Robotic Cholecystectomy

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Thomas Swope

Cholecystectomy is one of the most common general surgery procedures performed each year. Laparoscopic cholecystectomy remains the standard of care for symptomatic gallbladder disease and has replaced open cholecystectomy for the vast majority of cases. Robotic surgical technology continues to advance, and robotics has become an attractive alternative to laparoscopic surgery for many surgeons. Robotic cholecystectomy, either multiport or single site, is an operation that is gaining traction. Robotic cholecystectomy keeps the advantage of a minimally invasive procedure but adds wristed instruments, a 3D immersive experience, fluorescence imaging, and greater surgeon comfort. Robotic surgery may potentially decrease the 5–10% open conversion rate that has been reported in the literature [1]. Situations that make surgery more difficult and can lead to open conversion include acute inflammation (infection or gangrene), scarring from previous surgery or infection, significant bleeding, advanced age, male gender, or injury to bile ducts or bowel. Lee et al. found a lower complication rate (3.8% vs 20.4%) and open conversion rate (0.0% vs 1.9%) in a study comparing robotic to laparoscopic cholecystectomy [2]. Other studies have not demonstrated a difference in clinical outcomes between robotic and laparoscopic cholecystectomy [3, 4]. A retrospective analysis comparing laparoscopic to robotic cholecystectomy found a lower conversion rate to open cholecystectomy with robotic cholecystectomy but with a slightly longer operative times and cost [5]. I am personally happy to accept a longer operative time on a difficult gallbladder and not have to convert to an open procedure. The patient benefit to me is worth the added time and effort in the operating room. The complications from an open subcostal incision include more pain, increased wound morbidity, longer recovery, and a higher hernia rate vs the smaller trocar incisions. The robot enables the ability to suture ligature, clip, or tie off the cystic duct. The suction irrigator is a wristed instrument that allows both suction and dissection which is very helpful in situations when there is an inflamed gallbladder with adhesions. When these enhanced abilities are combined with fluorescence imaging, the need for open conversion has decreased in my experience.

Multiport Cholecystectomy

Cholecystectomy was the introductory procedure for me into robotic surgery. Multiport cholecystectomy provides 3D immersion, wristed instrumentation, and fluorescence imaging. Once I worked past the loss of haptics on my initial cases and gained visual haptics, my technique greatly improved. Early in my experience, there was a tendency to pull too hard on the gallbladder with my robotic retracting instrument (i.e., my left hand) which led to gallbladder tearing and bile leakage in my first couple of cases. At first I was using the ProGrasp to retract the gallbladder because it had the greatest grip strength. As I quickly learned, unless you are very careful in the beginning stage with the ProGrasp, you will tear gallbladders. I quickly switched to the Caudier instrument to retract the gallbladder with my left hand, and the issues resolved immediately. There are three different grasping strengths among the graspers, with the ProGrasp having the strongest grip strength, the Caudier the weakest, and the bipolar grasper in between. My point is that there is a learning curve with every operation. Be patient and slow down in the beginning to be safe. My mantra with robotics is "get good, get fast, and then get cheap." In the early part of your learning curve you will be slower, have little patience for instrument exchanges, and have to learn to depend on your first assist more than you did laparoscopically. With experience not only you will become faster, but so will your team. They are learning a new system and your preferences. Only with repetition will consistency and speed be achieved.

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Multiport Setup

My preference is to use two robotic operative arms and the camera for a cholecystectomy. Some surgeons prefer the fourth arm for retraction using another robotic instrument to hold the gallbladder anteriorly and superiorly. I substitute a disposable 5 mm port laterally on the right abdominal wall and use a laparoscopic grasper to retract the gallbladder to save on cost. The patient is positioned in 10–15° of reverse Trendelenburg. Arms are usually tucked at the sides, but the left arm can be left out for anesthesia access if desired.

Si System

On the Si system, I dock the camera arm to a 12 mm disposable port at the umbilicus. That is where I remove the specimen later. I place an 8.5 mm port in the left upper abdominal wall and another in the right mid-abdomen (Fig. 10.1). Alternatively a fifth port can be placed to assist with retraction as seen in Fig. 10.2.

I place the left upper quadrant port lateral to the falciform ligament. This is different than the laparoscopic upper midline epigastric port placement. Other than that, my port placement is the same as a laparoscopic case on the Si. The disposable 5 mm port is placed far laterally in the right upper quadrant through which the gallbladder is retracted.

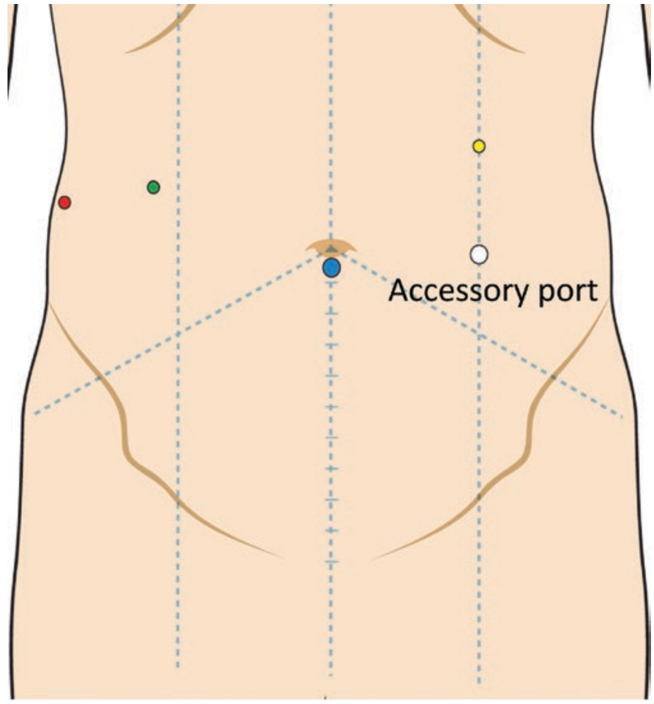

Fig. 10.2 Alternative Si port placement. (©2018 Intuitive Surgical, Inc. Used with permission)

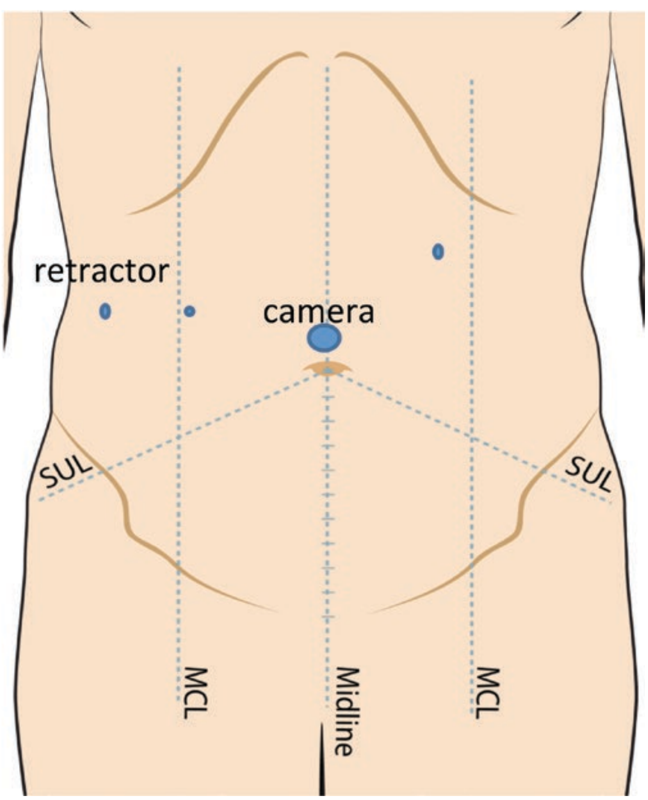

Fig. 10.1 Si port placement. (©2018 Intuitive Surgical, Inc. Used with permission)

Xi System

The port placement on the Xi is different than the SI. On the Xi, the ports are all aligned in a row parallel to your working area, in this case the right upper quadrant. I use three 8.5 mm ports (Fig. 10.3). I prefer to go in optically using a 5 mm laparoscope inside an 8.5 mm trocar with an optical obturator in place. Alternatively you could place a disposable 12 mm trocar at the umbilicus and then piggyback an 8.5 mm port through that as the camera port. The camera arm will only dock to an 8.5 mm port and not a 12 mm disposable port as it does on the Si system. Your method of establishing pneumoperitoneum laparoscopically should not change with the robot. Whether you prefer an optical entry, a Veress needle, or an open Hasson technique, your approach should remain the same and be something with which you are comfortable. Lastly, I place a disposable 5 mm port in the right lateral abdominal wall similar to my Si setup for retraction, but another robotic port and use of a third robotic arm for retraction are alternatives.

Instrumentation varies based on surgeon preference as it does laparoscopically. I prefer to use a Caudier and a hook to do the dissection. Others use a scissor or a Maryland dissector instead of a hook. Still others will use a bipolar instrument to

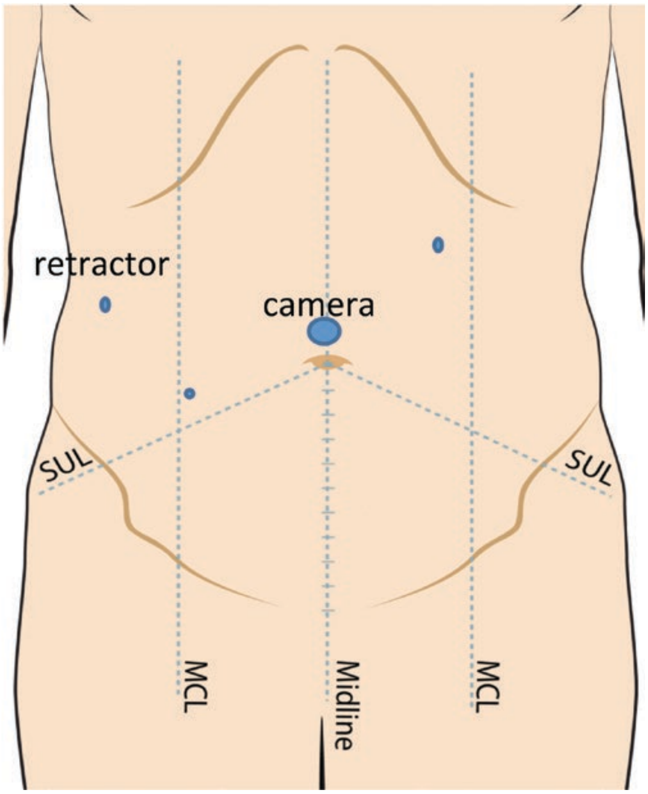

Fig. 10.3 Xi port placement. (©2018 Intuitive Surgical, Inc. Used with permission)

retract and for additional hemostasis. The bottom line starting out is to use similar instruments that you are already comfortable using to perform the case laparoscopically and modify from there if needed as your experience increases.

Single Site

I performed a lot of single-site laparoscopic surgery (SILS), and this approach is actually what initially drew me into robotics. I was exploring all technology related to single-incision minimally invasive surgery. I felt that the single-site robotic platform would solve some of the difficulties I experienced with SILS, namely, the sword fighting and lack of triangulation. By providing curved cannulas, the robotic platform gave back the triangulation that was missing with SILS. The triangulation isn't quite as good as multiport laparoscopy in my opinion, but it is adequate to operate safely and much better than traditional SILS. However, no wrist motion is provided on the single-site instruments. A prospective, multicenter, randomized controlled trial comparing robotic single-site cholecystectomy (RSSC) to multiport laparoscopic cholecystectomy (MPLC) found no difference in quality of life or complication rates between the techniques [6]. Operative times were longer for RSSC (61 min) vs MPLC (44 min). However, RSSC demonstrated significant superiority in cosmetic satisfaction and body image perception with no difference in quality of life.

The single-site port is soft with an hourglass shape. It has an air insufflation channel, a camera port channel, two operative port channels, and an assist port channel (Fig. 10.4). Insertion is generally performed at the umbilicus. An incision can be made splitting the umbilicus vertically or horizontally (Fig. 10.5). Alternatively a curvilinear incision can be made beneath the umbilical fold preserving the umbilical stalk (Fig. 10.6). The advantage of the curvilinear incision is the preservation of the umbilical stalk. When the umbilical stalk is split, there is a higher incidence of wound complications in my experience. When drainage occurs, it will typically begin at about 2–3 weeks after surgery. Usually it is serosanguinous and resolves with time, but occasionally

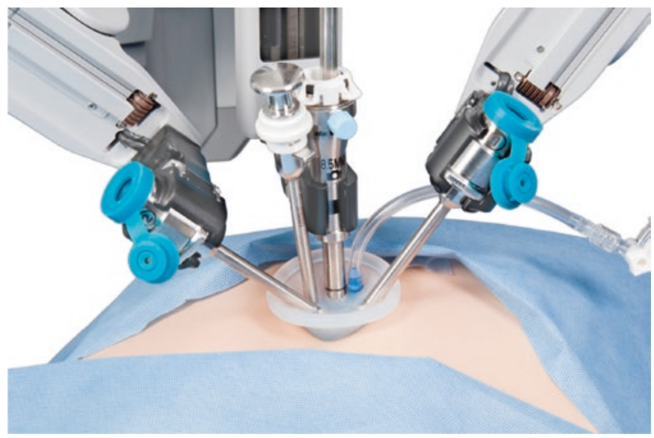

Fig. 10.4 Single-site port. (©2018 Intuitive Surgical, Inc. Used with permission)

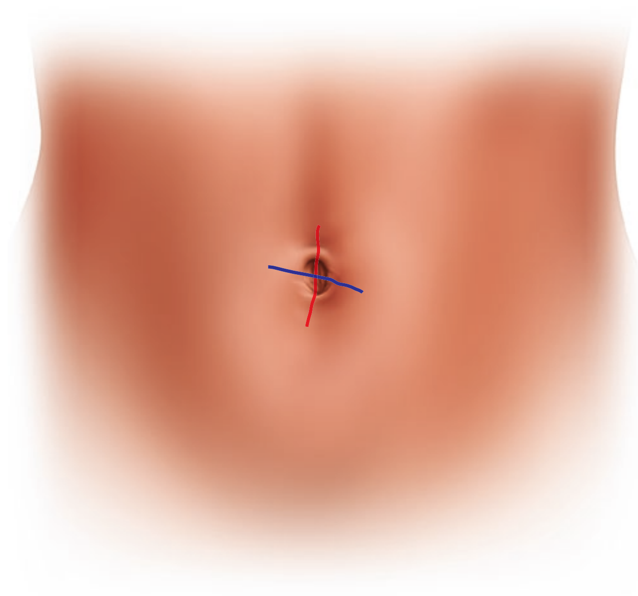

Fig. 10.5 Splitting the umbilical stalk. (©2018 Intuitive Surgical, Inc. Used with permission)

wound infections arise requiring drainage and antibiotics. To avoid that problem, I began preserving the umbilical stalk and switched to the curvilinear incision beneath the umbilical fold. There may a slight cosmetic advantage to splitting the umbilicus, but the trade-off is more frequent drainage and the resultant post-op visits and phone calls. This is not an issue in thinner patients where I continue to split the umbilicus. The issue is more prevalent in the obese patient population as you would expect.

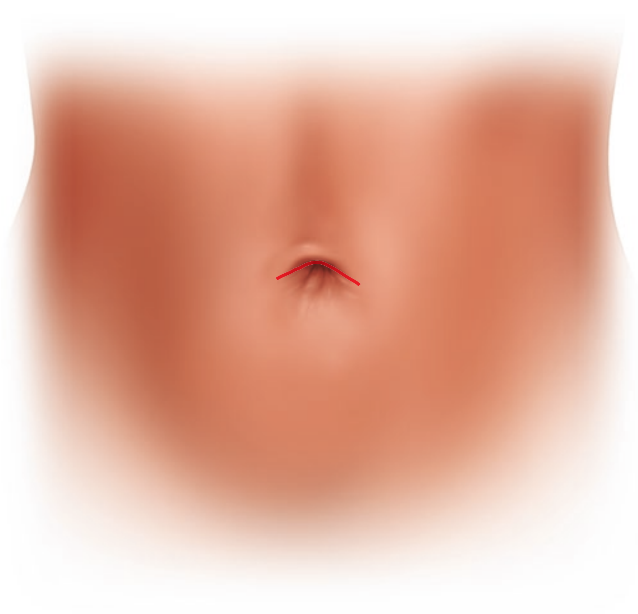

Fig. 10.6 Preserving umbilical stalk. (©2018 Intuitive Surgical, Inc. Used with permission)

The skin incision needs to be approximately 3 cm in length. Dissection is carried down to the fascia. A 2–2.5 cm opening is made in the fascia and the peritoneum is opened. My rule of thumb is that if the middle knuckle of my index finger fits through easily, the fascial defect will usually accommodate the port nicely. A finger is introduced, and the peritoneum of the abdominal wall is swept to make sure there are no adhesions in the area which would interfere and potentially complicate port insertion. Once assured there are no adhesions in the area, the insertion process continues. Next an Army Navy retractor is placed into the abdominal cavity. To insert the port I, place a large Kelly clamp about ¾ of the way across the port paralleling the internal skirt leaving about 2 cm of the port distal to the tip of my clamp. Using abdominal lift with the Army Navy retractor in my non-dominant hand, the port is then placed by applying pressure downward and toward the head to avoid the bowel with my dominant hand (Fig. 10.7). Once it is seated nicely, insufflation tubing is connected and pneumoperitoneum is established. The orientation arrow on the port is aimed at the area of the gallbladder. The camera trocar is then gently inserted lining up the marking on the port with the level of the fascia. The peritoneal cavity is then inspected using the robotic camera in a handheld fashion. I then place the curved operative trocars under vision. There are short (250 mm) and long (300 mm) versions of the operative trocars. I prefer the lon-

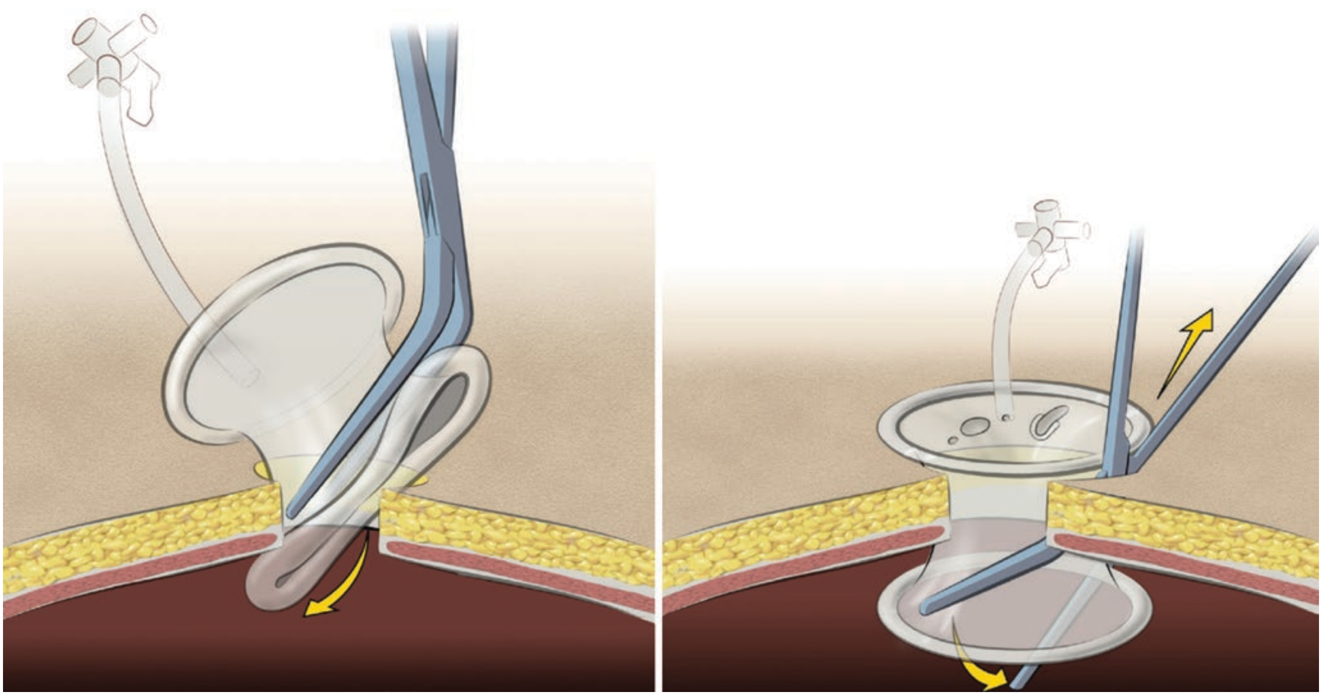

Fig. 10.7 Placing the single-site port. (©2018 Intuitive Surgical, Inc. Used with permission)

ger trocars as I feel they provide a greater arc inside of which I can move the camera without collisions. Others prefer the shorter trocars, especially if the umbilicus is close to the right upper quadrant. My advice is to try both and see which works better for you. The robot is then docked. Intuitive surgical training has you docking the robot to the camera first and then placing the operative ports after camera docking. I found it faster to place the curved trocars under visualization before docking to the camera trocar, using the robotic camera in a handheld fashion. On the Xi, there is a grounding cable that needs to be connected to the camera port. The patient is placed in 10–15° of reverse Trendelenburg. At this stage, I bring the robot in and dock. Docking all occurs from a lateral approach on the Xi since the boom is able to rotate into any position. On the Si, however, I like to turn the patient table after induction and before the patient is prepped. I turn the head of the OR table toward the direction of the robot to allow the robot to come in over the right shoulder at about a 45-degree angle (Fig. 10.8). I only want the nurse driving the robot in and out from the patient in a straight line for simplicity, repetition, and speed. On the Si, the elbows of the robotic arms need to face outward to minimize collisions. After docking I place the accessory trocar last. Through the accessory port, I place a laparoscopic grasper to hold the gallbladder anteriorly and superiorly. If the gallbladder needs to be decompressed, that can also be done through the accessory port using a laparoscopic needle aspiration instrument. Zero-degree and 30-degree camera both work. I prefer the zero-degree camera, keeping the retracting instrument superior to the camera. Others prefer a 30-degree scope either looking upward or downward. After docking sometimes the port is too close or too far away from the gallbladder. In that situation, the port complex can be moved slightly toward or away from the gallbladder by burping all three arms simultaneously with your first assist helping. The port complex can also be lowered or more likely elevated to get the view and working distance that is needed. Alternatively the longer or shorter operative ports can be exchanged depending on how close the umbilicus is to the gallbladder.

Single site can be challenging in the obese patient. Early in your learning curve I would approach these patients in a multiport fashion. However, with experience they can be performed with single site as well. There is likely a higher hernia rate in the obese patient population with single site. If the port is too short to bridge the distance from inside the abdominal cavity to the skin surface, you have a couple of options. You can simply seat the port nicely in the fascia and have the upper surface in the subcutaneous space. Some surgeons will suture the skin down to the fascia to allow the port to seat nicely. The alternative that also works here is to use a small wound protector and then seat the single-site port inside of that. The last alternative is to use a gel port (GelPOINT). The gel port is placed, and then the single-site trocars are placed through the gel port in a similar configuration to the single-site port followed by docking. This does increase cost but is always effective.

Once the dissection is done and the critical view of safety has been obtained and verified using fluorescence imaging, the cystic duct and artery are clipped and divided. Critical view of safety entails seeing two structures (the cystic duct and artery) going to the gallbladder with the cystic plate exposed in the background (Fig. 10.9). This is obtained after clearing the hepatocystic triangle and freeing the lower third of the gallbladder off of the liver bed. Once critical view of safety is obtained, the cystic duct and artery are clipped and divided depending on your preferred method.

To save time, I single clip the artery and divide it with the hook cautery toward the gallbladder in coagulation mode. The remaining gallbladder is then freed from the gallbladder

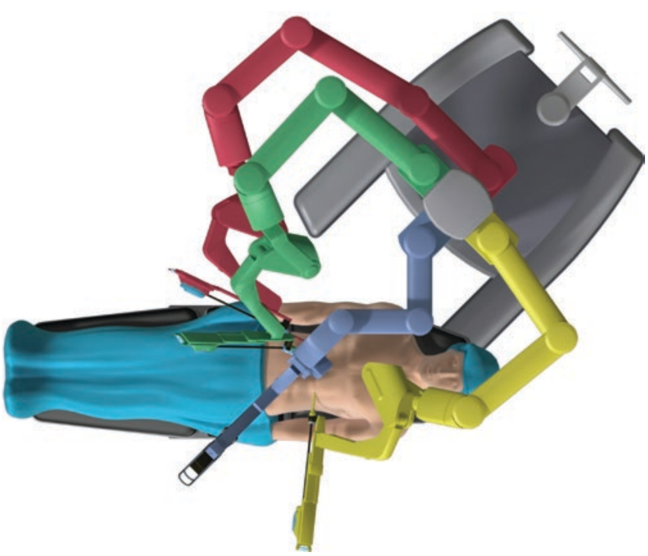

Fig. 10.8 Si Single-site robot position. (©2018 Intuitive Surgical, Inc. Used with permission)

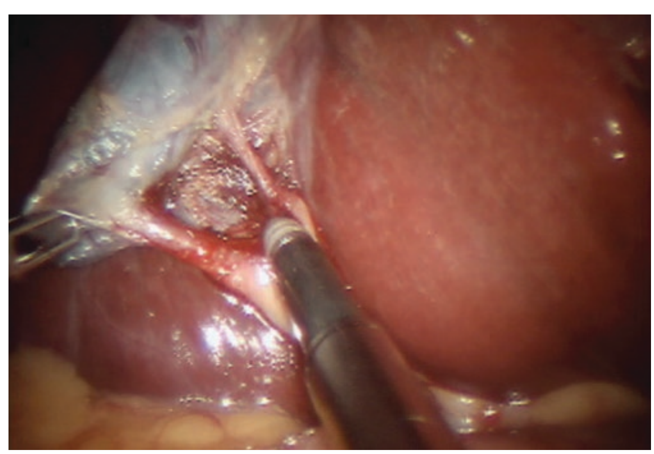

Fig. 10.9 Critical view of safety. (©2018 Intuitive Surgical, Inc. Used with permission)

fossa using hook cautery or your instrument of choice. Once the gallbladder is freed from the liver, the robot is undocked, the camera trocar and operative trocars are removed, and the port is removed through the umbilicus with the gallbladder attached to the grasper. Alternatively a 5 mm specimen bag can be used placing the gallbladder in the bag prior to removal.

Attention is then turned toward closing the fascia. I initially used 0-Vicryl figure-of-eight sutures to close the fascia but noticed a few hernias early in my SILS experience. I quickly switched to PDS, and the hernias dropped off quickly. I now close the fascia with 2–0 PDS taking 0.5 cm bites spaced 0.5 cm apart in a running fashion. The dermis is then reapproximated with absorbable deep dermal sutures. If the umbilicus was split, the base of the umbilicus is sutured to the fascia to reconstruct the umbilicus. Dermabond or Steri-Strips can be applied. I like to use a vacuum dressing for these cases. A 2 × 2 inch gauze is scrunched up and pushed inside the umbilicus and covered by a flat piece of 2 × 2 gauze. That is then covered with a large clear adhesive dressing. A 25-gauge needle is inserted laterally into the gauze in the center of the dressing, and air is aspirated out creating a vacuum dressing. I have my patients remove the dressing once the vacuum seal is gone. Postoperatively the only physical limitations are patient comfort levels. Patients can drive as soon as they are off pain medication and can comfortably drive without putting themselves or someone else at risk.

Fluorescence Cholangiography Utilizing Indocyanine Green (ICG)

ICG is a tricarbocynanine dye that has been used clinically for over 50 years for hepatic clearance, cardiovascular function testing, and retinal angiography on the basis of its dark green color, typically administered at concentrations of 2.5 mg/ml at typical total doses of 25 mg in adults [7]. It binds to albumin in the bloodstream and is selectively excreted through the biliary system. It fluoresces at near-infrared light making it very useful for identification of the biliary anatomy. It is not useful for identifying common bile duct stones and, therefore, is not a substitute for traditional intraoperative cholangiography for this purpose with the possible exception of an obstructing common bile duct stone blocking passage of the ICG. In terms of its safety profile, the incidence of mild adverse reactions was 0.05% and 0.05% for severe adverse reactions, with no deaths after 1923 procedures [7]. In a study of 2820 patients who underwent ICG angiography, the incidence rate of adverse events was 0.07% [8]. In comparison, the incidence rate reported for isosulfan blue dye in SLN identification was 1.1% [9].

The primary cause of bile duct injury is misinterpretation of the biliary anatomy which occurs in 71–97% of all cases [10]. According to Dip et al., the cystic duct was identified by intraoperative fluorescence cholangiography (IOFC) in 44 out of 45 patients (97.77%) [11]. Individual median cost of performing IOFC was cheaper than intraoperative cholangiography (IOC) (13.97 ± 4.3 vs 778.43 ± 0.4 USD) per patient (p = 0.0001). IOFC was faster than IOC (0.71 ± 0.26 vs 7.15 ± 3.76 min, $p < 0.0001$). Firefly imaging allows visualization of accessory ducts and superficial gallbladder bed ducts which in my experience occurs in approximately 2% of cholecystectomy cases. Schnelldorfer et al. in a systemic review identified a 4% incidence of accessory ducts [12]. Images of aberrant anatomy can be seen in Figs. 10.10 and 10.11. In Fig. 10.10, an accessory duct can be seen communicating between the common hepatic duct and the cystic duct/gallbladder junction. Fig. 10.11 demonstrates an aberrant duct between the right hepatic duct and the gallbladder. This patient also had the cystic duct inserting at the junction of the left and right hepatic ducts, all of which was easily identified using fluorescence imaging.

With ICG fluorescence, imaging of the bile ducts occurs in real time during the dissection and can be achieved without cutting any biliary structures to complete the imaging vs

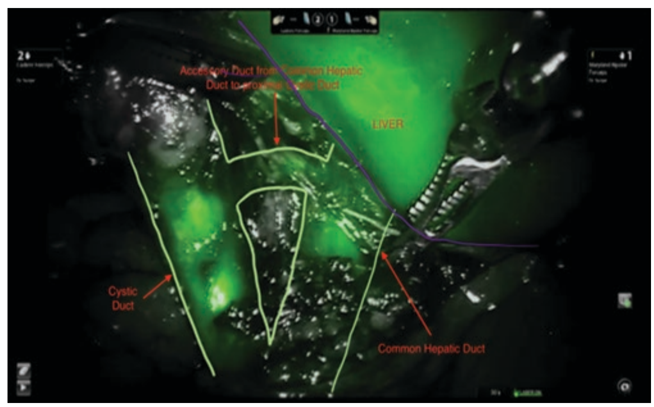

Fig. 10.10 Accessory duct from common hepatic duct to cystic duct

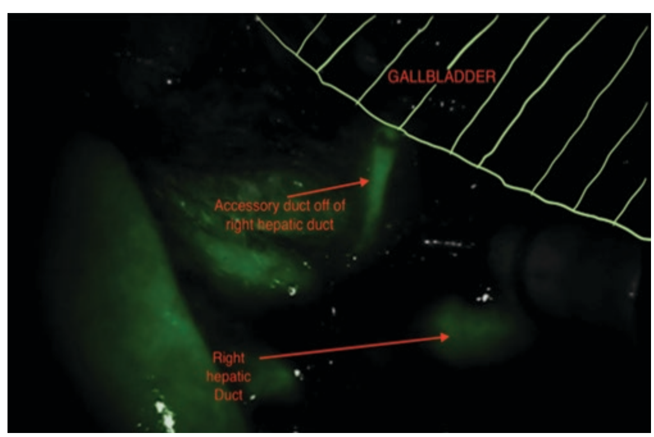

Fig. 10.11 Accessory duct from right hepatic duct to gallbladder

traditional cholangiography. It also eliminates radiation exposure to the patient and the OR staff that occurs with traditional cholangiography. In addition to being more easily able to identify aberrant anatomy, fluorescence imaging more easily allows identification of the anatomy on difficult cases. This in turn can allow a lower rate of open conversion in challenging cholecystectomy cases [13]. The intensity of the fluorescence can be adjusted using the brightness control on the console as well as by how close you are to the target tissue. Greater camera proximity to the target tissue gives a more robust fluorescence response.

The ICG needs to be injected IV at least 30 min before fluorescence imaging is utilized. At my institution, I have the anesthesia team give it in the pre-op area as they are evaluating the patient. That allows the ICG to circulate and be present in the liver and biliary tree during the operation. The usual dose is 2.5 mg (1 ml). If the patient is obese, I increase the dose to 5 mg (2 ml). That is my own protocol and is based on my clinical experience.

Traditional Cholangiography

Traditional cholangiography can also be performed during robotic cholecystectomy. A cholangiogram catheter is introduced through an angiocatheter in the right upper quadrant. The cholangiogram catheter is then introduced into the cystic duct as is done traditionally after clipping the proximal duct and opening the duct toward the common duct. Once inserted, the catheter can be held in position by placing a clip across the catheter and cystic duct securing the catheter in place. The clip will not prevent the ability to inject contrast. Alternatively the Reddick cholangiogram catheter curved introducer sheath can be passed through the accessory port and the balloon tipped catheter introduced into the cystic duct using the clip applier or Maryland grasper. The groove at the end of the clip applier is well suited for grasping and manipulating the catheter into the duct prior to clipping. To use the C-arm, the number 1 arm is undocked and moved out of the way. The C-arm is then rotated slightly clockwise to allow it to pass under the patient and not contact to the other robotic arms (Fig. 10.12). Once in position, the cholangiogram catheter is injected and fluoroscopic images are obtained. Once completed, the catheter is removed, and another clip can be placed on the cystic duct before complete division of the duct is performed.

Postoperative Care

Robotic cholecystectomy is an outpatient procedure for the majority of patients unless there are underlying comorbidities. Diet is initiated as tolerated as is postoperative activity and return to work.

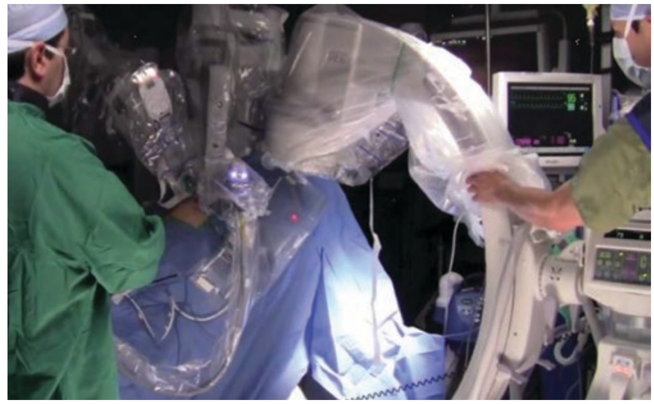

Fig. 10.12 Using the C-arm. (©2018 Intuitive Surgical, Inc. Used with permission)

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