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Single-incision laparoscopic surgery (SILS) vs. conventional multiport cholecystectomy: systematic review and meta-analysis

S. R. Markar · A. Karthikesalingam · S. Thrumurthy · L. Muirhead · J. Kinross · P. Paraskeva

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Abstract

Background Single-incision laparoscopic surgery (SILS) has gained increasing attention due to the potential to maximize the benefits of laparoscopic surgery. The aim of this systematic review and pooled analysis was to compare clinical outcome following SILS and standard multiport laparoscopic cholecystectomy for the treatment of gallstone-related disease.

Methods An electronic search of Embase and Medline databases for articles from 1966 to 2011 was performed. Publications were included if they were randomised controlled studies in which patients underwent either single-incision or multiport cholecystectomy. The primary outcome measures for the meta-analysis were postoperative complications and postoperative pain score [visual analogue scale (VAS) on the day of surgery]. Secondary outcome measures were operating time and length of hospital stay. Weighted mean difference was calculated for the effect size of SILS on continuous variables, and pooled odds ratios were calculated for discrete variables.

Results In total, 375 cholecystectomy operations from 7 randomised controlled trials were included, 195 by single-incision (SILS) and 180 by conventional multiport. Operating time was significantly longer in the SILS group compared to the standard multiport laparoscopic cholecystectomy group (weighted mean difference = 2.13; $P = 0.0001$). There was no significant difference in the incidence of postoperative complications, postoperative pain score (VAS), or the length of hospital stay between the two groups.

Conclusion The results of this meta-analysis demonstrate that single-incision laparoscopic cholecystectomy is a safe procedure for the treatment of uncomplicated gallstone disease, with postoperative outcome similar to that of standard multiport laparoscopic cholecystectomy. Future high-powered randomized studies should be focused on elucidating subtle differences in postoperative complications, reported postoperative pain, and cosmesis following SILS cholecystectomy in more severe biliary disease.

Keywords Pancreatobilio · Cancer · Cholecystectomy · SILS

S. R. Markar (✉) · L. Muirhead · J. Kinross · P. Paraskeva
Academic Surgical Unit, St. Mary's Hospital, 10th Floor, Praed Street, London W2 1NY, UK
e-mail: sheraz_markar@hotmail.com

A. Karthikesalingam · S. Thrumurthy
Department of General Surgery, St. George's Hospital, London, UK

Cholecystectomy has emerged as the gold-standard surgical treatment for gallstone-related disease. The first open cholecystectomy was performed in 1882 by Langenbuch [1] on a 43-year-old man with symptomatic gallstone disease. In 1985 Muhe [2] performed the first laparoscopic cholecystectomy using a modified laparoscope, and following this, Mouret in 1987 [3] performed the first video-assisted laparoscopic cholecystectomy.

Laparoscopic cholecystectomy is the gold-standard surgical treatment for gallstone-related disease, with reduced postoperative pain, shortened hospital stay, faster recuperation, and earlier return to normal function compared to open surgery [4]. In order to enhance the benefits of laparoscopic surgery, surgeons in recent years have attempted to use even more minimally invasive surgical techniques. These include minimizing the number of incisions via single-incision laparoscopic surgery (SILS), laparoendoscopic single site (LESS) surgery, or natural orifice transluminal endoscopic surgery (NOTES). The benefits of SILS have yet to be formally proven. However, the hypothesized benefits of SILS would include those of standard laparoscopic surgery plus improved cosmesis, with surgery being performed through one incision.

In the field of cholecystectomy there is at present very limited evidence comparing conventional laparoscopy with the SILS approach. There has hitherto been no meta-analysis of results, despite suggestions that a pooled analysis of the available individually small trials is required to eliminate any type II error. The aim of this systematic review and meta-analysis was therefore to compare clinical outcomes following SILS and standard multiport laparoscopic cholecystectomy for the treatment of gallstone-related disease.

Methods

An electronic search of Embase and Medline databases for publications from 1966 to 2011 was performed. The search terms "laparoscopy," "single incision," "single port," "single site," "SILS," "LESS," "cholecystectomy," and "laparo-endoscopic," and MeSH headings "Laparoscopy" (MeSH), "Cholecystectomy" (MeSH), and "Single incision" (MeSH) were used in combination with the Boolean operators AND and OR. Two authors independently performed the electronic search in September 2011. The electronic search was supplemented by a hand search of published abstracts from meetings of the Surgical Research Society, the Society of Academic and Research Surgery, the Association of Surgeons of Great Britain and Ireland, Society of American Gastrointestinal and Endoscopic Surgeons, and European Association of Endoscopic Surgeons from 1980 to 2011. The reference lists of articles obtained were also searched to identify further relevant citations. Finally, the search included the Current Controlled Trials Register (http://www.controlled-trials.com) and the Cochrane Database of Controlled Trials. Abstracts of the citations identified by the search were then scrutinized by two of the authors (SRM and SM) to determine eligibility for inclusion in the meta-analysis. Publications were included if they were randomised controlled trials in which patients underwent either single-incision (SILS or LESS) or multiport cholecystectomy. Studies were excluded if they were noncomparative, retrospective, observational, or nonrandomised, NOTES procedures, or not focused on the adult population.

SILS cholecystectomy was defined as laparoscopic cholecystectomy performed through a single incision. This encompassed studies that used multiport devices and studies that used two to three individual ports through a single incision. Standard three- to four-port laparoscopic cholecystectomy was used as the control in all studies, with ports placed in the infraumbilical area, epigastrium, and the right lower and upper abdomen (in most cases).

The primary outcome measures for the meta-analysis were postoperative complications and postoperative pain score (as measured by the visual analogue score [VAS]) on the day of surgery (time of this measurement varied between 6 and 24 h after surgery). A postoperative complication was defined as a complication that developed within 30 days of the procedure and occurred as a direct result of the surgery. Secondary outcome measures were operating time and length of hospital stay.

Data from eligible trials were entered into a computerized spreadsheet for analysis. Statistical analysis was performed using StatsDirect 2.5.7 (StatsDirect, Altrincham, UK). Weighted mean difference was calculated for the effect size of single-incision laparoscopy on continuous variables such as operating time, postoperative pain score (VAS), and length of hospital stay. Pooled odds ratios were calculated for the effect of single-incision laparoscopy on discrete variables such as postoperative complications.

All pooled outcome measures were determined using random-effects models as described by DerSimonian and Laird [5]. Heterogeneity among trials was assessed by means of Cochran's Q statistic, a null hypothesis in which $P < 0.05$ is taken to indicate the presence of significant heterogeneity. The Egger test was used to assess the funnel plot for significant asymmetry, indication of possible publication bias, or other biases.

Results

The literature search identified seven randomised controlled studies that met the inclusion criteria to undergo analysis in this study [6–12]. Figure 1 shows the PRISMA flowchart for the literature search. In total, 335 cholecystectomy operations were included, 175 by single-incision (SILS) and 160 by conventional multiport cholecystectomy. Table 1 gives the basic demographic data from each trial, which was similar between the groups. Table 2 gives the surgical information from each publication included. Tables 3 and 4 give the primary and secondary outcome results from each trial.

Primary outcome measures

Table 3 reports the primary outcome measures from each publication.

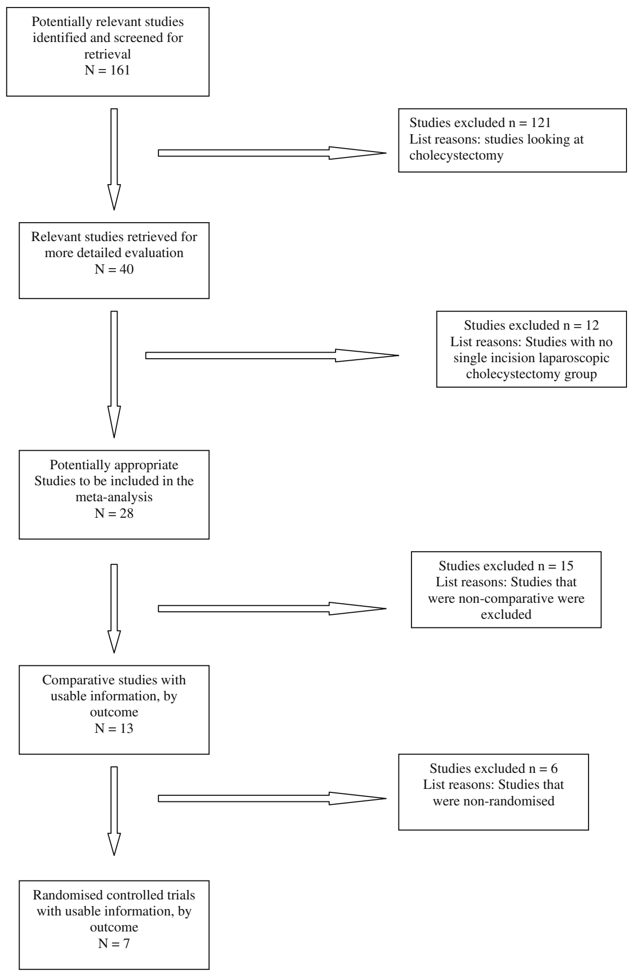

Fig. 1 PRISMA flowchart

Postoperative complications

Postoperative complications were reported in seven studies [6–12]. There were 20 (10.26%) complications in the SILS group and 16 (8.89%) complications in the multiport laparoscopic cholecystectomy group. There was no statistically significant difference between the groups (Fig. 2) (pooled odds ratio = 1.10; 95% CI = 0.50–2.44; $P = 0.81$). There was no evidence of statistical heterogeneity (Cochran Q = 3.08; $P = 0.38$) or statistical bias (Egger test = −1.93; 95% CI = −5.47 to 1.60; $P = 0.14$). Table 5 gives a breakdown of the complications described by the studies included in the analysis.

VAS on day of surgery

VAS on the day of surgery (6–24 h after surgery) were reported in six studies [6–10, 12]. One study was excluded as it failed to provide information regarding standard deviation [8]. There was no statistically significant difference between the groups (Fig. 3) (weighted mean difference = −0.21; 95% CI = −0.73 to 0.31; $P = 0.42$). There was evidence of statistical heterogeneity (Cochran Q = 16.40; $P = 0.003$), but there was no evidence of statistical bias (Egger test = −2.57; 95% CI = −30.72 to 25.59; $P = 0.79$).

Secondary outcome measures

Table 4 reports the secondary outcome measures from each publication.

Operative time

Operative time was reported in seven studies [6–12], but one study was excluded as it failed to provide information regarding standard deviation [8]. Operative time was significantly longer in the SILS group compared to the standard multiport laparoscopic cholecystectomy group (Fig. 4) (weighted mean difference = 2.13; 95% CI = 1.05–3.20; $P = 0.0001$). However, there was evidence of significant statistical heterogeneity (Cochran Q = 78.92; $P < 0.0001$) and statistical bias (Egger test = 10.95; 95% CI = −3.53 to 18.37; $P = 0.01$).

Table 1 Patient demographic data

Author	No. pts. (S)	No. pts. (M)	Age (S)	Age (M)	M:F ratio (S)	M:F ratio (M)	BMI (S)	BMI (M)
Aprea [6]	25	25	45.5 ± 9.4	44 ± 10	14:16	06:19	25.9 ± 5.8	23.7 ± 4.6
Asakuma [7]	24	25	55.8 ± 1.6	64.8 ± 1.7	11:13	13:12	24.1 ± 1	23.6 ± 1
Ma [8]	21	22	57.3 ± 16	45.8 ± 11.9	–	–	28.2 ± 5.3	30.7 ± 6.1
Lee [9]	35	35	51 ± 13.5	53.3 ± 15.5	13:22	15:20	24.2 ± 3.4	25.8 ± 3
Lirici [10]	20	20	44.8 ± 2.5	48 ± 2.7	6:14	6:14	24.3 ± 1.4	25.5 ± 1.4
Marks [11]	50	33	40.2 ± 11.8	42 ± 14.1	–	–	29.4 ± 5.9	28.9 ± 4.6
Tsimoyiannis [12]	20	20	49.2 ± 16.9	47.9 ± 9.8	5:15	1:19	–	–
Total	195	180	–	–	–	–	–	–

All averages are presented as mean ± standard deviation

S Single-incision laparoscopic cholecystectomy group, *M* multiport conventional laparoscopic cholecystectomy group

Table 2 Surgical information

Author	Open conv (S)	Open conv (M)	IO cholangio (S)	IO cholangio (M)	Add ports (S)	Add ports (M)
Aprea [6]	0	0	3	2	2	1
Asakuma [7]	1	2	12	14	0	0
Ma [8]	0	0	0	0	14	0
Lee [9]	0	0	–	–	2	1
Lirici [10]	0	1	–	–	2	0
Marks [11]	0	0	–	–	–	–
Tsimoyiannis [12]	0	0	–	–	–	–
Total	1 (0.51%)	3 (1.67%)	15 (7.69%)	16 (8.89%)	20 (10.26%)	2 (1.11%)

S Single incision laparoscopic cholecystectomy group, *M* multiport conventional laparoscopic cholecystectomy group, *Open conv* conversion to open surgical procedure, *IO cholangio* intraoperative cholangiogram, *Add ports* number of procedures requiring additional port placement

Table 3 Primary outcome measures

Author	Postoperative complication (S)	Postoperative complication (M)	VAS day 1 (S)	VAS day 1 (M)
Aprea [6]	0	0	3.9 ± 1.8	3.5 ± 1.6
Asakuma [7]	0	0	2.4 ± 2.1	4.5 ± 2
Ma [8]	6	4	2.7	1.8
Lee [9]	0	0	2.1 ± 0.9	2.2 ± 0.8
Lirici [10]	0	3	3.75 ± 1.15	3.15 ± 1.22
Marks [11]	13	7	–	–
Tsimoyiannis [12]	1	2	1 ± 0.85	1.6 ± 0.88
Total	20 (10.26%)	16 (8.89%)	–	–

All averages are presented as mean ± standard deviation

S Single-incision laparoscopic cholecystectomy group, *M* multiport conventional laparoscopic cholecystectomy group

Table 4 Secondary outcome measures

Author	Operative time (min) (S)	Operative time (min) (M)	Length of hospital stay (days) (S)	Length of hospital stay (days) (M)
Aprea [6]	41.3 ± 12	35.6 ± 5.6	1.2 ± 0.4	1.16 ± 0.37
Asakuma [7]	109.3 ± 2.8	99 ± 3	3 ± 0.6	3.5 ± 0.8
Ma [8]	88.5	44.8	–	–
Lee [9]	71.7 ± 11.6	48.4 ± 10.5	2.4 ± 0.8	2.9 ± 0.4
Lirici [10]	76.75 ± 3.42	48.25 ± 6.65	2.5 ± 0.91	2.65 ± 1.08
Marks [11]	58.2 ± 25.3	44 ± 16.2	–	–
Tsimoyiannis [12]	49.65 ± 9	37.3 ± 9.2	1.25 ± 0.44	1.1 ± 0.44

All averages are presented as mean ± standard deviation

S Single-incision laparoscopic cholecystectomy group, *M* multiport conventional laparoscopic cholecystectomy group

Length of hospital stay

Length of hospital stay was reported in five studies [6, 7, 9, 10, 12]. There was no significant difference between the groups with respect to length of hospital stay (Fig. 5) (weighted mean difference = −0.25; 95% CI = −0.69 to 0.18; $P = 0.25$). However, there was evidence of significant statistical heterogeneity (Cochran Q = 11.77; $P = 0.02$). There was no evidence of statistical bias (Egger test = 11.23; 95% CI = −10.63 to 33.08; $P = 0.20$).

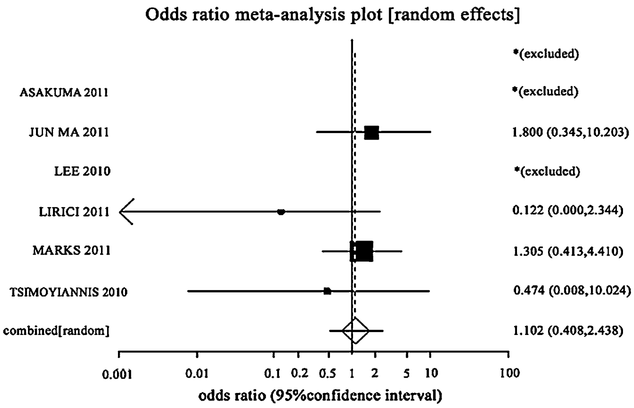

Fig. 2 Forrest plot for postoperative complications following SILS vs. multiport cholecystectomy

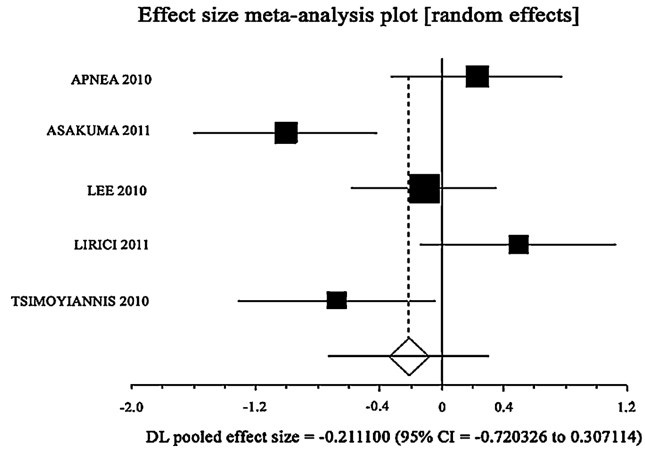

Fig. 3 Forrest plot for postoperative pain score (VAS) on the day of surgery following SILS vs. multiport cholecystectomy

Discussion

This pooled analysis of seven randomised controlled trials comparing single-incision and conventional multiport laparoscopic cholecystectomy represents the first attempt to pool together the data on this topic for analysis. Primary outcome analysis showed no statistically significant difference between the groups (Fig. 2) (pooled odds ratio = 1.10; 95% CI = 0.50–2.44; $p = 0.81$) in the incidence of postoperative complications. There was no statistically significant difference between the groups (Fig. 3) (weighted mean difference = −0.21; 95% CI = −0.73 to 0.31; $P = 0.42$) in postoperative pain score on the day of surgery. Secondary outcome analysis revealed no significant difference between the groups for length of hospital stay. The only significant difference between the groups was a longer operating time associated with single-incision laparoscopic cholecystectomy (Fig. 5) (weighted mean difference = −0.25; 95% CI = −0.69 to 0.18; $P = 0.25$).

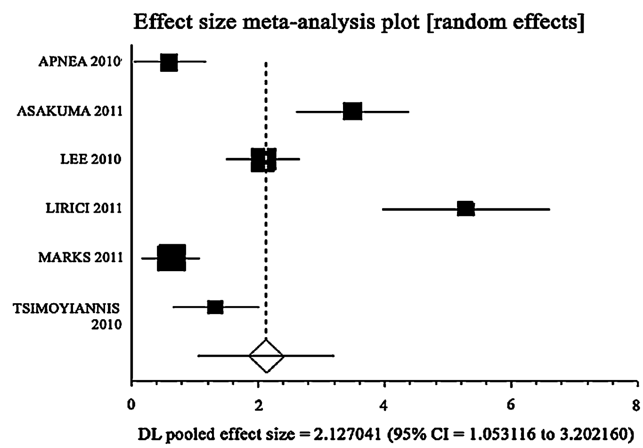

Fig. 4 Forrest plot for operative time for SILS vs. multiport cholecystectomy

These results show that SILS cholecystectomy is a safe procedure, with postoperative outcome similar to that of standard multiport laparoscopic cholecystectomy. The only

Table 5 Breakdown of postoperative complications as described in included publications

Author	CBD injury (S)	CBD injury (M)	Bile leak (S)	Bile leak (M)	Bleeding (S)	Bleeding (M)	Wound infection (S)	Wound infection (M)	Port site hernia (S)	Port site hernia (M)
Aprea [6]	0	0	0	0	1	0	0	0	0	0
Asakuma [7]	0	0	0	0	0	0	0	0	0	0
Ma [8]	0	0	0	0	1	0	3	4	1	0
Lee [9]	0	0	0	0	0	0	0	0	0	0
Lirici [10]	0	0	0	1	0	2	0	0	0	0
Marks [11]	–	–	–	–	–	–	–	–	1	0
Tsimoyiannis [12]	0	0	1	2	0	0	0	0	0	0

S Single-incision laparoscopic cholecystectomy group, *M* multiport conventional laparoscopic cholecystectomy group, *CBD* common bile duct

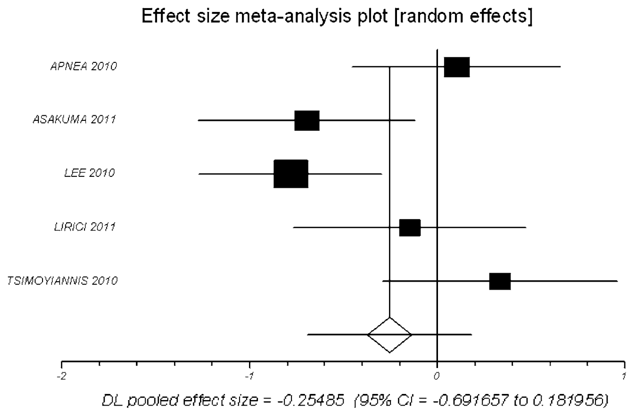

Fig. 5 Forrest plot for length of hospital stay following SILS vs. multiport cholecystectomy

difference between the two groups was the longer operating time associated with SILS cholecystectomy. There is a learning curve associated with the adoption of any new surgical technique, which probably explains this phenomenon. Studies have demonstrated that as surgeons gain more experience with SILS procedures, they overcome this learning curve and the operating time decreases [13, 14]. Because of the potential benefits for the patient from a SILS approach, there is pressure for authors to publish their initial data, where the effect of the SILS learning curve would be at its greatest. Thus, future studies may be able to extrapolate for the effect of this learning curve upon operating time during SILS cholecystectomy.

Economic considerations must also be factored in when considering the merits of SILS cholecystectomy. Two studies have reported similar operative costs associated with SILS compared to standard multiport cholecystectomy [15, 16]. Further studies on this topic should focus on the economic considerations associated with SILS cholecystectomy to factor in operating time and length of hospital stay. Over recent years there has been a drive by a number of companies to produce different multiports for SILS, all of which vary in cost. Thus, future studies must also be aimed at evaluating the cost efficiency of these different multiports and comparing this cost with that of standard three- or four-port laparoscopic cholecystectomy.

Several of articles failed to comment on the operative experience of the surgeons performing the SILS cholecystectomies (Table 6). It could be assumed that experienced laparoscopic surgeons would perform better at SILS cholecystectomy and thus would have a shorter learning curve [17]. Similarly, it may be that the surgeons currently performing this technique do not yet have the technical competency to ensure that the maximum benefits from this procedure are translated into the outcome data. The duration of the learning curve associated with SILS compared to standard laparoscopic multiport cholecystectomy could also be an interesting subject to evaluate in future studies [18].

One of the major benefits of laparoscopic over open surgery is a reduction in postoperative pain [4]. Six studies examined postoperative pain following SILS cholecystectomy and pooled analysis failed to demonstrate a significant difference between the groups [6–10, 12]. Two studies demonstrated reduced postoperative pain on the day of surgery as measured by VAS in the SILS cholecystectomy group [7, 12]. Furthermore, the major benefit of SILS operations may be an improved postoperative cosmetic appearance. In a medical era where patient autonomy is playing an increasingly larger role in decisions regarding surgery, postoperative cosmesis is an important factor to be taken into account. Three studies from this analysis reported improved patient wound (cosmetic) satisfaction scores and demonstrated a benefit to SILS cholecystectomy over standard multiport cholecystectomy [6, 10, 11]. This is an important consideration in determining choice of surgery, and future high-powered randomized controlled studies are required to elucidate differences in patient wound satisfaction and postoperative pain associated with these different surgical techniques.

Table 6 Surgeon experience as described in publication prior to commencement of trial

Author	Surgeon experience
Aprea [6]	Same surgeon for all procedures–experienced laparoscopic surgeon (does not quantify previous experience)
Asakuma [7]	Two surgeons each had performed more than 50 conventional laparoscopic cholecystectomies and had some experience with single-incision laparoscopic surgery
Ma [8]	Surgeons had extensive experience with classic laparoscopic cholecystectomy and advanced laparoscopic techniques. Each surgeon had performed fewer than five single-incision laparoscopic cases
Lee [9]	Same performing surgeon with experience in over 100 multiport and 20 single-incision laparoscopic cholecystectomy cases
Lirici [10]	Two laparoscopic surgeons with more than 15 years experience in advanced laparoscopic surgery
Marks [11]	Multicentre trial with no description of performing surgeons' experience
Tsimoyiannis [12]	No description of operating surgeon's previous laparoscopic experience

Table 7 Operative technique

Author	Method of single-incision laparoscopy
Aprea [6]	Olympus triport device
Asakuma [7]	Glove with 5-mm trocars for instrument introduction
Ma [8]	ASC triport
Lee [9]	Quadraport (LAGIS)
Lirici [10]	Olympus triport device
Marks [11]	Single-incision laparoscopy port (not specified)
Tsimoyiannis [12]	3 standard ports inserted through single umbilical incision

One of the major principles of standard laparoscopy is correct port placement and triangulation. This principle allows for improved ergonomics during surgery. The nature of SILS means that triangulation is not possible, thus creating a technical obstacle for surgeons trained in using a standard technique. The implication is that surgeons are subjected to poorer operative ergonomics compared with standard multiport laparoscopic surgery [19]. There also is significant heterogeneity amongst the surgical procedures described as single incision in this analysis. Some authors use a multiport device for insertion of laparoscopic instruments, whilst others use three separate trocars in one incision and yet others use a modified technique, using sutures to provide retraction upon the gallbladder to facilitate dissection (Table 7). Thus, it is clear that the best technique for SILS cholecystectomy is still a matter of debate, and a standardized procedure will help comparison with multiport laparoscopic cholecystectomy in the future.

A further interesting point is selection of patients to undergo single-incision laparoscopic cholecystectomy. The publications included in this meta-analysis were randomised controlled trials with patient cohorts well matched for a number of confounding variables. Table 8 lists the inclusion and exclusion criteria used for patient selection in each of the studies analysed. This table demonstrates that all studies included in this analysis excluded patients with more complex biliary disease (acute cholecystitis, CBD stones, and acute pancreatitis) [6–12]. Although this meta-analysis has demonstrated comparable outcomes between the groups for the treatment of biliary colic, these results

Table 8 Patient selection for randomized controlled trial: inclusion/exclusion criteria

Author	Inclusion/exclusion criteria
Aprea [6]	Exclusion criteria:
	Previous abdominal surgery
	Signs of acute cholecystitis, choledocholithiasis + acute pancreatitis
	ASA III or more
	Lack of written consent
	BMI > 30 kg/m^2
Asakuma [7]	Inclusion criteria:
	Age 20–85 years
	Exclusion criteria:
	Patients diagnosed with CBD stones before or during surgery
	Previous upper abdominal surgery
	Emergency presentation
Ma [8]	Inclusion criteria:
	Indications for laparoscopic cholecystectomy with no evidence of choledocholithiasis
	Age 18–85 years
	BMI > 40 kg/m^2
	Creatinine < 2 mg/dl, AST/ALT $< 5 \times$ upper limit of laboratory normal, and total bilirubin within normal range
	Exclusion criteria:
	Acute cholecystitis
	Gallstones > 2.5 cm in greatest diameter
Lee [9]	Exclusion criteria:
	Patients with acute cholecystitis and CBD stones
	Patients with severe obesity (not quantified)
	Previous abdominal surgery

Table 8 continued

Author	Inclusion/exclusion criteria
Lirici [10]	Inclusion criteria:
	Age 18–75 years
	BMI < 30 kg/m^2
	No previous abdominal surgery
	US findings–gallstones
	ASA grade I–III
	Nassar grade I–III
	Exclusion criteria:
	Age < 18 or > 75 years
	BMI > 30 kg/m^2
	Previous upper GI surgery, right colonic surgery
	US findings–acute cholecystitis, bile duct stones, pancreatitis
	ASA grade $>$ III
	Nassar grade $>$ IV
Marks [11]	Inclusion criteria:
	Age 18–85 years
	BMI < 45 kg/m^2
	Patients with clinical evidence of biliary colic
	US findings–gallstones or gallbladder polyps
	Patients with biliary dyskinesia with a documented ejection fraction of $< 30\%$
	Exclusion criteria
	Pregnancy
	Acute calculus or acalculous cholecystitis
	Presence of upper midline or right subcostal incision
	Preoperative indication for cholangiogram
	ASA grade $>$ III
	Ongoing peritoneal dialysis
	Presence or previous repair of umbilical hernia
Tsimoyiannis [12]	Inclusion criteria:
	BMI < 30 kg/m^2
	Some attacks of pain from cholelithiasis
	ASA grade I–II
	Exclusion criteria:
	BMI > 30 kg/m^2
	Signs of acute cholecystitis, choledocholithiasis + acute pancreatitis
	ASA grade $>$ II

cannot be extrapolated to more complex biliary disease. Table 5 shows the very low incidence of operative complications in both groups associated with surgery in uncomplicated biliary disease. High-powered randomised controlled trials with more complex variants of biliary pathology are required to demonstrate the subtle differences in postoperative complications between the techniques that may not have been demonstrated in current randomised controlled trials.

Furthermore, the influence of patient factors, including BMI and high ASA grade, upon choice of surgical technique requires further investigation. The randomised controlled trials included in this meta-analysis excluded patients with a high BMI and a high ASA grade, which represents a limitation in interpreting the clinical context of the results presented. Future randomised clinical trials need to include patients with more complex biliary pathology and premorbid status (ASA grade and obesity), as this meta-analysis has demonstrated the safety of single-incision laparoscopic cholecystectomy in the treatment of uncomplicated disease.

This pooled analysis is limited by the literature currently available on this topic. There is vast heterogeneity in the quality of trials on this topic, with variable attention paid to previous laparoscopic experience, standardization of operative technique, and the learning curve associated with a new surgical technique. The wide confidence intervals for several of the outcomes does serve as evidence that high-powered multicentre randomised controlled trials are required to provide further evidence on this topic. Future studies on this topic could focus on the potential benefits of SILS cholecystectomy, including cosmetic appearance, postoperative pain, and requirement for analgesia. These future studies must also include more challenging cases (e.g., more complex biliary disease and obese patients) now that safety has been demonstrated with SILS cholecystectomy in uncomplicated patients. Given the low complication rate associated with standard multiport laparoscopic cholecystectomy demonstrated in this analysis, it may be difficult to demonstrate the advantages of SILS in cholecystectomy. However, it may serve as a useful training operation to allow surgeons to gain confidence prior to performing more complex single-incision laparoscopic surgical resections in the future.

Conclusion

The results of this meta-analysis demonstrate that single-incision laparoscopic cholecystectomy is a safe procedure for the treatment of uncomplicated gallstone disease, with postoperative outcome similar to that of standard multiport laparoscopic cholecystectomy. Future high-powered randomised studies should be focused on elucidating subtle differences in postoperative biliary complications, reported postoperative pain, and cosmesis following SILS cholecystectomy.

Disclosures S. R. Markar, A. P. Karthikesalingam, S. Thurumathy, L. Muirhead, J. Kinross, and P. Paraskeva have no conflicts of interest or financial ties to disclose.

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