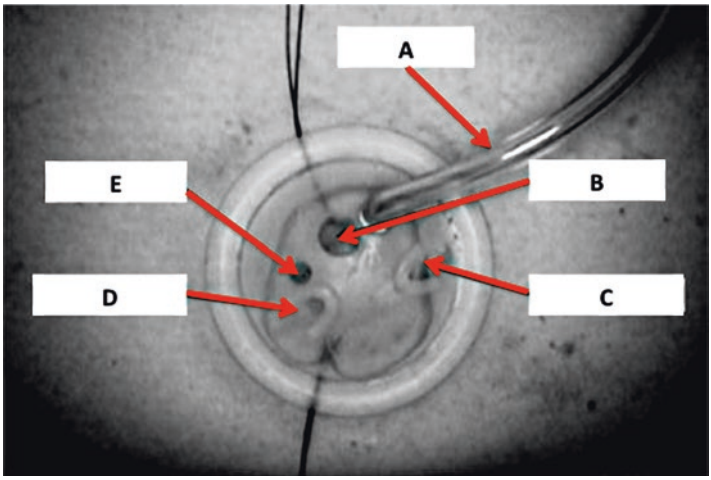

Fig. 19.2 The da Vinci single-site port. (**a**) CO_2 insufflation tubing, (**b**) camera port, (**c**) curved working port—Arm 1, (**d**): curved working port—Arm 2, (**e**) assistant port

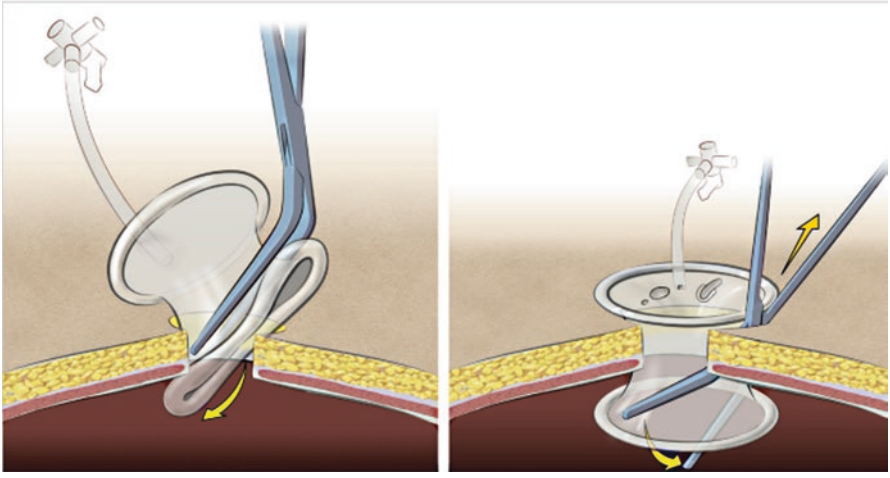

Fig. 19.3 Insertion of single-incision port

The first 8.5 mm trocar is placed (for the camera), and the camera trocar is docked prior to placing the remaining ports. Once docked, an 8 mm 30° down facing camera is introduced and used for visualization of the remaining ports. Next, the two robotic curved trocars are placed through the port under direct vision. These cannulae cross at the fascial level to allow appropriate triangulation for the semi-rigid instruments during dissection. Because the instruments cross in the port, the intra-abdominal instrument position is reversed. The instrument that enters the abdomen from the left reaches the operative field on the right and vice versa (Fig. 19.4). The curved cannulae are docked to the robotic arms. Finally, a fourth (5 mm)

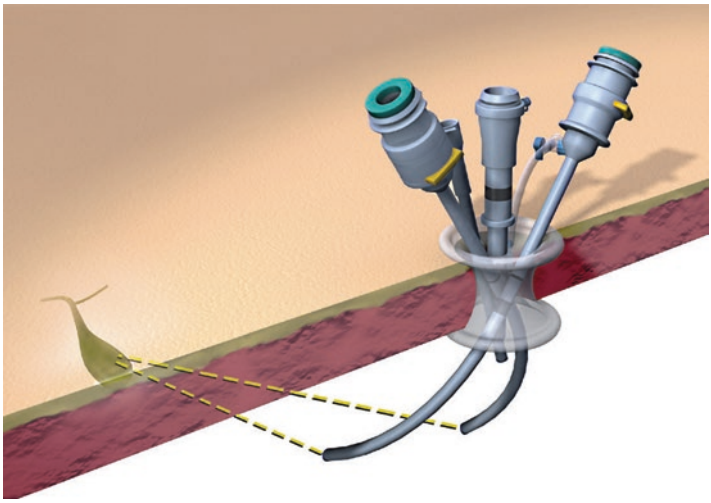

Fig. 19.4 Single-site cannula crossing within the trocar. The end of the ports aims toward target anatomy

trocar for the bedside assistant is placed through the port, also under direct visualization. With the cannula tip in view, the Crocodile grasper is inserted in arm 1, and the monopolar cautery hook is inserted in arm 2.

Technical Pearls

- Use clamps on each side of the silicone port to prevent slippage during trocar insertion.
- Lubricate all trocars with saline.
- For obese patients, use the long curved metal trocars, as tip deflection is less common.

Robotic Dissection and Fluorescence Imaging

The cholecystectomy is performed in a similar manner as a routine laparoscopic cholecystectomy. The operating surgeon starts the dissection phase at the console with the assistant helping to retract the gallbladder cephalad with a grasper through the assistant port. The camera is driven under the assistant grasper, which gives the console surgeon partial control of fundal retraction. The crossing of the cannulae inside the port internally increases the distance between the instruments tips to overcome the SILC parallelism, while the curvature of the cannulae internally allows the instruments to reach the operative field in a convergent way. This restores the correct triangulation and allows exposure to Callot's triangle with the combination of

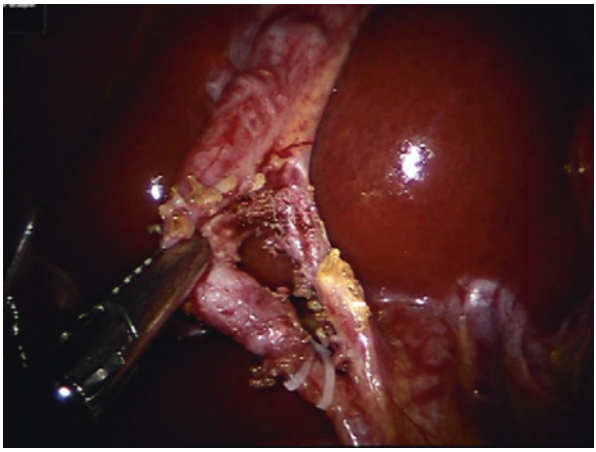

Fig. 19.5 Intraoperative dissection of triangle of Calot (picture from the University of California, Davis, Department of Surgery Archive)

the assistant grasper and the Crocodile grasper. The da Vinci software automatically associates the surgeon's hands to the ipsilateral instrument tips to restore intuitive control of the instruments.

Although we do not routinely use indocyanine green (ICG) and near infrared fluorescence for real-time cholangiography to help identify the ductal structures, studies show that it may improve the safety of SIRC by preventing inadvertent bile duct injuries [15]. The robotic platform allows the surgeon to easily switch from white light to fluorescence imaging after the administration of IV ICG. The cystic duct and artery are dissected with monopolar hook and divided between Hem-o-lok (Weck Closure Systems, Research Triangle Park, NC) clips (Fig. 19.5). Due to the flexibility of the instruments, care must be taken with the tension applied to the monopolar hook electrocautery to prevent spring-like deflection of the tip. The gallbladder is detached from the liver bed with the hook cautery.

At this point, the patient-side cart is undocked and the curved cannula is removed. The gallbladder is subsequently removed directly out of the single-site port incision, or it can be placed into a 10-mm disposable specimen bag inserted through the assistant port. The single-site port is finally removed through the abdominal incision with the gallbladder. The size of the single incision allows for easy specimen removal, even with large gallbladders or stones. The peritoneum is closed with absorbable suture followed by careful fascial closure with interrupted absorbable or permanent sutures in a horizontal vest over pants fashion. The skin is re-approximated with subcuticular continuous suture and adhesive glue for dressing.

Technical Pearls

- Swap the hook and grasper instruments to dissect laterally using your left hand.
- Perform extensive medial dissection prior to clipping the cystic duct or artery.

- If using ICG and near infrared fluorescence for real-time cholangiography, give 2.5 mg of ICG 45 min prior to the start of the procedure.
- If using a specimen bag, upsize the assistant port to a 10 mm port after removal of the curved cannulae, and use a specimen bag to scoop the gallbladder.

Summary

The ideal robotic platform should have minimal setup time; a low external profile, the possibility of being deployed through a single access site, and the possibility of restoring intra-abdominal triangulation while maintaining the maximum degree of freedom for precise maneuvers and strength for reliable traction. SIRC addresses some of these requirements while maintaining similar outcomes to traditional laparoscopic cholecystectomy.

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