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Analysis of perioperative factors and cost comparison of single-incision and traditional multi-incision laparoscopic cholecystectomy

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Abstract
Background Recent technological advances in single-incision platforms have allowed many general surgeons to add single-incision laparoscopic cholecystectomy (SILC) to their armamentarium. However, adopting new surgical technologies comes at a cost to the patient and the surgeon. This study compared retrospective case-matched SILC and traditional multi-incision laparoscopic cholecystectomy (MILC) to evaluate the effects of SILC on perioperative outcomes and patient cost.
Methods The study compared 50 patients who underwent SILC with a case-matched population of individuals who underwent traditional MILC. The SILC technique was performed using one of three commercially available single-incision platforms currently used for single-incision laparoscopic surgery (SILS) cholecystectomies. All the SILS platforms were placed in a 2-cm supraumbilical incision. All statistical analyses were performed using Microsoft Excel 2008 for Macintosh, with statistical significance determined by a p value of 0.05 or less.
Results The average operative time was 42 min for the SILC group and 45 min for the MILC group. The difference was not statistically significant. Similarly, the average estimated blood loss was 14 ml for the SILC group and 11 ml for the MILC group. Again, the difference was not statistically significant. Moreover, the body mass index (BMI) did not differ statistically between the SILC group (28.4 kg/m^2) and the MILC group (32.2 kg/m^2). The average patient cost was $18,447 for SILC and $17,701 for MILC, yielding a cost difference of $746. This difference was not statistically significant.
Conclusions At the authors' institution, SILS cholecystectomy was performed with blood loss, operating room time, and cost equal to that for MILC. Further research is necessary to assess the economic feasibility of SILC and the trade-off of cost with the improved cosmesis, decreased pain, greater patient satisfaction, reduced postoperative analgesic requirement, and faster return to work to determine the overall value and superiority of SILC compared with MILC.

Keywords Laparoscopic cholecystectomy · SILS · SILS cost analysis · Single-incision laparoscopic cholecystectomy · Single-incision laparoscopy

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The first laparoscopic cholecystectomy, completed successfully in 1987, was met with immediate opposition and skepticism. It has since evolved into the standard of care and currently is the most commonly performed laparoscopic procedure in the United States.

Over the past several years, modifications of minimally invasive laparoscopic cholecystectomy have been developed, including single-incision laparoscopic cholecystectomy (SILC). The SILC technique has been developed and performed using a variety of single-incision platforms and ports. As with all new technology, scrutiny of safety and efficacy is essential. Many publications have documented the safety and efficacy of these procedures [1–8].

However, the question remains: Is single-incision laparoscopic cholecystectomy (SILC) superior to the traditional multi-incision laparoscopic cholecystectomy (MILC)?

Materials and methods

After receiving institutional review board (IRB) approval, a retrospective review of the first 50 SILC cases by one surgeon at one institution was completed. The SILC technique was offered to all patients who had a body mass index (BMI) lower than 35 kg/m^2 and no history of hepatobiliary surgery during the period of the study. The patient then was given the choice of undergoing the standard MILC or SILC. This was done after a discussion of both procedures that addressed the risks and benefits of each.

The patients who chose SILC then underwent the single-incision procedure, whereas those who chose MILC underwent the traditional laparoscopic cholecystectomy. The patients in each group during this period required to accrue 50 SILC cases then were used as the cases for the study. The BMI and diagnosis were comparable for all the patients.

All MILCs were performed using the same technique and the same instruments at the same hospital by the same surgeon. The MILC was performed using a Hasson trocar at the umbilicus, three 5-mm step ports, and an Endo Catch bag (Covidien, Mansfield, MA, USA).

The SILC was performed using one of the three following single-incision port platforms via a 2-cm periumbilical incision: GelPOINT (Applied Medical, Rancho Santa Margarita, CA, USA), SILS (Covidien), or TriPort (Advanced Surgical Concepts, Bray, Ireland). Two Davis and Geck atraumatic graspers, a Maryland grasper, laparoscopic scissors, a 5-mm clip applier (Covidien), and a hook electrocautery were used for MILC. All the instruments used for SILC were the same except that only one Davis and Geck (D & G) grasper was used and an Endo Catch bag was not used.

The same surgical instrument sets were pulled for both the SILC and the MILC. Therefore, the difference in number of D&G graspers between the two groups did not change the cost. All the instruments were reusable except the laparoscopic scissors, the Endo Catch bag, and the clip applier.

A 5-mm, 30° camera (Stryker, Kalamazoo, MI, USA) was used for the MILC cases, and a 5-mm, 30° bariatric camera (Stryker) was used for the SILC cases.

Both the MILC and the SILC were performed using the same technique after the corresponding trocars were placed. For the MILC, three 5-mm ports were placed in the epigastrium and in the right upper quadrant, and one 10-mm incision was made at the umbilicus.

For the SILC cases, only one 10-mm incision was made at the umbilicus. The gallbladder was retracted cephalad and laterally. The cystic artery and duct were dissected from the surrounding tissues. The "critical view" was obtained, identifying the cystic artery, duct, common bile duct, and liver edge (Fig. 1). The cystic artery and duct were clipped using a 5-mm clip applier to place two clips proximally and one clip distally. Both structures then were divided using a laparoscopic scissors.

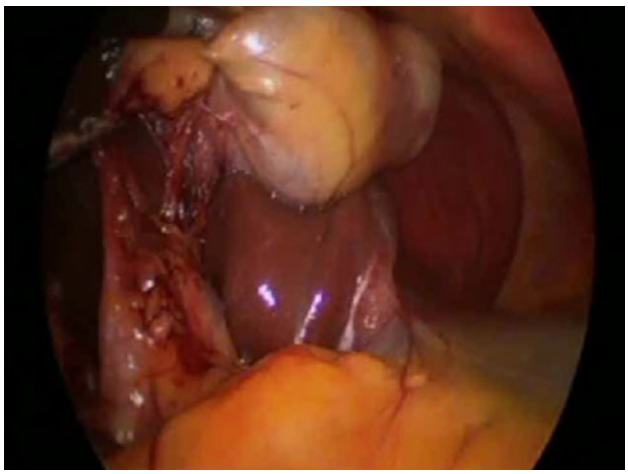

Fig. 1 Critical view of the cystic duct, cystic artery, and liver edge as completed during a single-incision laparoscopic cholecystectomy

Next, the gallbladder was dissected from the gallbladder fossa using electrocautery. For the MILC cases, the gallbladder then was placed in an Endo Catch bag to ensure wound protection and delivered through the umbilical incision. For the SILC cases, the gallbladder was retracted into the single-incision port and delivered out through the umbilical port together with the entire port to protect the wound. Because the single-incision ports have wound protectors as part of their device, no Endo Catch bag was needed.

The operative time and estimated blood loss (EBL) were recorded and compared because these can have a significant effect on both the patient's recovery and the overall cost and efficiency of a procedure. The cost end point was determined by the total hospital charges.

All statistical analyses were performed using Microsoft Excel 2008 for Macintosh (Redmond, WA). Statistical significance was determined by a p value of 0.05 or less.

Results

Because the surgical technique was standardized across the SILC and MILC groups, the major difference was in the ports used. As mentioned previously, the SILC was performed using one of three commercially available single-incision platforms: TriPort, GelPOINT, or Covidien's single-incision port. The MILC was performed using a Hasson trocar and

Table 1 Instrument costs for single-incision laparoscopic cholecystectomy (SILC) and multi-incision laparoscopic cholecystectomy (MILC)

	SILC	MILC
Cost for standard instruments unique to each technique[a,b]	$335.75–573[c]	$399.83

[a] Excluding the cost of instruments used in both procedures such as a 5-mm clip applier

[b] SILC requires one single-incision port platform; MILC requires one Hasson trocar, three 5-mm ports, and an Endo Catch™ bag

[c] The exact cost depends on the brand of the single-incision port used

Table 2 Cost analysis

	SILC ($n = 50$)	MILC ($n = 50$)	p Value
Average total cost	$18,442.96	$17,701.33	>0.05
SD	10,052.71[a]	$4170.54	
Maximum cost	$92,412.00[b]	$38,235.60[c]	
Minimum cost	$12,240.50	$12,240.50	
Average within one	$17,043.90	$16,873.52	>0.05

SD standard deviation

[a] SD affected by large outlier

[b] Maximum outlier due to prolonged preoperative stay on a medical service secondary to unrelated pathology

[c] Maximum outlier secondary to postoperative one-night stay with continuous pulse oximetry and telemetry due to severe sleep apnea

three 5-mm ports, all of which were disposable, based on hospital practices.

The use of differing ports and the use of an Endo Catch bag were the only standardized differences in equipment use across the groups. The costs of these differences are reflected in Table 1. The single-incision platforms cost between $335.75 and $573. The ports used in a MILC cost $323.53 at our hospital. The Endo Catch bag costs $76.30, which does not significantly increase the cost of the MILC compared with SILC.

The difference in these costs is minimal compared with the overall cost, thus showing that the equipment cost itself does not significantly affect the cost difference between the two groups. Notably, because two of the single-incision ports come with a wound protector, an Endo Catch bag is not needed with SILC. However, our standard practice during a MILC is always to use an Endo Catch bag.

The patients' costs, as reflected in hospital charges, are shown in Table 2. The average cost of the SILC was $18,442.96, whereas the average cost of the MILC was $17,701.33. The cost difference between the two groups was not significant.

However, there were several outliers in the two groups. The patient with the highest hospital cost in the SILC group had an extended preoperative stay on a medical service

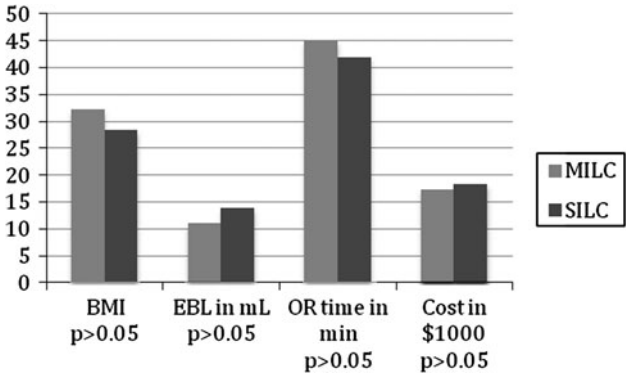

Fig. 2 Results for the primary end points: body mass index (BMI), estimated blood loss (EBL), operating room (OR) time, and cost

before the surgical team was consulted and before the surgery. Unfortunately, this cost could not be broken down further for our study due to the manner in which the data was collected. It is outside one standard deviation of the mean for this group. The patient with the highest cost in the MILC group had an increased cost due to the need for 24 h of continuous pulse oximetry and telemetry secondary to severe sleep apnea. When the patients with costs outside one standard deviation are removed, there still is no significant difference in the costs between the two groups.

No significant difference in our primary end points (BMI, estimated blood loss, operative time, and cost) was discovered between the two groups, as reflected in Fig. 2. In all end points, SILC was equal to MILC, the standard of care. Therefore, SILC is as efficacious, with the same cost.

Discussion

Single-incision surgery is becoming more prevalent in many fields of surgery and encompasses many different procedures. Due to the prevalence of symptomatic cholelithiasis and other biliary pathologies requiring cholecystectomy, laparoscopic cholecystectomy is the most common laparoscopic procedure currently performed in the United States. The experience with MILC therefore allows an easier transition to a single-incision cholecystectomy compared with other single-incision procedures. Many have documented the safety and efficacy of this procedure compared with the standard laparoscopic cholecystectomy. Currently, the debate is focused on the value in SILC and the added benefit of performing this procedure through a single incision when the standard cholecystectomy has such great outcomes.

The important components of value potentially associated with SILC include no increase in operative time, an acceptable learning curve, less pain, faster return to work postoperatively, improved cosmesis, and consumer demand. Although many have mentioned improved cosmesis and

ability to hide the incision in the umbilicus, making the scar invisible, conflicting results have been presented in the literature. Aprea et al. [9] and Bucher et al. [10], however, have shown improved cosmesis for patients undergoing SILC, as determined by postoperative surveys of their patients.

Less perioperative pain, decreased use of pain medication, and faster return to work have been shown with SILC [10, 11], yet others have shown no difference in pain or time until return to work [3]. This aspect is very important in determining the overall cost and value of a procedure. When a patient undergoes an operation, he or she must take time off work, not only for the operation itself, but also for convalescence. For many patients, return to work can be accomplished only when narcotic use is no longer required. In addition, family members often also take time off work to help care for the patient at home. Both of these leaves of absence decrease overall productivity and therefore result in an increased cost to society as a whole. Minimizing postoperative narcotic use and leave from work decreases the overall cost of a procedure and increases its overall value to society. This is an important factor to consider when the benefits of a new procedure are determined. Although these data can be collected easily from patients using postoperative surveys, it is highly biased by the individual patient. Nonetheless, this factor should be considered when the overall cost of a procedure is evaluated.

The operative time and the total cost of the procedure, however, can be studied without patient bias, and these directly affect outcome. Increased operative time has a direct effect on cost because operating room time typically is charged in 15-min increments. This also has an important influence on patient safety. Without question, the longer a patient is on the operating table, the more susceptible he or she is to perioperative complications such as deep vein thrombosis and pneumonia. This is amplified in obese patients, and obesity often is a characteristic of patients with cholelithiasis and other biliary pathology.

Because this is a concern for new surgical procedures, the learning curve, as it affects operative time, is very important. Several groups have shown an acceptable learning curve for both attending and resident surgeons. This should then translate into comparable operative times for both procedures [2, 12, 13].

In fact, several other groups have demonstrated no increase in operative time or operative costs [2, 8, 13]. Joseph et al. [4] performed a retrospective analysis of SILC versus the standard laparoscopic cholecystectomy. A multivariate regression analysis was performed to control for a variety of patient, hospital, and disease factors in comparing the two surgical techniques. No significant difference was found between the two techniques. These authors also found that the costs were dependant on operative times and instrument costs. When these costs were equivalent, the overall costs of the procedures were equivalent.

Similarly, Love et al. [14] found that the costs were similar in their comparison of MILC and SILC because they did not use any different instruments in the two cases, and the operative times were similar. Our data also indicate equivalent operative time and cost.

Although the value of a procedure can be difficult to measure, an important component is a patient's viewpoint of the procedure. If patients desire SILC over MILC due to perception via word of mouth that SILC results in improved cosmesis and decreased pain, inspiring their desire for the "newest and best" procedure, they will seek surgeons that can perform this procedure. As patient demand increases for single-incision and incisionless surgery, the value of these procedures rises for surgeons and hospitals due to the influx of patients requesting these techniques [8].

Health care costs have reached unprecedented heights in the United States. Furthermore, efficiency and cost effectiveness in health care delivery are topics of discussion from the individual to the state and federal governments. Therefore, it is of utmost importance that the bottom-line dollar cost remain low for new surgical techniques.

Our findings indicate that SILC can be performed at a cost similar to that of the gold standard while equal operative time and blood loss is maintained in comparable patient populations. More studies are needed with larger patient enrollments across many hospitals and surgeons to ensure value as determined by overall cost, which includes such factors as improved cosmesis, less pain, patient satisfaction, hospital charges, and faster return to work within a patient population.

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