Single-Incision Laparoscopic Cholecystectomy: Initial Experience with Critical View of Safety Dissection and Routine Intraoperative Cholangiography

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BACKGROUND: Single-incision laparoscopic cholecystectomy (SILC) is emerging as a potentially less invasive alternative to standard laparoscopic cholecystectomy and natural orifice transluminal endoscopic surgery cholecystectomy. As this technique is more widely used, it is important to maintain well-established practices of the critical view of safety (CVS) dissection and intraoperative cholangiography (IOC). We present our initial experience with SILC using CVS dissection and routine IOC.

STUDY DESIGN: Fifty-four patients with biliary colic were offered SILC, which was performed through the umbilicus. CVS with photo documentation was attained before clipping and transecting the cystic structures. IOC was done using various needle puncture techniques. Assessment of CVS was carried out by independent surgeon review of operative still photos or videos using a 3-point grading scale: visualization of only 2 ductal structures entering the gallbladder; a clear triangle of Calot; and separation of the base of the gallbladder from the cystic plate.

RESULTS: SILC was performed in 54 patients (15 male and 39 female). Six patients required 1 supplementary 3- or 5-mm port. Complete IOC was successful in 50 of 54 patients (92.6%). CVS was achieved at the time of operation in all 54 patients. Photo documentation review confirmed 3 of 3 CVS criteria in 32 (64%) patients, 2 of 3 in 12 patients (24%), 1 of 3 in 3 patients (6%), and 0 in 3 patients (6%).

CONCLUSIONS: As laparoscopic cholecystectomy becomes less invasive, proven safe dissection techniques should be maintained. Dissection to obtain the CVS should be the goal of every patient and IOC can be accomplished in a high percentage of patients. This approach places patient safety considerations foremost in the evolution of minimally invasive cholecystectomy. (J Am Coll Surg 2010;211:1–7. © 2010 by the American College of Surgeons)

Laparoscopic cholecystectomy (LC) has been the gold standard for removal of the gallbladder since the early 1990s.[1] As technology has progressed, surgeons have begun to develop less invasive methods for this commonly performed procedure. In 1997, Navarra and colleagues performed the first single-incision laparoscopic cholecystectomy (SILC).[2] In 2007, the first natural orifice transluminal endoscopic surgery (NOTES) cholecystectomy was performed by Marescaux and colleagues.[3] The NOTES approach eliminated an abdominal wall incision, but concern about closing the access route to the abdomen (eg, gastrotomy), lack of standardized equipment, and technical challenges have precluded the applicability of this investigative approach beyond a small number of centers. Unlike NOTES, laparoscopic surgery through a single-incision access site can be performed with existing instrumentation, although some specialized equipment has been developed and is readily available.

As more reports of SILC appear in the literature, it is critically important that the same dissection principles and operative goals be maintained that have been in place for standard LC for many years. The foremost of these is dissection to the critical view of safety (CVS) described in 1995.[4] In addition, the ability to carry out intraoperative cholangiography (IOC) should be an integral requirement

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Abbreviations and Acronyms

CVS = critical view of safety
IOC = intraoperative cholangiography
LC = laparoscopic cholecystectomy
NOTES = natural orifice transluminal endoscopic surgery
SILC = single-incision laparoscopic cholecystectomy

of any new approach to surgical removal of the gallbladder. In July 2008, we initiated a program of SILC at our institution, with the goal of obtaining the CVS dissection and performing routine IOC. We now report our early results with this technique and review rates of obtaining the CVS and performing an IOC in the first 54 patients.

METHODS

A retrospective medical record review was carried out of 54 consecutive patients undergoing a single-incision approach to LC from July 2008 through October 2009. All procedures were performed by 2 attending surgeons (LMB and BDM) with assistance by a surgical resident or Minimally Invasive Surgery Fellow. Study approval was obtained from the Institutional Review Board of the Washington University School of Medicine and Barnes-Jewish Hospital.

Patients selected for the SILC approach had uncomplicated symptomatic gallstone disease or biliary dyskinesia. Exclusions for the SILC approach were acute cholecystitis or previous periumbilical midline abdominal surgery. Patients with severe morbid obesity were also generally not considered candidates for this approach. Data analyzed included patient demographics (ie, age, gender, body mass index, American Society of Anesthesiologists score), operative time, operative approach (ie, 2- versus 3-port technique), results of attempted cholangiography, postoperative length of stay, and complications. Data presented are mean ± SD (range).

Operative technique

All laparoscopic cholecystectomies were initiated as a single-site technique. The initial incision was a 1.5- to 2-cm vertical incision made directly through the umbilicus or a transverse supraumbilical incision. Pneumoperitoneum to 15 mmHg was created either by direct insertion of a 5-mm optical trocar through the natural fascial defect at the umbilicus or by a Veress needle insertion at that location, followed by optical trocar placement. Flaps were dissected cephalad for 2 to 3 cm and a second 5-mm low-profile trocar (Covidien or Apple Medical) was placed above the initial port. The gallbladder was identified and the fundus was exposed. For the 2-port technique with a double-suture retraction method, a 2-0 Prolene (Ethicon) suture on a Keith needle was then inserted through the abdominal wall in the mid-clavicular line and was retrieved intra-abdominally. This suture was then passed through the fundus of the gallbladder and back out the abdominal wall to provide cephalad retraction. A second suture was placed through the abdominal wall just to the right of the falciform ligament and was then passed through the infundibulum of the gallbladder and returned outside the body at the right mid-axillary line 2 cm below the rib. Clips were placed on the suture on each side of where it exited the gallbladder neck. This allowed the gallbladder to be "puppeteered" back and forth in order to provide medial and lateral retraction and to expose both the anterior and dorsolateral views of the hepatocystic triangle. Alternatively, a 3-port technique with a single suture for retraction of the fundus was used in which a 3- or 5-mm low-profile trocar was placed above and to the left of the camera port, which eliminated the need for a retraction suture on the gallbladder infundibulum (Fig. 1). An additional 3- or 5-mm port at an alternate site, usually subcostal, was added at the discretion of the attending surgeon if exposure with this approach was inadequate.

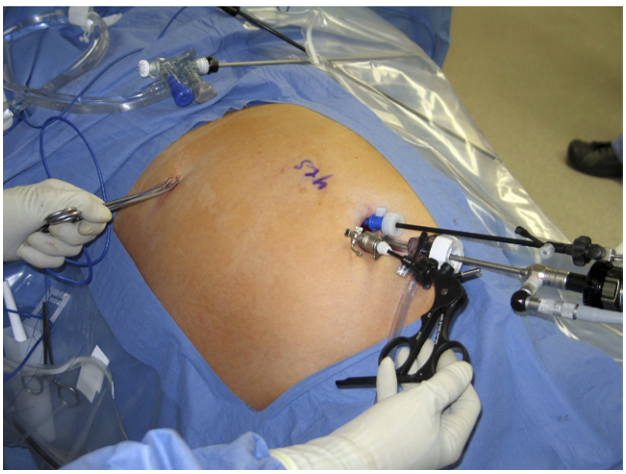

Figure 1. Operative view of 3-port, single-suture retraction single-incision laparoscopic cholecystectomy technique.

In each patient, the primary goal of the dissection was to dissect the hepatocystic triangle to the CVS. This entailed isolation of the cystic duct and artery, clearing the hepatocystic triangle of all extraneous tissue, and separating the lower part of the gallbladder from the liver bed (to visualize the cystic plate) before clipping any ductal structures. An IOC was routinely attempted after the CVS was obtained using various needle puncture techniques. Most commonly, a 4F ureteral catheter was introduced into the abdomen either through a reusable Veress needle or a 14-gauge angiocatheter placed at the mid-clavicular line approximately 2 cm below the costal margin. The catheter

Table 1. Patient Demographics

Patients	
Male, n	15
Female, n	39
Total, n	54
Age (y), mean ± SD (range)	47 ± 17.5 (20−78)
BMI, mean ± SD (range)	27.7 ± 4.7 (17.8−40.9)
ASA score, mean ± SD (range)	2 ± 0.5 (1−3)
Preoperative diagnosis, n	
Symptomatic cholelithiasis	49
Biliary dyskinesia	5

ASA, American Society of Anesthesiologists; BMI, body mass index (calculated as kg/m^2).

was then secured in a standard fashion with a cholangioclamp. After completion of the cholangiogram, the cystic duct and cystic artery were doubly clipped with a 5-mm disposable clip applier and then divided. For patients in whom the cystic duct was thickened, it was further secured with a pretied 0-polydioxanone loop suture. The gallbladder was then dissected off the liver bed using a hook electrocautery and removed at the camera port site by enlarging the fascial opening as needed. All 5-mm fascial defects at the umbilicus were closed using 0-gauge absorbable or nonabsorable suture and the single skin incision site was closed with a 4-0 absorbable subcuticular suture.

Photo documentation

As a part of the implementation strategy for SILC at our institution, an attempt was made to routinely obtain photo documentation of the CVS before clipping and cutting the cystic artery and duct. In some patients, video recording of the CVS sequence was obtained in lieu of still photographs. These images were then independently reviewed by an experienced biliary surgeon (SMS) and were assessed using 3 criteria for the critical view: ie, clear hepatocystic triangle; lower gallbladder dissected off the cystic plate; and 2 and only 2 structures entering the gallbladder.

RESULTS

Fifty-four patients underwent attempted SILC. The mean age was 47 ± 17.5 (range 20 to 78) years, and 72% were female (Table 1). Mean body mass index was 27.7 ± 4.7 (range 17.8 to 40.9). Three patients had a body mass index >35. Five patients had symptomatic biliary dyskinesia and the rest had uncomplicated symptomatic cholelithiasis. All procedures were elective.

Operative results are shown in Table 2. A 3-port, single-site technique was used in 26 patients. The remaining 28 procedures were initiated as a 2-port, double-suture retraction technique. Overall, 6 patients required placement of one 3- or 5-mm subcostal or epigastric port to complete the procedure. There were no conversions to a standard 4-port LC or to an open procedure. Of the 2 approaches, 5 patients required 1 additional 3- or 5-mm subcostal or epigastric port in the 2-port approach versus only 1 in the 3-port technique. One 2-port case also required both the addition of a 5-mm port at the umbilicus and an epigastric port. Mean operating room time was 113.1 ± 27.9 (range 55 to 206) minutes.

Table 2. Operative Results

Operative time (min), mean ± SD (range)	113.1 ± 27.9 (55−206)
Convert to standard laparoscopic cholecystectomy, n	0
Intraoperative cholangiogram, n	54
Completed, n (%)	50 (93)
Completed as single incision	
2-port technique, n	28
No additional ports, n (%)	23 (82)
3-port technique, n	26
No additional ports, n (%)	25 (96)
Total, n	54
No additional ports, n (%)	48 (89)

An IOC was attempted in all patients and was successful in 50 (92.6%) (Fig. 2). The duct could not be cannulated in 3 patients and x-ray was not available in 1 patient after the duct was cannulated. In addition, extravasation of dye from the insertion site resulted in an incomplete IOC in 1 patient. No intraoperative complications occurred.

The surgeon considered CVS to have been achieved in all patients, which was confirmed by review of the operative notes. No photo documentation was available for review in 4 patients. Of the 50 patients in whom photographic or video documentation was achieved, all 3 criteria for the CVS were independently verified in 32 (64%) patients (Fig. 3). In 12 patients (24%), 2 of 3 criteria were identified; in 3 patients (6%), 1 of 3 criteria; and in 3 patients (6%), no criteria were visualized photographically.

There were no intraoperative complications and mean postoperative length of stay was <24 hours. Postoperatively, 2 patients presented with umbilical wound drainage and infection, 1 at 11 days and the other at 25 days after surgery, which resolved with oral antibiotics and open packing. There were no other complications observed during a mean follow-up of 31 ± 9.7 (range 5 to 50) days. Cosmetic outcomes at follow-up were excellent with a minimal, barely visible scar in most patients.

DISCUSSION

Single-incision or single-site approaches to laparoscopic surgery are being increasingly described as potentially less

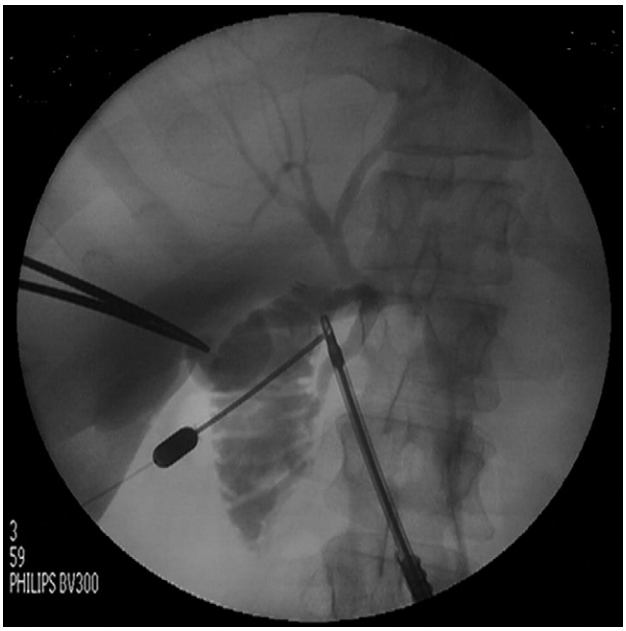

Figure 3. Intraoperative cholangiogram obtained during single-incision laparoscopic cholecystectomy.

Figure 2. (A, B) Photo documentation of the critical view of safety during single-incision laparoscopic cholecystectomy.

invasive, "scarless" procedures, and have been performed for such indications as appendectomy,[5] adrenalectomy,[6] gastric banding,[7] and donor nephrectomy.[8] Despite that SILC was first reported 13 years ago by Navarro and colleagues,[2] the number of procedures performed was limited until the last 2 to 3 years. Development of NOTES cholecystectomy, which leaves no abdominal scar, might be the primary impetus for the recent surge in interest in single-incision laparoscopic approaches.[9] Numerous educational programs and courses, largely sponsored by industry, have been developed to teach surgeons this new approach. A PubMed search using various terms[10] referring to single-incision approaches for cholecystectomy identified 35 different case or series reports to date, which included a total of >500 patients. Because single-incision laparoscopic surgery can be performed with existing "off the shelf" equipment, it appears to be gaining traction in the surgical community, in contrast to NOTES cholecystectomy. In 1 comprehensive review, there were only 25 patients who had undergone a NOTES cholecystectomy compared with 142 who had a SILC procedure.[9]

With the introduction of LC into clinical practice in the 1990s, a concomitant rise in biliary injuries was seen.[4,11-16] Although SILC does not represent as a major a shift in approach or technique, such as that which occurred during the transition from open to LC, there are technical aspects of this operation that are departures from some of the basic tenets of laparoscopic surgery. First and foremost is that, by virtue of placing both the laparoscopic camera port and all dissecting instruments through a single umbilical incision, triangulation between the camera and the working ports is lost. This results in a parallel instrument alignment and an "in-line" view of the anatomy and field of dissection. Because of the closely placed parallel ports, "sword fighting" of instruments can restrict freedom of movement and viewing, as well as dissecting angles. Finally, many surgeons, including our group, have used ≥1 sutures placed directly through the gallbladder to provide retraction and exposure. Although this does allow manipulation of the gallbladder,

the degree of cephalad retraction might not be as great as with a subcostally placed grasper. Also, there is some degree of bile spillage from the suture punctures with this technique.

Biliary injuries continue to occur with standard LC, despite the availability of well-defined strategies for minimizing the risk, including CVS dissection[4,11-13,17] and use of IOC.[14-16] It is critically important, therefore, that any new approach to cholecystectomy maintain safe dissection principles in order to avoid an increase in bile duct injuries, especially when the primary benefit is improved cosmesis.[18] Indeed, the main benefit of the single-incision approach described here might be cosmetic, with minimal or no impact on other outcomes measures, such as postoperative pain, recovery times, or complication rates.

It was with this goal in mind that our group initiated a program for SILC. Before starting SILC, the practice of surgeons performing these procedures was to dissect to the CVS and perform an IOC in every case, an approach we sought to maintain with the single-incision approach. This approach was believed to be successful in achieving the CV dissection in every patient, and this was verified by independent review of operative photographs confirming all 3 CVS criteria in 64% of patients and in 2 of 3 criteria in another 24%. In the 6 remaining patients, 1 or no criteria could be identified on still images. Because the 2 surgeons who performed the SILC procedures in this study were highly experienced with LC and had been carrying out routine CVS dissection for >10 years, it is likely that the failure by the independent observer to confirm that CVS was present in these patients was related more to the ability to take convincing still photos of the CVS than the failure to achieve CVS. In some patients, only 1 still photograph was available for review, which made verification more difficult. Also, in the 4 patients in which a video segment was available for viewing, it was noted by the reviewer that it was much easier to confirm that CVS had been achieved than in still photos. This corresponds with the observation that, intraoperatively, CVS is often easier to see when moving the lower end of the gallbladder. Only 6 of the 35 studies listed in Table 3 mentioned CVS as a part of the dissection, and no documentation or photographic demonstration was found in any of these reports.

Population-based studies across multiple continents have demonstrated a reduction in biliary injury rates by approximately one-third in patients who underwent IOC compared with those who did not.[14-16] As a result, Massarweh and Flum recommended the use of routine IOC as a strategy for reducing the rate of bile duct injury during cholecystectomy.[15] However, most surgeons today perform IOC selectively in their practices. Because routine IOC was a part of our practice before beginning any SILC procedure, we made this an integral part of our implementation strategy for this approach. Using existing equipment in our operating rooms, we were successful in obtaining complete IOC in 93% of our patients. In contrast, only 6 of the 35 studies in Table 3 reported any IOC being done: Navarro and colleagues[2] performed an IOC in 8 of 30 patients, Bresadola and colleagues[19] in 25 of 28, Bucher and colleagues[35] in 10 of 11 patients, Kravetz and colleagues[40] in 1 of 20 patients, and Hernandez and colleagues[42] and Ponsky

Table 3. Published Series of Single-Incision Laparoscopic Cholecystectomy

First author	Publication date	n	Identification	IOC
Navarra[2]	5/1997	30	NR	8
Bresadola[19]	1/1999	28	NR	25
Piskun[20]	8/1999	10	NR	0
Cuesta[21]	5/2008	10	CV	0
Romanelli[22]	9/2008	1	NR	0
Rao[23]	10/2008	20	NR	0
Cugura[24]	12/2008	1	NR	0
Guo[25]	12/2008	1	NR	0
Mutter[26]	12/2008	1	NR	0
Merchant[27]	1/2009	21	NR	0
Hodgett[28]	2/2009	29	NR	0
Gumbs[29]	3/2009	2	NR	0
Petrotos[30]	3/2009	10	CV	0
Kroh[31]	4/2009	1	NR	0
Podolsky[32]	4/2009	5	NR	0
Tacchino[33]	4/2009	12	NR	0
Zhu[34]	4/2009	10	NR	0
Bucher[35]	5/2009	11	NR	10
Langwieler[36]	5/2009	14	NR	0
Ersin[37]	6/2009	20	NR	0
Hong[38]	6/2009	15	IJCBD	0
Nguyen[39]	6/2009	1	CV	0
Kravetz[40]	7/2009	20	IJCBD	1
Chow[41]	8/2009	23	NR	0
Hernandez[42]	8/2009	100	NR	Some
Lee[43]	8/2009	37	NR	0
Ponsky[44]	8/2009	17	NR	Some
Zhu[45]	8/2009	10	NR	0
Chow[46]	9/2009	14	NR	0
Dutta[47]	9/2009	3	NR	0
Dunning[48]	10/2009	12	CV	0
Vidal[49]	10/2009	19	NR	0
Hagen[50]	11/2009	1	CV	0
Philipp[51]	11/2009	29	CV	0
Ersin[52]	1/2010	20	NR	0

CV, critical view; IJCBD, identification of junction of cystic duct to common bile duct; IOC, intraoperative cholangiogram; NR, not reported.

and colleagues[44] each performed "some." In none of the remaining 29 studies was there any mention of an IOC being done or whether the failure to use an IOC was a change from the author's pre-existing practice. Although CVS and IOC can both be attained in the majority of SILC procedures, this study does not establish the safety of the approach with respect to biliary injury. However, it does establish that safe practices associated with a low incidence of biliary injury can be attained.

The primary benefit of the single-incision approach to cholecystectomy reported here appears to be improved cosmetic outcomes. Although not formally studied in our series, several patients commented on their inability to see any scar on the abdomen at their 1 month postoperative visit. The vertical orientation of the incision made directly through the middle of the umbilicus was an alteration from our previous practice of a transverse infraumbilical or supraumbilical incision and allows the scar to be relatively hidden, especially in patients who have a recessed umbilicus. It is unclear whether the umbilical incision used for single-site access will have more complications than with a standard LC. Two patients in our series had superficial umbilical wound infections that were managed by local wound drainage in the office and oral antibiotics. We are not aware of any umbilical hernias in our patients, although the follow-up interval in these patients has been short.

Cost considerations are also an issue with single-incision approaches. Although flexible-shaft disposable instruments and specially designed single-port devices are available to facilitate these procedures, we were able to largely use existing equipment with an additional material cost compared with conventional LC of approximately $410, most of which was for the 5-mm disposable clip applier. In addition to the 5-mm clip applier, some equipment modifications that were essential to these procedures to minimize "sword fighting" or clashing of instruments at the umbilical incision were a right-angle light cord adapter, an L-hook cautery in which the cautery post comes straight out the end, and low-profile accessory ports at the umbilical incision. Whether use of noncautery energy sources, flexible tip laparoscopes, or other special instrumentation will facilitate performance of single-incision procedures enough to make these added devices cost-effective remains to be seen.

In summary, we have shown that dissection to the CVS can be routinely accomplished with a single-incision, transumbilical laparoscopic approach to cholecystectomy. Intraoperative cholangiography can also be successfully performed in a high percentage of patients and we were able to establish photo documentation of the critical view in most patients. Efforts to further reduce the size and/or number of laparoscopic incisions should not compromise these important operative principles of cholecystectomy.

Author Contributions

Study conception and design: Hodgett, Matthews, Brunt
Acquisition of data: Rawlings, Hodgett, Matthews, Quasebarth, Brunt
Analysis and interpretation of data: Rawlings, Hodgett, Strasberg, Quasebarth, Brunt
Drafting of manuscript: Rawlings, Brunt
Critical revision: Matthews, Strasberg, Brunt

REFERENCES

1. Soper NJ, Stockmann PT, Dunnegan DL, Ashley SW. Laparoscopic cholecystectomy. The new 'gold standard'? Arch Surg 1992;127:917–921; discussion 921−923.
2. Navarra G, Pozza E, Occhionorelli S, et al. One-wound laparoscopic cholecystectomy. Br J Surg 1997;84:695.
3. Marescaux J, Dallemagne B, Perretta S, et al. Surgery without scars: report of transluminal cholecystectomy in a human being. Arch Surg 2007;142:823–826; discussion 826−827.
4. Strasberg SM, Hertl M, Soper NJ. An analysis of the problem of biliary injury during laparoscopic cholecystectomy. J Am Coll Surg 1995;180:101–125.
5. Vidal O, Valentini M, Ginestà C, et al. Laparoendoscopic single-site surgery appendectomy. Surg Endosc 2009 Aug 19. [Epub ahead of print].
6. Jeong BC, Park YH, Han DH, Kim HH. Laparoendoscopic single-site and conventional laparoscopic adrenalectomy: a matched case-control study. J Endourol 2009;23:1957–1960.
7. Nguyen NT, Slone J, Reavis K. Comparison study of conventional laparoscopic gastric banding versus laparoendoscopic single site gastric banding. Surg Obes Relat Dis 2009 Nov 10. [Epub ahead of print].
8. Canes D, Berger A, Aron M, et al. Laparo-endoscopic single site (LESS) versus standard laparoscopic left donor nephrectomy: matched-pair comparison. Eur Urol 2009 Jul 28. [Epub ahead of print].
9. Chamberlain RS, Sakpal SV. A comprehensive review of single-incision laparoscopic surgery (SILS) and natural orifice transluminal endoscopic surgery (NOTES) techniques for cholecystectomy. J Gastrointest Surg 2009;13:1733–1740.
10. Romanelli JR, Earle DB. Single-port laparoscopic surgery: an overview. Surg Endosc 2009;23:1419–1427.
11. Strasberg SM, Eagon CJ, Drebin JA. The "hidden cystic duct" syndrome and the infundibular technique of laparoscopic cholecystectomy—the danger of the false infundibulum. J Am Coll Surg 2000;191:661–667.
12. Strasberg SM. Biliary injury in laparoscopic surgery: part 1. Processes used in determination of standard of care in misidentification injuries. J Am Coll Surg 2005;201:598–603.
13. Strasberg SM. Biliary injury in laparoscopic surgery: part 2. Changing the culture of cholecystectomy. J Am Coll Surg 2005; 201:604–611.
14. Fletcher DR, Hobbs MS, Tan P, et al. Complications of cholecystectomy: risks of the laparoscopic approach and protective

effects of operative cholangiography: a population-based study. Ann Surg 1999;229:449–457.
15. Massarweh NN, Flum DR. Role of intraoperative cholangiography in avoiding bile duct injury. J Am Coll Surg 2007;204: 656–664.
16. Waage A, Nilsson M. Iatrogenic bile duct injury: a population-based study of 152 776 cholecystectomies in the Swedish Inpatient Registry. Arch Surg 2006;141:1207–1213.
17. Avgerinos C, Delgiorgi D, Touloumis Z, et al. One thousand laparoscopic cholecystectomies in a single surgical unit using the "critical view of safety" technique. J Gastrointest Surg 2009;13: 498–503.
18. Connor S. Single-port-access cholecystectomy: history should not be allowed to repeat. World J Surg 2009;33:1020–1021.
19. Bresadola F, Pasqualucci A, Donini A, et al. Elective transumbilical compared with standard laparoscopic cholecystectomy. Eur J Surg 1999;165:29–34.
20. Piskun G, Rajpal S. Transumbilical laparoscopic cholecystectomy utilizes no incisions outside the umbilicus. J Laparoendosc Adv Surg Tech A 1999;9:361–364.
21. Cuesta MA, Berends F, Veenhof AA. The "invisible cholecystectomy": a transumbilical laparoscopic operation without a scar. Surg Endosc 2008;22:1211–1213. Epub 2007 Oct 18.
22. Romanelli JR, Mark L, Omotosho PA. Single port laparoscopic cholecystectomy with the TriPort system: a case report. Surg Innov 2008;15:223–228.
23. Rao PP, Bhagwat SM, Rane A, Rao PP. The feasibility of single port laparoscopic cholecystectomy: a pilot study of 20 cases. HPB (Oxford) 2008;10:336–340.
24. Cugura JF, Janković J, Kulis T, et al. Single incision laparoscopic surgery (SILS) cholecystectomy: where are we? Acta Clin Croat 2008;47:245–248.
25. Guo W, Zhang ZT, Han W, et al. Transumbilical single-port laparoscopic cholecystectomy: a case report. Chin Med J (Engl) 2008;121:2463–2464.
26. Mutter D, Leroy J, Cahill R, Marescaux J. A simple technical option for single-port cholecystectomy. Surg Innov 2008;15: 332–333.
27. Merchant AM, Cook MW, White BC, et al. Transumbilical Gelport access technique for performing single incision laparoscopic surgery (SILS). J Gastrointest Surg 2009;13:159–162.
28. Hodgett SE, Hernandez JM, Morton CA, et al. Laparoendoscopic single site (LESS) cholecystectomy. J Gastrointest Surg 2009;13:188–192.
29. Gumbs AA, Milone L, Sinha P, Bessler M. Totally transumbilical laparoscopic cholecystectomy. J Gastrointest Surg 2009;13: 533–534.
30. Petrotos AC, Molinelli BM. Single-incision multiport laparoendoscopic (SIMPLE) surgery: early evaluation of SIMPLE cholecystectomy in a community setting. Surg Endosc 2009 Mar 6. [Epub ahead of print].
31. Kroh M, Rosenblatt S. Single-port, laparoscopic cholecystectomy and inguinal hernia repair: first clinical report of a new device. J Laparoendosc Adv Surg Tech A 2009;19:215–217.
32. Podolsky ER, Rottman SJ, Poblete H, et al. Single port access (SPA) cholecystectomy: a completely transumbilical approach. J Laparoendosc Adv Surg Tech A 2009;19:219–222.
33. Tacchino R, Greco F, Matera D. Single-incision laparoscopic cholecystectomy: surgery without a visible scar. Surg Endosc 2009;23:896–899.
34. Zhu JF, Hu H, Ma YZ, et al. Transumbilical endoscopic surgery: a preliminary clinical report. Surg Endosc 2009;23:813–817.
35. Bucher P, Pugin F, Buchs N, et al. Single port access laparoscopic cholecystectomy (with video). World J Surg 2009;33:1015–1019.
36. Langwieler TE, Nimmesgern T, Back M. Single-port access in laparoscopic cholecystectomy. Surg Endosc 2009;23:1138–1141.
37. Ersin S, Firat O, Sozbilen M. Single-incision laparoscopic cholecystectomy: is it more than a challenge? Surg Endosc 2009 Jun 17. [Epub ahead of print].
38. Hong TH, You YK, Lee KH. Transumbilical single-port laparoscopic cholecystectomy : scarless cholecystectomy. Surg Endosc 2009;23:1393–1397.
39. Nguyen NT, Reavis KM, Hinojosa MW, et al. Laparoscopic transumbilical cholecystectomy without visible abdominal scars. J Gastrointest Surg 2009;13:1125–1128.
40. Kravetz AJ, Iddings D, Basson MD, Kia MA. The learning curve with single-port cholecystectomy. JSLS 2009;13:332–336.
41. Chow A, Purkayastha S, Aziz O, Paraskeva P. Single-incision laparoscopic surgery for cholecystectomy: an evolving technique. Surg Endosc 2009 Aug 18. [Epub ahead of print].
42. Hernandez JM, Morton CA, Ross S, et al. Laparoendoscopic single site cholecystectomy: the first 100 patients. Am Surg 2009;75:681–685; discussion 685−686. Erratum in: Am Surg 2009;75:1030.
43. Lee KS, You YK, Park JH, et al. Single-port transumbilical laparoscopic cholecystectomy: a preliminary study in 37 patients with gallbladder disease. J Laparoendosc Adv Surg Tech A 2009; 19:495–499.
44. Ponsky TA, Diluciano J, Chwals W, et al. Early experience with single-port laparoscopic surgery in children. J Laparoendosc Adv Surg Tech A 2009;19:551–553.
45. Zhu JF, Hu H, Ma YZ, Xu MZ. Totally transumbilical endoscopic cholecystectomy without visible abdominal scar using improved instruments. Surg Endosc 2009;23:1781–1784.
46. Chow A, Purkayastha S, Paraskeva P. Appendicectomy and cholecystectomy using single-incision laparoscopic surgery (SILS): the first UK experience. Surg Innov 2009;16:211–217.
47. Dutta S. Early experience with single incision laparoscopic surgery: eliminating the scar from abdominal operations. J Pediatr Surg 2009;44:1741–1745.
48. Dunning K, Kohli H. Transumbilical laparoscopic cholecystectomy: a novel technique. Arch Surg 2009;144:957–960.
49. Vidal O, Valentini M, Espert JJ, et al. Laparoendoscopic single-site cholecystectomy: a safe and reproducible alternative. J Laparoendosc Adv Surg Tech A 2009;19:599–602.
50. Hagen ME, Wagner OJ, Thompson K, et al. Supra-pubic single incision cholecystectomy. J Gastrointest Surg 2009 Nov 12. [Epub ahead of print].
51. Philipp SR, Miedema BW, Thaler K. Single-incision laparoscopic cholecystectomy using conventional instruments: early experience in comparison with the gold standard. J Am Coll Surg 2009;209:632–637.
52. Ersin S, Firzat O, Sozibilen M. Single incision laparoscopic cholecystectomy: is it more than a challenge? Surg Endosc 2010;24: 68–71.