

Single-port laparoscopic cholecystectomy: initial experience

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Abstract

Background As surgeons embrace the concept of increasingly less invasive surgery, techniques using only a single small incision have begun to gain traction. Several commercially available products have emerged recently. The TriPort™ system and the SILS™ Port are single-port devices that allow the surgeon to perform laparoscopic surgery through a 2- to 3-cm periumbilical incision. This study aimed to ascertain whether these devices allow safe and reliable access for laparoscopic cholecystectomy.

Methods From March 2008 to June 2009, single-port laparoscopic cholecystectomy was attempted for 22 patients with an average age of 40 years (range, 23–73 years). The data collected prospectively after institutional review board approval included demographics, operative time, complications, and reasons for conversion to standard four-port laparoscopic surgery.

Results The operation was completed successfully for 21 of the 22 patients (15 women and 7 men) using five different techniques. The mean body mass index (BMI) of the patients was 32.7 kg/cm² (range, 22.3–46.1 kg/cm²). Three of the patients had previously undergone laparoscopic Roux-en-Y gastric bypass. The mean operative time was 80.8 min (range, 51–156 min). One patient experienced a Richter's hernia postoperatively, which required a reoperation and subsequent bowel resection. One patient required conversion to a standard four-port laparoscopic cholecystectomy

because the articulating instrument could not reach the gallbladder from the umbilicus.

Conclusion The results from the current series show single-port laparoscopic cholecystectomy to be a promising technique. A variety of patient demographics appear suited to this approach. The operative time in this series compares favorably with that for the standard four-port operation. The feasibility of single-port laparoscopic cholecystectomy is now established. However, routine application of this novel technique requires an evaluation of its safety and cost effectiveness in larger studies. In addition, its superiority over standard laparoscopic cholecystectomy in terms of postoperative pain, cosmesis, and overall patient satisfaction requires further study. Refinements in instrumentation will enable wider use of this novel minimally invasive approach.

Keywords Cholecystectomy · Laparoscopic surgery · Single-port surgery

Single-port or single-incision laparoscopic surgery is a recent technical advancement in minimally invasive surgery. The concept revolves around the idea that all the laparoscopic instrumentation is introduced via the same access point in the abdominal wall. Some of these procedures are performed with new access devices such as the TriPort™ (Advanced Surgical Concepts, Wicklow, Ireland) (Fig. 1), the SILS™ Port (Covidien, Inc., Norwalk, CT, USA) (Fig. 2), the Uni-X™ Single-Port System (Pnavel Systems, Inc., Morganville, NJ, USA) (Fig. 3), and the Airseal™ (SurgiQuest, Inc., Orange, CT, USA) (Fig. 4). Another concept beginning to gain traction is placement of multiple trocars via separate fascial punctures through the same abdominal incision.

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Fig. 1 TriPort™ (Advanced Surgical Concepts, Wicklow, Ireland)



Fig. 2 SILS™ Port (Covidien, Inc., Norwalk, CT, USA)



Fig. 3 Uni-X™ (Pnavel Systems, Inc., Morganville, NJ, USA)

Single-port or single-incision laparoscopic cholecystectomy was reported first in 1997 [1] and then again in 1999 [2, 3]. Earlier reports of single-incision surgery in the general surgery arena appeared between 1992 and 1998 [4–7]. The recent popularity of this approach stems from an increasingly accepted shift away from the dogmatic concept of triangulation in minimally invasive surgery. We believe this shift is directly due to the development of natural orifice transluminal endoscopic surgery (NOTES®).

The NOTES® technique requires in-line viewing because the instruments are passed through the working channels of the endoscope. General surgeons are becoming gradually more comfortable with the concept of in-line viewing as their facility with advanced endoscopy increases. It is interesting to note that this type of viewing has long been used by both gastroenterologists and gynecologists, who have worked with operative laparoscopes or endoscopes for many years.



Fig. 4 Airseal™ (SurgiQuest, Inc., Orange, CT, USA)

Many recent case reports involve single-port or single-incision surgery. Surgeons have reported cases involving cholecystectomy [1–3, 8–22], appendectomy [4–7], colectomy [23–25], adrenalectomy [26], and bariatric procedures such as gastric banding [27] and sleeve gastrectomy [28, 29]. Urologists and gynecologists also have reported several procedures. In fact, much of the early enthusiasm for single-port surgery has come from urology.

Despite the recent enthusiasm for this new type of minimal access surgery, the terminology remains confusing. The early name to emerge for single-port surgery was single-port access (SPA), which came from Drexel University in Philadelphia. Interestingly, most of the procedures performed at Drexel University are carried out currently via the multiple-trocar, single-incision technique (Curcillo PG, personal communication). Other names to gain popularity are single-incision laparoscopic surgery (SILS) and single-site laparoscopy (SSL). Still other names published in the literature feature a similarity to NOTES, such as embryonic natural orifice surgery (e-NOTES) [30] and natural orifice transumbilical surgery (NOTUS) [15]. Additional proposed names include single-laparoscopic-incision transabdominal surgery (SLIT) [27], single-instrument-port laparoscopy (SIMPL) [31], and laparoscopic single-site surgery (LESS) [10].

Despite the multitude of acronyms, surgeons most commonly refer to this concept simply as “single-port” surgery, then proceed to describe the precise technique. Hopefully, at some point a consensus will be reached by experts in the field to simplify academic discussion of the topic. This report describes our initial experience with single-port surgery for cholecystectomy.

Patients and methods

The 22 patients (15 women and 7 men) in this series were offered single-port laparoscopic cholecystectomy. The average age of the patients was 40 years (range, 23–73 years). Two of the patients had undergone a previous pseudocystgastrostomy via a natural orifice approach using a technique described by our group [32]. Three other patients had previously undergone gastric bypass surgery, including one patient who had surgery through an upper midline incision. In that case, adhesiolysis via the single port was successful enough to clear an operative field for safe visualization of the gallbladder and surrounding structures.

Our first exposure to the concept of single-incision laparoscopic surgery came via the TriPort™, and 11 of the patients for whom single-port laparoscopic surgery was attempted were offered the procedure using this device. Four patients underwent single-incision laparoscopic surgery via

multiple trocars through separate fascial punctures, one of whom underwent the procedure with the aid of the daVinci® Surgical Robot (Intuitive Surgical, Mountain View, CA, USA). Six recent patients underwent the procedure using the SILS™ Port. Finally, one patient underwent the procedure via a single 12-mm Airseal™ trocar.

From all the patients, informed consent was obtained for the procedure, and the difference between the single incision and the standard four-incision approach was explained. Data were collected prospectively for quality assurance and then analyzed retrospectively after institutional review board approval to do so was obtained. Access to the peritoneal cavity via the umbilicus was obtained for all the patients. For all the patients except the Airseal™ patient, a 2- to 3-cm infraumbilical curvilinear incision was made. For the patients who underwent the multiple-trocar approach, a 12-mm trocar was placed at the umbilicus, with two 5-mm trocars placed laterally (on either side) and cephalad to the initial trocar.

After the fundus of the gallbladder was visualized, a 2-0 nylon suture on a straight needle was introduced through the abdominal wall using a technique described previously by our group [9]. The suture was grasped and passed through the fundus of the gallbladder, then passed back through the abdominal wall. Traction on the suture, which was clamped at the skin level, retracted the gallbladder. If visualization of the infundibulum of the gallbladder was deemed to be inadequate, a second traction suture was placed in a similar fashion further down the body of the gallbladder for further retraction.

Once visualization of all appropriate structures was obtained, an articulating grasper was placed on the infundibulum of the gallbladder (Roticulator™ EndoGRASP™; Covidien). The grasper then was articulated distally such that the grasper itself moved out of the field of view. Next, dissection was performed in the standard fashion using straight reusable laparoscopic instruments.

After appropriate exposure of the hepatocystic triangle was obtained, the cystic duct and artery were clipped and divided using standard laparoscopic instrumentation. The gallbladder was dissected away from the liver using a hook electrocautery. Just before completion of the liver dissection, irrigation and hemostasis of the liver bed were undertaken. The gallbladder was removed with the single-port device or placed in an endoscopic retrieval bag (Endo Catch™; Covidien Inc.) in the case of the multiple-trocar and SILS™ Port cases, then removed and sent for pathologic analysis.

Results

Single-port or single-incision cholecystectomy was attempted for 22 patients. For one patient, the technique was

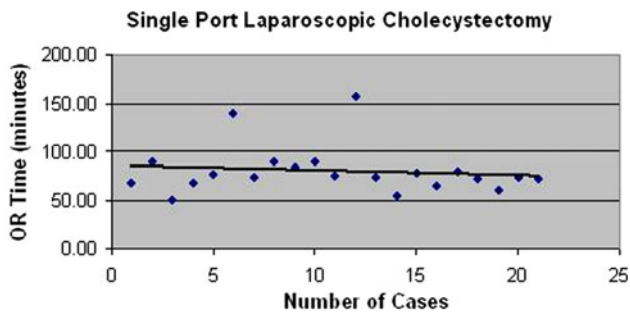


Fig. 5 Graph of single-port laparoscopic cholecystectomy operative times

quickly abandoned because the articulating grasper could not reach the gallbladder from the umbilical position, due to the patient's height (180.3 cm), particularly the patient's torso length. Instead of trying to perform the procedure via the single port exclusively with straight instruments, the patient was "converted" to a standard four-trocar laparoscopic cholecystectomy. The procedure was successful for all the other patients. Although for most of completed cases use of the TriPort™ was attempted, no particular device or technique seemed to confer a favorable difference in outcomes. All the patients were electively scheduled for chronic cholecystitis, biliary colic, or biliary dyskinesia.

Of the 22 procedures, 18 were completed by a single surgeon (J.R.R.), whereas 3 others were completed by another surgeon (D.B.E.). The mean operative time, as measured from skin incision to closure, was 80.76 min (range, 51–156 min). Increased experience tended to reduce the operating times, with a Pearson's coefficient of -0.44 (Fig. 5). The case that required 156 min was complicated by a failed attempt to use the daVinci® Surgical System via three transumbilical trocars, a technique that was successful in the remaining case. For this patient, the extreme torque on the trocars necessary to produce the motions required for gallbladder retraction and dissection caused a loss of pneumoperitoneum, and thereby a loss of the visual field. This technique was eventually abandoned, but the procedure still was completed successfully using multiple trocars via a single incision.

Patient 15 in the series experienced an incarcerated hernia in the fascial incision due to a technical error at closure of the fascial opening. She required reoperation with small bowel resection and recovered from that point uneventfully.

Discussion

Single-port or single-incision laparoscopic surgery is a growing trend in minimally invasive surgery. The potential for less pain, faster recovery, and improved cosmesis has

surgeons, their patients, and the industry interested in pushing the technique forward. Studies are needed to examine the true impact of this new technique in terms of outcomes.

When a new technology is adopted, the question must be raised whether clinicians are adhering to important surgical principles. Certainly, with any new technique, the complication rate is expected to be higher for surgeons early in their learning curve, as was the case with the introduction of laparoscopic gallbladder surgery two decades ago. To date, the true complication rate of single-incision laparoscopic cholecystectomy is unknown. It can only be hoped that the lessons learned in the implementation of laparoscopic cholecystectomy will guide adherence to certain dogmatic principles in the name of patient safety.

Cholecystectomy is performed with a low morbidity rate across the world, but one important factor with laparoscopic approaches to the gallbladder is the ability to see the "critical view." Most surgeons who routinely perform laparoscopic cholecystectomy would be greatly disinterested in a new technique if the critical view was compromised. For all the cases in this series, the critical view was obtained (Fig. 6), using the combination of one or more traction sutures, an articulating grasper, and an angled laparoscope. We believe that the inability to achieve the critical view at this time should result in "conversion" to standard laparoscopic cholecystectomy.

It also is important to note that all the patients in this series had normal liver function tests, a normal common bile duct diameter on ultrasound imaging, and no anatomic questions at the time of surgery. In all cases, cholangiography was omitted. Although it was potentially possible to place a Kumar Pre-View Cholangiography clamp (Nashville Surgical Instruments, Nashville, TN, USA) across the infundibulum of the gallbladder or to place other percutaneous cholangiography catheters via an angiocatheter

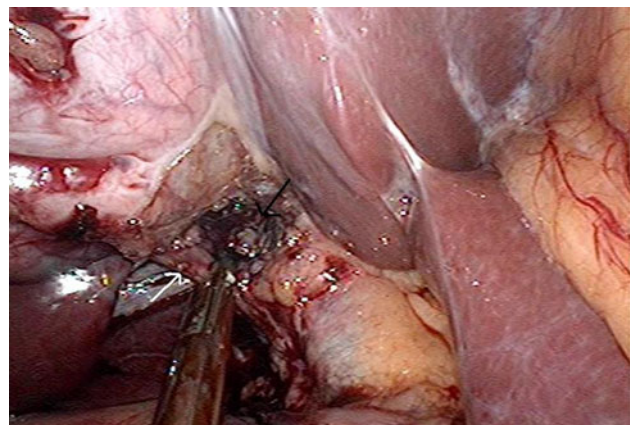


Fig. 6 Critical view of the cystic duct (white arrow) and divided cystic artery (black arrow)

through a separate 1-mm incision, we did not attempt this in our series of patients, and the results in terms of operative time should be viewed in that regard.

The question is raised whether the angle of approach from the umbilicus would be appropriate for cholangiography and what effect that would have on the ultimate image obtained. One early case series did report the successful use of cholangiography with a single-port approach [16].

One concept that must be understood with single-port or single-incision surgery is cross-handedness. Early in our experience, we tended to struggle with hand placement outside the abdomen because the sphere of space that the external components of the instrumentation and the surgeons' hands inhabit is decidedly smaller. To obtain a reasonable angle of distraction of the tissues in the operative field, the surgeon must cross hands such that the instrument on the left side of the monitor is the surgeon's right hand, and vice versa. In fact, with our operative technique, the dissection is performed with the surgeon's left hand, something that may cause discomfort to right-hand-dominant surgeons. A recent review article on single-port surgery authored by our group [33] contains a more detailed discussion on this subject and the ramifications it has for single-site surgery.

Although a look at our learning curve shows a general trend toward faster operating times, it is difficult to determine how fast the learning curve is decreasing for two reasons. First, the procedures were not all performed by a single surgeon, and the second surgeon performed only three of the procedures, so the two surgeons occupied different places "on the curve." Second, the variety of devices and techniques used is a confounding variable with regard to calculation of the reduction in operative times. A single surgeon's series with one device and technique would provide a much more accurate way to determine how many cases constitute the learning curve for single-port or single-incision laparoscopic cholecystectomy. Nonetheless, we suspect that our mean operative time of 80.8 min approaches our mean operative time of 73.4 min for all laparoscopic cholecystectomies in the preceding 2 years by the primary surgeon (J.R.R.), although the latter series also includes patients with acute cholecystitis as well as those who required cholangiography, which in many cases may take longer to perform safely.

One complication occurred in this series, namely, an incarcerated hernia at the site of the single incision. Although this complication may cause alarm, it is fair to suggest that incarceration certainly is more possible with a larger fascial opening. The larger skin incision should have made it this easier to see compared with a standard 12-mm trocar site. Nonetheless, this complication did occur, and recognition of this potential problem with a new approach demands attention. No patients in the series experienced

complications related specifically to the cholecystectomy (i.e., bile leaks or ductal injuries).

Conclusion

Single-port or single-incision laparoscopic surgery is a new technique that can be performed with fewer skin incisions. This potentially allows for less pain and faster recovery, although future studies are needed to reach this conclusion. The placement of the single infraumbilical incision also may confer a cosmetic benefit to patients. Although devices to facilitate single port procedures are becoming widely available, development of new instrumentation may allow for the wide dissemination of these techniques into the hands of many surgeons. The procedure appears to be safe because the critical view was visualized in all cases. Although the length of the learning curve remains unclear, understanding basic concepts about single-port or single-incision surgery will help the surgeon achieve successful results.

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