Single-Incision Laparoscopic Surgery for Cholecystectomy

A Retrospective Comparison With 4-Port Laparoscopic Cholecystectomy

Andre Chow, BSc, MRCS; Sanjay Purkayastha, MD, MRCS; Omer Aziz, BSc, MRCS; Dina Pefanis, BSc, MBBS; Paraskevas Paraskeva, PhD, FRCS

Objectives: To report our experience with single-incision laparoscopic surgery (SILS) for cholecystectomy and to perform a retrospective comparison with conventional 4-port laparoscopic cholecystectomy.

Design, Setting, and Patients: Data were prospectively collected for all patients undergoing SILS for cholecystectomy at St Mary's Hospital, Imperial College NHS Trust, London, England (n=41 patients between June 13, 2008, and June 30, 2009) and compared with data for those who had undergone conventional 4-port laparoscopic cholecystectomy in the preceding year (n=58 patients between June 26, 2007, and May 30, 2008). This included patient demographic data and intraoperative and postoperative outcomes.

Interventions: Four-port laparoscopic cholecystectomy and SILS for cholecystectomy.

Main Outcome Measures: Operative time, conversion to open operation, and length of hospital stay.

Results: Operative time was longer with SILS for cholecystectomy compared with conventional laparoscopic cholecystectomy (P < .001). A correlation was seen between reducing SILS operative time and increasing experience (Spearman rank correlation coefficient, −0.29). Three patients in the SILS for cholecystectomy group required the addition of extra laparoscopic ports. No patients in the SILS for cholecystectomy group required conversion to open surgery compared with 4 patients in the standard laparoscopic cholecystectomy group. Patients stayed an average of 0.76 days following SILS for cholecystectomy and 1.53 days following conventional laparoscopic cholecystectomy. One patient in each group had a postoperative biliary leak.

Conclusions: Single-incision laparoscopic surgery for cholecystectomy may be equal to conventional laparoscopic cholecystectomy in terms of safety and efficacy. Further randomized studies are required to investigate any significant advantages of this new and attractive technique.

Arch Surg. 2010;145(12):1187-1191

MINIMALLY INVASIVE SURGERY allows us to undertake complicated surgical procedures with minimal surgical trauma. Uptake of laparoscopic techniques has been rapid despite initial reservations, with laparoscopic approaches now being thought of as the gold standard in surgical conditions such as gallstone disease and benign and a significant proportion of malignant colorectal pathological conditions.

Recently, surgeons have begun performing laparoscopic surgery through a single umbilical incision. The potential benefits of this method include reducing port-site complications owing to the reduced number of incisions required. This may also lead to reduced postoperative pain and earlier return to normal function. Added to this is the prospect of virtually scarless surgery as the surgical incision can be almost completely hidden within the umbilicus.

Although several groups advocate the feasibility of single-incision laparoscopic surgery (SILS) for a number of procedures including appendectomy, cholecystectomy, sleeve gastrectomy, gastric banding, colectomy, and nephrectomy, this does not in itself justify its use. The benefits of this new technique have yet to be proven, and at present there is little evidence comparing conventional laparoscopy with the SILS approach.

The aims of this analysis are to report our experience with the use of SILS for...
cholecystectomy and to perform a retrospective comparison with conventional 4-port laparoscopic cholecystectomy.

**METHODS**

**DATA COLLECTION**

Retrospective data collection was carried out from a combination of case notes and the operating theater database. Single-incision laparoscopic surgery for cholecystectomy was performed following local ethical approval by the internal review board at Imperial College NHS Trust, London, England. All patients undergoing SILS for cholecystectomy were operated on by a single surgeon (P.P.). Data were logged in a prospectively updated database. All patients awaiting laparoscopic cholecystectomy were considered for SILS for cholecystectomy, and they were excluded only in the presence of previous extensive upper abdominal surgery and when the patient chose to undergo conventional laparoscopic cholecystectomy. Data for patients undergoing conventional laparoscopic cholecystectomy were included in this study. Patients undergoing conventional laparoscopic cholecystectomy were operated on by surgeons-in-training as well as by the consultant surgeon (P.P.). Collected data included patient demographic characteristics, preoperative investigations, intraoperative data (intraoperative complications, conversion to open surgery, and duration of surgery), and postoperative data (including length of stay and early complications [within 28 days of surgery]). Patients were analyzed on an intention-to-treat basis. All patients awaiting cholecystectomy underwent full preassessment including imaging of the biliary tree by ultrasonographic scanning or magnetic resonance imaging and liver function tests. Patients with suspected biliary tree obstruction were referred for endoscopic retrograde cholangiopancreatography prior to operation.

**DATA ANALYSIS**

Data were analyzed with the Microsoft Excel software package (Microsoft Corp, Redmond, Washington). The Spearman rank correlation was used to investigate any relationship between operative time and experience. Significant differences between groups were investigated using the t test.

**SILS CHOLECYSTECTOMY TECHNIQUE**

This procedure has been described previously. In summary, the operation is performed under general anesthesia with the patient positioned in the modified Lloyd-Davies position. The umbilicus is everted with a Littlewoods Forcep and 2-0 Prolene stay sutures (Ethicon, Inc, New Brunswick, New Jersey) inserted. An incision is made between the stay sutures. For the best cosmetic result, it is important that the incision does not breach the umbilical ring. Dissection is continued, followed by a fascial incision with the peritoneum opened under direct vision. A blunt 10-mm trocar (Covidien, Mansfield, Massachusetts) is inserted and the pneumoperitoneum is established. Laparoscopy can proceed with a 5-mm, 30° laparoscope. One or two additional 5-mm Dexide ports (Covidien) are inserted through the fascia adjacent to the 10-mm port. The Calot triangle is then dissected in the standard manner using standard straight or roticator instruments (Covidien). However, in our experience, using supporting stitches to maneuver the gallbladder can aid in retraction and improve visualization of the Calot triangle. It is very important to achieve the critical view of safety to correctly identify the cystic duct.1,2,3 A 1 Prolene suture (Ethicon, Inc) on a straight needle is passed into the abdomen under direct vision in the right subcostal region. This is passed through the gallbladder fundus before being pushed out of the abdominal cavity again. This can be used as a pulley to elevate the fundus ventrally. A second suture can be placed from the subxiphoid position and inserted through the Hartmann pouch, exiting the abdominal cavity through the right lateral abdominal wall. Placement of titanium clips on the suture using the Endo Clip device (Covidien) on either side of the Hartmann pouch allows the gallbladder to be pulled from side to side by traction on the sutures. Once the cystic artery and duct have been exposed, they are clipped using a 10-mm clip (Endo Clip; Covidien) and divided. The gallbladder is then dissected off the liver bed with diathermy and removed.

**RESULTS**

**PATIENTS**

Fifty-eight patients underwent standard 4-port laparoscopic cholecystectomy between June, 26, 2007, and May 30, 2008, and 41 patients underwent SILS for cholecystectomy from June 13, 2008, to June 30, 2009 (Table). The standard laparoscopic cholecystectomy group consisted of 42 women and 16 men, and the SILS for cholecystectomy group consisted of 29 women and 12 men. The patients undergoing standard laparoscopic cholecystectomy were significantly older than those undergoing SILS for cholecystectomy (mean age, 50.9 vs 43.3 years, respectively; P = .02). There was no significant difference between groups regarding patient body mass index (BMI) (calculated as weight in kilograms divided by height in meters squared; mean, 28.2 for standard laparoscopic cholecystectomy vs 26.6 for SILS for cholecystectomy, respectively; P = .18). Eleven patients in the standard laparoscopic cholecystectomy group had a history of cholecystitis demonstrated on imaging, whereas 10 patients had a history of cholecystitis in the SILS for cholecystectomy group. Two patients in each group underwent surgery in the acute setting as a “hot” gallbladder. Two patients in the SILS for cholecystectomy group required preoperative endoscopic retrograde cholangiopancreatography and sphincterotomy for common bile duct stones compared with 7 patients in the standard laparoscopic cholecystectomy group. Three patients in each group had previously had acute pancreatitis. The remaining patients in both groups had a diagnosis of biliary colic.

**OPERATIVE COURSE**

Of the SILS for cholecystectomy group, 3 patients required the addition of extra laparoscopic ports. Two patients required a standard 4-port laparoscopic cholecystectomy, and 1 patient required a single port to be added in the epigastrium. The need for insertion of additional ports was owing to technical difficulty with failure to adequately expose the Calot triangle secondary to extensive adhesions. There were no conversions to open surgery in the SILS for cholecystectomy group. In the standard laparoscopic group, 4 patients required conversion to open sur-
The first-ever SILS for cholecystectomy at our institution took 202 minutes to perform, with the most recent case taking 75 minutes, demonstrating a 63% reduction in operating time over 41 cases. There was a correlation of reduced SILS operative time with increasing experience, with a Spearman rank correlation coefficient of −0.29. Overall, SILS for cholecystectomy took longer to perform than standard laparoscopic cholecystectomy (mean [SD], 126.0 [42.9] vs 95.8 [33.1] minutes, respectively; P < .001). If patients with a history of acute cholecystitis were excluded from the analysis, the mean operative times were 120.3 and 91.1 minutes, respectively.

POSTOPERATIVE COURSE

Patients stayed in the hospital for a mean of 0.76 days following SILS for cholecystectomy and 1.53 days following standard laparoscopic cholecystectomy. Although this demonstrates a trend toward a reduced postoperative stay following SILS for cholecystectomy, this difference did not reach statistical significance (P = .07).

In total, 2 patients had a postoperative biliary leak. The first patient underwent standard laparoscopic cholecystectomy that was converted to open surgery owing to multiple adhesions. Endoscopic retrograde cholangiopancreatography revealed persistent biliary leakage from the cystic duct remnant. This patient required transfer to our hepatobiliary unit. The second patient underwent SILS for cholecystectomy. Postoperatively, she was found to have biliary leakage from an accessory duct of Lushka. This settled with percutaneous drainage and endoscopic management.

One patient in the standard laparoscopic cholecystectomy group had a postoperative intra-abdominal hemorrhage forming a large hematoma in the gallbladder fossa. This was treated conservatively and did not require reoperation.

One patient in the standard laparoscopic cholecystectomy group had a minor wound infection. There were no other early postoperative complications in either group.

COMMENT

In this study, we have performed a comparative analysis of our experience of SILS for cholecystectomy vs standard laparoscopic cholecystectomy. There are several limitations to the study. The study was retrospective, thus increasing the risk of bias. Study groups were not sufficiently powered to detect differences of rare complications such as a biliary leak. Study groups were not matched or randomized and were taken from separate periods. These issues may well have affected our results. Analysis of patient demographic characteristics has demonstrated that although patient groups were similar in terms of BMI, patients undergoing standard laparoscopic cholecystectomy were significantly older than patients undergoing SILS for cholecystectomy. This indicates that patient groups were not well matched. Also, although all SILS for cholecystectomy procedures were performed by the same surgeon (P.P.), the standard laparoscopic cholecystectomy procedures were performed by multiple surgeons. These caveats must be kept in mind while interpreting results.

At present, the operating time for SILS for cholecystectomy is significantly longer than for standard laparoscopic cholecystectomy, with an average difference of approximately 30 minutes. Analysis with Spearman rank correlation has demonstrated a relationship between reduction in operating time and increasing experience. Similarly, the last 5 cases took significantly less time to perform than our initial 5 cases. This demonstrates the learning curve required when using a new technique such as SILS. The surgical team is still early in the learning curve for this procedure, and we fully expect operating times for SILS for cholecystectomy to continue to improve in the future. This may be aided by the development of new instrumentation specifically for SILS. It may also be possible to reduce the effect of the learning curve by simulator-based training, which has been demonstrated to improve performance during real laparoscopic procedures in terms of operative time and surgical error. Introduction of a virtual reality training curriculum for laparoscopic cholecystectomy has been considered recently, and it may be beneficial for the SILS technique to be included in this program. Single-incision laparoscopic surgery for cholecystectomy was performed successfully in patients with BMIs ranging from 18 to 42, indicating that morbid obesity is not a contraindication to this technique. Also, 2 patients in the SILS for cholecystectomy group had undergone previous mid-
line laparotomy, indicating that previous abdominal surgery is also not a contraindication to SILS.

Postoperative length of stay was found to be shorter in the SILS for cholecystectomy group compared with the standard laparoscopic cholecystectomy group, but this did not reach statistical significance. Although this is an encouraging finding that may imply reduced pain postoperatively, we must be careful not to draw firm conclusions. This study did not measure pain scores objectively, and multiple administrative and hospital protocol-related factors such as increased use of the day surgery unit in 2008 to 2009 compared with 2007 to 2008 may be responsible for the difference in postoperative length of stay. Similarly, the fact that our patient groups were not matched, with patients undergoing standard laparoscopic cholecystectomy being older than those undergoing SILS for cholecystectomy, may explain this apparent difference. Currently, many laparoscopic cholecystectomies are being performed in the day surgery setting, with patients expected to go home within 23 hours of operation. In this setting, this analysis would not be expected to demonstrate a reduced postoperative time course following SILS. It may, however, demonstrate that SILS for cholecystectomy has not led to longer postoperative stay compared with standard laparoscopic cholecystectomy.

Postoperative complications occurred in both surgical groups. Although the numbers in this study are far too few to detect significant differences in rare complications such as biliary leakage, it is encouraging to note that at present there is no trend to suggest that SILS may increase operative risk. In the case of intraoperative difficulty, we advocate the addition of extra laparoscopic ports to improve surgical dexterity. Additional ports can be added with ease to convert SILS for cholecystectomy to a 2-, 3-, or 4-port laparoscopic cholecystectomy. It is important to realize that the addition of further ports should be thought of as not as a failure of the SILS technique but as the correct action for a difficult case. It is the practice of our department to consent patients for a laparoscopic cholecystectomy with the use of a single incision to 4 incisions depending on the level of surgical difficulty. In our unit, patients suspected of having biliary obstruction are referred for preoperative endoscopic retrograde cholangiopancreatography. Intraoperative cholangiography is not routinely performed. Should intraoperative cholangiography be required, it is our view that this would be possible using the SILS technique with the aid of the suspending sutures.

One of the critical steps of laparoscopic cholecystectomy is achieving the critical view of safety to correctly identify the cystic duct and avoid injury to the common bile duct. In our experience, the use of a high-quality, 30° laparoscope with an experienced camera operator, together with the suspending sutures, allows good visualization of the Calot triangle. In the future, new flexible laparoscopes as well as techniques for visualizing the biliary anatomy such as the use of intravenous indocyanine green with fluorescent imaging may help to further reduce the risk of bile duct injury.

Single-incision laparoscopic surgery has the potential of further minimizing the trauma associated with surgical access. In addition to improved patient cosmesis and satisfaction, there may be a reduction in the number of port-site complications such as port-site hernias, which have been reported in up to 5.2% of patients undergoing laparoscopic cholecystectomy. However, SILS does have several obstacles that need to be addressed.

Single-incision laparoscopic surgery is not ergonomic for the surgeon, who must adapt to a new method of positioning and instrumentation. As the camera and instruments are introduced through the same port, the traditional laparoscopic principal of triangulation is lost. The operator often works in positions where his or her right hand is controlling the left-sided instrument on screen and vice versa. This reversed view can make movements less intuitive than in conventional laparoscopic surgery, leading to the need for increased concentration. Accurate communication between operator and assistant is vital as movements of the camera can easily impede the operating surgeon. Instruments often interfere with each other within the abdomen and extracorporeally, where attachments such as the camera light lead often restrict movement. These difficulties may be partially alleviated by instruments such as in-line laparoscopes with a longer shaft to allow the assistant to position his or her hands away from those of the operating surgeon.

The first cholecystectomy was performed in 1882, with the first laparoscopic cholecystectomy occurring only approximately 100 years later in 1985. The advent of laparoscopic surgery is an example of a technology that has significantly changed the way surgeons operate today. In its infancy, laparoscopy was beset with numerous obstacles to its progress. Concerns regarding costs, operating times, and possible increased risks of complications such as bile duct leakage have been mostly resolved, although there is still a significantly higher risk of bile duct injury following the laparoscopic approach. Today the laparoscopic approach is the gold standard of treatment for gallstone disease. Although SILS is not as revolutionary a concept as the initial forays into laparoscopy, it is still beset with numerous concerns regarding higher costs, longer operating time, and, among many, a feeling of disbelief regarding its potential advantages. It is important that new surgical techniques are supported by strong evidence to demonstrate their benefits to the patient. In the case of SILS for cholecystectomy, studies so far have demonstrated that it is a safe and efficacious method of surgery. Further clinical trials are now needed to demonstrate the advantages of this new and attractive technique.

This study adds to a growing number of publications demonstrating SILS to be a feasible and safe approach to surgical procedures. Although the small number of patients and retrospective nature of the study preclude us from drawing firm conclusions, we can at least infer that SILS for cholecystectomy may at least be equal to standard laparoscopic cholecystectomy in terms of efficacy and patient safety. Future development of specific instrumentation for SILS will help to overcome ergonomic obstacles to this technique, which may in turn help to reduce the currently prolonged operating time. Large, randomized, prospective studies will be required in the future to investigate the potential benefits of the SILS technique such as reduced port-site complications, reduced postoperative pain, improved cosmesis, and improved pa-
Single-Incision Laparoscopic Surgery

Are We Doomed to Repeat the Mistakes of the Past?

Although Chow and colleagues postulate several potential benefits to SILS, thus far the only proven ones have been improved cosmesis and patient satisfaction. Patient satisfaction is an important outcome variable, but it decreases in importance if the new procedure is associated with increased operative time, increased cost, and/or increased complication rates without any other benefits.

There was a significant learning curve associated with the transition from open to laparoscopic surgery, and many of the arguments made against laparoscopic cholecystectomy 20 years ago are similar to the arguments currently voiced against SILS. However, the transition from open to laparoscopic surgery was associated with significant patient-related benefits including less pain, shortened hospital stay, earlier return to normal activities, and a decrease in some complications. Benefits do not appear to apply to SILS. The benefit is much smaller, yet many people have found the difficulty in learning laparoscopic surgery to be similar to that in learning SILS. Single-incision laparoscopic surgery is associated with significant technical difficulties including poor ergonomics, lack of triangulation, multiple collisions, and need for a skilled assistant.

As we explore this new technique, many of the lessons learned with laparoscopic cholecystectomy need to be ap-

REFERENCES


