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TOPIC HIGHLIGHT

WJG 20th Anniversary Special Issues (15): Laparoscopic resection of gastrointestinal

Therapeutic advances: Single incision laparoscopic hepatopancreatobiliary surgery

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Abstract

Single-port laparoscopic surgery (SPLS) is proposed to be a step towards minimizing the invasiveness of surgery, and has since gained popularity in several surgical sub-specialties including hepatopancreatobiliary surgery. SPLS has since been applied to cholecystectomy, liver resection as well as pancreatectomy for a multitude of pathologies. Benefits of SPLS over conventional multi-incision laparoscopic surgery include improved cosmesis and potentially post-operative pain at specific time periods and extra-umbilical sites. However, it is also associated with longer operating time, increased rate of complications, and increased rate of port-site hernia. There is no significant difference between length of hospital stay. SPLS has a significant learning curve that affects operating time, rate of conversion and rate of complications. In this article, we review the literature on SPLS in hepatobiliary surgery - cholecystectomy, hepatectomy and pancreatectomy, and offer tips on overcoming potential technical obstacles and minimizing the complications when performing SPLS - surgeon position, position of port and instruments, instrument crossing position, standard hand grip *vs* reverse hand grip, snooker cue guide position, prevention of incisional hernia. SPLS is a promising direction in laparoscopic surgery, and we recommend step-wise progression of applications of SPLS to various hepatopancreatobiliary surgeries to ensure safe adoption of the surgical technique.

Key words: Single port laparoscopic; Cholecystectomy; Hepatectomy; Pancreatectomy; Liver resection

Core tip: This manuscript is an up-to-date review of the recent developments in single port laparoscopic hepatopancreatobiliary surgeries. A comprehensive review of all meta-analyses published on the topic of single port laparoscopic cholecystectomy will be discussed as well as a summary of the published literature of the application of single port laparoscopic surgery in liver and pancreatic surgeries will be presented. The author who has a personal experience of more than 350 single port laparoscopic hepatopancreatobiliary surgeries will offer a detailed description of his technique and tips on how to avoid the pitfalls as well as adopting the technique easily.

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INTRODUCTION

Since Eric Muhe first described laparoscopic cholecystectomy in 1985[1], minimally invasive surgery has revolutionized surgical techniques, and has made a huge impact particularly in hepatopancreatobiliary surgery. Benefits over traditional open surgery include improved cosmesis, decreased post-operative pain, shortened length of hospital stay and faster return to function[2].

Single-port laparoscopic surgery (SPLS) was first described by Inoue *et al*[3] for appendectomy, and is proposed to be a step towards the same direction of minimizing the invasiveness of surgery; potentially offering benefits such as improved cosmesis, decreased post-operative pain and shorter length of hospital stay as compared to conventional multi-incision laparoscopic surgery. This technique has since gained popularity in several surgical subspecialties, including hepatopancreaticobiliary diseases. SPLS for cholecystectomy gained popularity in 2000s and has since been applied to more complex procedures, including hepatectomies and pancreatectomies.

To date, there is a significant amount of literature available on SPLS for a vast range of diseases, ranging from single case reports to meta-analyses on the feasibility and outcomes of SPLS. There is a need to consolidate the evidence available for clinicians to better understand this surgical technique and its benefits and potential risks. This article reviews the literature on SPLS in hepatobiliary surgery - cholecystectomy, hepatectomy and pancreatectomy, and offers tips in overcoming potential technical obstacles when performing SPLS.

SINGLE-PORT LAPAROSCOPIC CHOLECYSTECTOMY

Currently, laparoscopic cholecystectomy is the gold standard for surgical treatment of benign gallbladder diseases. SPLS for cholecystectomy was first described by Navarra *et al*[4] in 1997. Today, SPLS is most commonly applied to cholecystectomy, as clearly demonstrated by the large amount of literature on single-incision laparoscopic cholecystectomy (SILC) in contrast to other single-port laparoscopic surgeries.

There have been several meta-analyses[5-10] published comparing SILC with CLC in a large range of parameters - from operating time, complications, to cosmesis. While there are slight differences in conclusions with regards to rate of procedural failure and complications, most derive results that concur with each other.

Safety and complications of SILC

Safety of the procedure is commonly determined by the incidence and rate of complications. SILC is considered to be a safe and effective procedure for the treatment of carefully selected patients with uncomplicated benign gallbladder disease[5]. Although there is a reported higher complications rate with SILC as compared to CLC, it is not statistically significant. Common post-operative complications include wound site infection (4.0% *vs* 1.6%)[5] and gallbladder perforation (1.9% *vs* 1.3%)[1]. Of importance, bile duct injury is found in 0.72%[11] for SILC, compared to 0.5[12] in CLC. This is likely due to the fact that many of the studies were in their early stages of SILC, and could have experienced difficulty in visualizing the Calot's triangle in order to facilitate safe dissection. We offer tips to overcome this obstacle in later sections. SILC is also associated with higher intra-operative blood loss (1.0% *vs* 0.9%), although not shown to be statistically significant[5].

Procedural failure rate

The rate of conversion to open surgery is comparable to that of CLC (mean 0.4% *vs* 0.7%)[5]. When including the addition of a port to SILC procedures or conversion to CLC as a procedural failure, the failure rate is higher (8.4% *vs* 0.7%)[6]. There is a median of 8.55% of SILCs that required an additional port[13]. Trastulli *et al*[6] also found a higher rate of failure when using a transparietal suture to anchor the gallbladder to the abdominal wall as compared to using a grasper to retract the gallbladder. The higher rate of conversions may be due to the learning curve associated with SILC. In a study of the learning curve of SILC by Tay *et al*[14], 80% of conversions took place in the surgeon's first 20 cases, and were usually due to the obscured anatomy of Calot's triangle. Rate of conversion is likely to decrease with experience.

Intra-operative time and learning curve

All meta-analyses[5-10] have shown that intra-operative time with SILC is significantly longer than CLC. A meta-analysis of prospective randomized controlled trials by Pisanu *et al*[5] found that the mean time for SILC is 63.0 min *vs* 45.8 min in CLC [SMD = 1.004 (0.434-1.573)]. The longer operating times have been attributed to the learning curve associated with the adoption of a new technique. A study by Tay *et al*[14] on a single institution experience of the learning curve of SILC shows that the mean operating time of a surgeon is significantly lower (62.5 min *vs* 90.6 min) after overcoming the learning curve, and continues to decrease to 37 min after performing 60 cases. As surgeons gain more experience with SPLS, the operating time consistently reduces[15,16], and the operating time for SILC decreases with experience to a comparative level of CLC[14,17]. The number of cases required to overcome the learning curve ranges from 5-10[18] to 20-25[19,20]. The wide range of learning curve may be due to the degree of ease of surgery based on the indication for surgery and patient profile (*e.g.*, high BMI), or the prior experience of the surgeon with laparoscopy.

Post-operative pain and recovery time

Several meta-analyses[5-9] found no statistically significant differences in post-operative pain. This may be due to the increase in total tension of the umbilical incision[21]. However, it is worth noting that the studies thus far have assessed post-operative pain as an overall score that is neither site-specific nor time-specific. Geng *et al*[10] found significant difference in post-operative pain (by VAS scores) between the SILC and CLC groups when specific

Table 1 Comparing mean post-operative pain between study arms

				Technique		Reduction of pain in SILC:	*P* value[1]	Conclusions regarding SILC
				SILC (s.d.)	LC (s.d.)	Mean (95%CI)		
Pain score: mean	4 h post-procedure	Umbilical	At rest	1.604 -1.644	2.085 -2.275	0.48 (-0.657-1.618)	0.400	Non-inferior
			On movement	2.275 -2.063	2.469 -2.479	0.194 (-1.109-1.497)	0.766	Inconclusive
		Extra-umbilical	At rest	0.933 -1.764	1.631 -2.621	0.697 (-0.567-1.962)	0.272	Non-inferior
			On movement	1.258 -2.147	1.773 -2.656	0.515 (-0.866-1.895)	0.457	Non-inferior
	24 h post-procedure	Umbilical	At rest	2.300 -1.895	2.652 -2.632	0.352 (-0.965-1.669)	0.593	Non-inferior
			On movement	3.613 -2.668	3.548 -3.196	-0.065 (-1.760-1.631)	0.939	Inconclusive
		Extra-umbilical	At rest	0.696 -1.406	2.684 -2.660	1.988 (0.763-3.213)	0.002	Superior
			On movement	0.942 -1.767	3.124 -3.104	2.182 (0.729-3.635)	0.004	Superior
	14 d post-procedure	Umbilical	At rest	0.833 -1.465	0.960 -1.457	0.127 (-0.713-0.966)	0.763	Non-inferior
			On movement	1.583 -1.717	1.720 -1.696	0.137 (-0.844-1.118)	0.781	Non-inferior
		Extra-umbilical	At rest	0.167 -0.637	0.400 -0.957	0.233 (-0.234-0.700)	0.319	Non-inferior
			On movement	0.375 -1.096	0.640 -1.551	0.265 (-0.510-1.040)	0.495	Non-inferior

[1]There is a significant reduction in extra-umbilical pain scores 24 h post-operatively. SILC: Single-incision laparoscopic cholecystectomy.

time periods were analysed; patients who underwent SILC had less pain at 3-4 h (-0.704 favouring SILC), and at 6-8 h (0.613 favouring SILC).

Our institution investigated post-operative pain in SILC *vs* CLC in a randomized controlled trial[22], where we measured post-operative pain by site and severity at 4 h, 24 h, 2 wk and 6 mo. We found that at 24 h post-operatively, there is significantly less extra-umbilical pain at rest and on movement, with mean reduction of 1.988 (0.763-3.3213) and 2.182 (0.729-3.635) in pain score at rest and on movement respectively (Table 1). This could suggest superiority of pain reduction in SILC at site specific areas. Otherwise, there is also no significant difference in the length of hospital stay[5-9].

Port site hernia

There appears to be a higher incidence of port site hernia in patients who undergo SILC compared to CLC (1.43% *vs* 0.32%)[8], although not statistically significant. However, the length of post-operative follow-up is not known. In a systematic review by Hall *et al*[13], the overall rate of incisional hernia is 0.35%, but the 49 studies had a range of follow-up from 2 wk to 1 year. The increase in port site hernias with SILC may be due to the longer incision made for single-incision surgeries, particularly with multi-port devices. Longer length of follow-up is required to make a better conclusion on whether port site hernia is a significant long term complication with SILC. Experience in port-site close is also vital in prevention of incision hernias, and will be discussed in a later section.

Cosmesis

The satisfaction with cosmesis in patients who underwent SILC is undeniably greater than patients who underwent CLC, and is likely the largest benefit that SILC confers to patients. Post-operative satisfaction with cosmesis from the meta-analysis by Pisanu *et al*[5] favours the SILC group (8.2 *vs* 7.2 on a 10-point scale, SMD = -0.759), and Trastulli *et al*[6] reported that there is a significant difference in satisfaction with cosmesis from 2 wk after surgery, with an overall weighted mean difference of 0.97 [-1.51-(-0.43)] in favour of SILC ($P < 0.001$).

Cost-effectiveness

It is difficult to compare the cost-effectiveness of SILC with CLC as there is a wide variation of methods applied under "single-incision". Although all SPLS make use of a single intra-umbilical incision, techniques range from using multi-port devices, to making use of surgical gloves to insert multiple ports while maintaining pneumoperitoneum[23]. The cost of using surgical gloves was shown to be one-quarter of the cost of CLC[13], while Chang *et al*[24] used ports specific to SPLS and described costs as greater than CLC (USD $2547 *vs* $1976). The use of surgical gloves is a promising method that may significantly reduce costs for the patients while providing quality results.

SILC for complicated patients and diseases

Currently, SILC is only performed for a select group of patients, with common exclusion criteria including BMI > 30[25], ASA > Ⅲ[26] > Ⅱ[27], and acute cholecystitis[25,26,28-30]. The safety of SILC on more complicated patients is not known and will require more evidence before deciding if this procedure can be more widely applicable.

Overall, SILC is proven to be safe and effective for patients with uncomplicated benign gallbladder disease, with significant benefits of improved cosmesis. The main drawback is that of longer operating time (which is associated with the learning curve), and possible long term increased risk for incisional hernia. Otherwise, the complications rate, rate of procedure failure, post-operative pain and recovery time are comparable with CLC, and post-operative pain may be superior in certain sites or time periods. It is difficult to assess cost-effectiveness due to the variety of methods used, but using ports tailored for SPLS is likely to be more expensive as compared to improvising with conventional instruments. More studies are needed to study the safety and complications of SILC with more complex patient factors and biliary pathologies.

SINGLE-PORT LAPAROSCOPIC LIVER SURGERIES

SPLS for liver surgery is a fairly new application, with the first case of single-incision laparoscopic hepatectomy (SILH) being described in 2010 by Cai *et al*[31] for a liver hemangioma. In contrast to SILC, SILH is performed less commonly and literature on SILH is limited to single case reports or small case series. To date, only 31 cases of SILH have been described[31-36]. This is because SILH is a technically demanding surgery with high risk of bleeding, thus requiring strict patient selection and also the use of specific surgical instruments that may not be widely available in institutions.

SILH confers essentially the same benefits of SPLS, and has been used for a larger variety of pathological conditions, from benign cysts to metastatic liver masses and in patients with poor Child-Pugh classification grades (*i.e.*, grade C[32]). Early experience with SILH has shown that it is a safe and effective procedure for selected patients with good recovery, and has not shown to have any post-operative complications.

Patient characteristics

From the pooled published patient data, the age of patients ranged from 52[32] to 90[32] years old, and majority were Child-Pugh grade A, although there was 1 patient each of Child-Pugh grade B and C. The indications for SILH included benign cyst fenestration[32-34], hepatectomy for hepatocellular carcinoma, distant metastasis (ovarian, colorectal)[33], endocrine tumour[32], or hemangioma[31].

Tumour characteristics

In the context of conducting SILH for malignant tumours, it is imperative to select appropriate cases based on the size and position of the tumour, as well as its relation with the peripheral great vessels[37]. Currently, cut-offs for size of the lesions are < 5 cm[35] or < 4 cm[31]. There is consensus of the need for the tumour to be superficial, although authors argue about the ideal location as either antero-lateral[32] or left liver[33]. In the studies, the location of mass differs vastly between each paper (segment 4, 8[32], and segment 2, 3, 4[33,35]), but is consistent with their selection criteria. Studies that recommend SILH for the left lobe of the liver argue that the suspensory ligament aids in the surgical-site exposure[33].

Surgical technique

Length of initial incision ranged from 0.7 cm[32] to 3 cm[31], although the length of incisions were occasionally extended in order to deliver the specimen out of the incision. All reports[31-37] used multi-port systems for single-port laparoscopic surgery, as well as a hemostatic coagulation device or clips and staplers to control bleeding and achieve hemostasis. Technical skills must also be available to allow the surgeon to perform laparoscopic intra-corporeal stitching and knot tying through the single incision site. Some studies also created a zone of heat-coagulative necrosis along the line of intended liver parenchyma division in order to maintain a blood free division[33,35,36]. Sasaki *et al*[34] also described the use of 2 trocars with a wire retractor in the same incision for deroofing of a liver cyst in order to reduce the number of instruments, hence minimizing collisions between devices. SILH for malignant tumours were performed under oncologic principles - no direct touching of tumour, and to ensure that radical excision (R_0) and adequate resection margins of at least 1 cm[38,39] is achieved.

Post-operative outcomes

Operating time for SILH ranged from 75[31] to 235 min[32]. The operating time has a large range due to the different complexities and pathology of each surgery, and is hence difficult to comment on. There were no reported cases of significant blood loss, with no patients requiring blood transfusion. Post-operatively, none of the patients reported significant pain, and length of hospital stay ranged from 3-11 d[32]. There were also no reported cases of complications such as hematoma, vessel or bile duct injury.

SILH with portal hypertension

Gaujoux *et al*[33] described a patient with a child alcoholic cirrhosis and portal hypertension who underwent SILH for a 2 cm solitary hepatocellular carcinoma. To reduce the risk of transecting umbilical varices and cause bleeding or worsened portal hypertension, a supra-umbilical incision was made instead. This is useful for future cases of patients with SPLS for engorged umbilical varices.

SILH is a highly challenging procedure that is at the early stages of development and is currently limited to select groups of patients under strict criteria, due to the high risks of morbidity from bleeding and potential difficulty in accessibility and execution. Early studies of SILH have shown that it is a safe procedure for a large variety of pathologies. SILH may be useful in small lesions that are on the peripheral and anterior surfaces of the liver, and could be used for HCC lesions that may not be easily accessible by radiofrequency ablation, such as tumours in the periphery of segment 3[36]. More studies are also needed to come up with more meaningful conclusions on whether the location of the lesion is useful to determine if SILH is appropriate treatment, and if so, which location. Overall, studies of a larger scale are needed in order to provide useful evidence on the safety and outcomes of SILH.

SINGLE-PORT LAPAROSCOPIC PANCREATECTOMY

Laparoscopic pancreatectomy is not frequently performed due to the limited cases that are suitable, the technical challenges involved and need for specialized surgical equipment[40]. Thus, single-port laparoscopic pancreatectomy (SPLP) have only been explored and described in recent years, and literature is limited mostly to single case reports or small case series, with a total of 11 cases being described[40-43].

Multi-incision laparoscopic pancreatectomy is usually performed for distal pancreatectomy, and has been performed for numerous pathologies - from benign[44,45] to malignant[46]. Laparoscopic surgery is preferred to open surgery in pancreatectomy due to benefits of decreased morbidity and faster recovery[42]. SPLP have been performed for distal pancreatectomy, including splenectomy for several cases[40,47,48]. Indications for SPLP range from benign serous cystadenomas[40,49], neuroendocrine tumours[48,49] or metastatic renal cell carcinoma[43].

Surgical technique

General surgical technique and difficulties faced with SPLS applies to SPLP, but surgeons have developed several ways to ensure proper traction and visualization of the lesion, which is important especially since the pancreas is a retroperitoneal organ. To achieve gastric traction, trans-abdominal sutures can be placed on the posterior gastric wall to sling it up in order to expose the pancreas[40,48], or a loop made of suture and plastic tubing from a IV serum set can be used to encircle the stomach corpus[43]. Some studies also made use of ribbon gauze to loop around the pancreas body to provide additional traction[40,48]. The pancreas was dissected either with electrocautery[40,43,48] or staplers[49], and the stump was reinforced with continuous suture and/or topical sealant[48,49].

Operative outcomes

There is only 1 study available comparing SPLP and conventional laparoscopic distal pancreatectomy (CLDP) by Haugvik *et al*[43]. They reported no significant differences in operating time, intra-operative bleeding, resection status, tumour size or length of hospital stay. Surgical morbidity is comparable with CLDP, and CLDP actually appears to be associated with more serious complications (2 patients with splenic artery bleeding, requiring laparoscopic revision, splenectomy and transfusion) as compared to SPLP. However, it is difficult to make a definitive evaluation given the small number of cases being compared.

Post-operative complications

Pancreatic fistulas are common post-operative complications in distal pancreas resection, and occur in 8%-30% of patients[50-52]. Haugvik *et al*[43] found no significant differences in occurrence of pancreatic fistulas, with 2 patients each from SILDP and CLDP groups developing post-operative pancreatic fistulas (ISGPF grade B[43]). Another complication reported was a delayed presentation of abscess formation at the pancreatic stump, which was treated with antibiotics and percutaenous catheter drainage[48].

Overall, SPLP appears to be a safe and feasible procedure for selected patients, and may potentially offer the same benefits of laparoscopic surgery with minimal abdominal trauma and improved cosmesis. More experience is needed to better evaluate the safety and morbidity of SPLP, and its applications with regards to pancreatic pathologies.

TIPS FROM OUR INSTITUTION’S EXPERIENCE WITH SPLS

In SPLS, multiple instruments (including the operating instruments and laparoscopic camera) are introduced into the same incision, the limited space is challenging for both the surgeon and assistant to work together compared to conventional multi-incision laparoscopic surgery. As such, instruments and the hands holding the instruments tend to “clash”. SILC also loses the principle of triangulation in laparoscopic surgery, and hence poses a new set of technical difficulties. The main challenges of SILC is hence to allow both surgeon and assistant to work together effectively in the space constraints, to avoid collision of instruments and to maintain adequate retraction for proper dissection. Authors have proposed different methods to overcome these difficulties, including a chopstick method, where instruments were crossed outside the abdomen to allow for the distal portion of the instruments within the abdomen to be further away from each other, hence minimizing instrument collisions. The use of roticulating instruments on a “mirror image”[5], as the left hand controlling the right-sided instrument on the screen and vice versa, takes time to get used to, and contributes toward the learning curve. We herein offer our techniques as practical solutions to overcome the technical obstacles.

Figure 1 Surgeon standing in between patient's legs with assistant on patient's left.

Figure 2 Position of instruments showing laparoscopic camera in most dependent position.

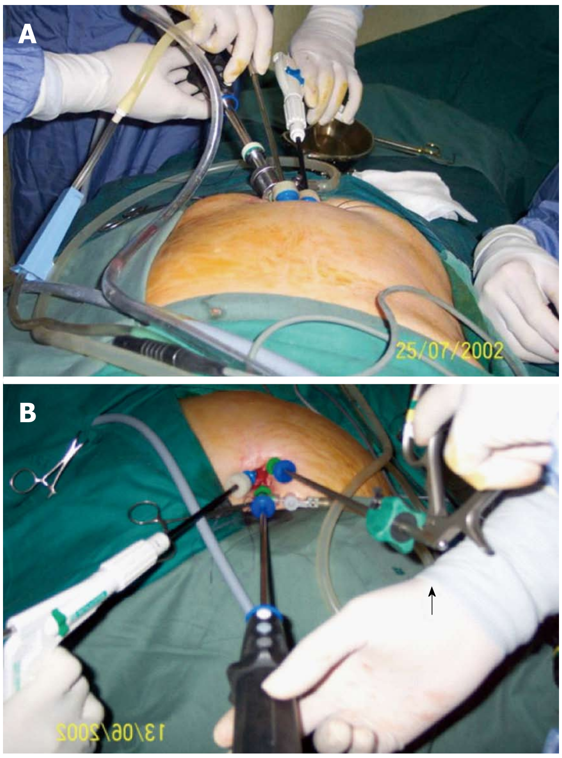

Figure 3 Surgeon demonstrating standard hand grip (A) and reverse hand grip (B).

Figure 4 "Snooker cue guide" position.

Surgeon's position

By placing the patient in a French position, it allows for adequate space for both the surgeon and assistant to work in coordination without awkward positions (Figure 1). The surgeon usually stands in between the patient's legs while the assistant stands on the patient's left. In the classical instrument holding position, the surgeon should be holding the 2 instruments while the assistant operates the camera seated in order to provide the surgeon maximum space for easier instrument manipulation.

Port position and SPLS instruments

A multi-port device for single-incision surgery is recommended. The laparoscopic camera should be placed in the most dependent position, with the instruments superior to the camera (Figure 2).

Instrument crossing positions

Instruments should be crossed inside the abdomen, ensuring that the distance between the crossing point and surgeon's hand is greater than the distance between the crossing point to the effector site. This is to reduce the chance of hand clashing and more accurate movement of the effector hand.

Standard hand grip vs reverse hand grip

Holding instruments conventionally with the finger rings inferiorly is not ergonomic in SPLS and often results in the surgeon colliding with the laparoscopic camera. Hence, we recommend that the surgeon should hold the instruments with key rings facing outwards (Figure 3A) or superiorly in a reverse hand grip (Figure 3B).

Snooker cue guide position

In this position, the surgeon handles both the instrument and camera (Figure 4). Given that the field of vision is significantly narrower with SILC, this is useful in fine dissection. The assistant retracts and the surgeon dissects smoothly while being in control of the field of vision, hence ensuring optimal visualization especially of the Calot's triangle, which is pertinent to minimize risks of bile duct injuries.

Figure 5 Enforced wound closure using two figure-of-8 stitches and interrupted stitch.

Prevention of incisional hernia

Early studies of long term complications with SPLS have shown an increased risk of incisional hernia compared to conventional laparoscopic surgeries. This may be due to the increased dissection of the umbilical wound with increased abdominal tension over a longer operating time, causing ischemia of the fascia. Closure technique is crucial to prevent incisional hernia, and a double figure-of-8 stitch (Figure 5) is usually needed.

CONCLUSION

SPLS is a promising direction in laparoscopic surgery, and is extending its applications to increasing types of hepatopancreaticobiliary surgeries. We recommend a step-wise approach to performing SPLS for hepatobiliary disease; starting from the least complicated cases in cholecystectomy and subsequently move to more complicated cases such as tumour removal in pancreatectomy in order to ensure a safe adoption of surgical technique. Further technical refinement of the instruments and innovations will be useful in improving the surgical technique in order to maximize the benefits of SPLS while minimizing complications and failure rates.

The evaluation of the real value of this approach will require randomized controlled trials of larger scale, with open reporting of both early and late complications. International consensus is needed before its adoption into routine practice.

REFERENCES

1 **Reynolds W**. The first laparoscopic cholecystectomy. *JSLS* 2001; **5**: 89-94 [PMID: 11304004]

2 **Keus F**, de Jong JA, Gooszen HG, van Laarhoven CJ. Laparoscopic versus open cholecystectomy for patients with symptomatic cholecystolithiasis. *Cochrane Database Syst Rev* 2006; (**4**): CD006231 [PMID: 17054285]

3 **Inoue H**, Takeshita K, Endo M. Single-port laparoscopy assisted appendectomy under local pneumoperitoneum condition. *Surg Endosc* 1994; **8**: 714-716 [PMID: 8059314 DOI: 10.1007/BF00678574]

4 **Navarra G**, Pozza E, Occhionorelli S, Carcoforo P, Donini I. One-wound laparoscopic cholecystectomy. *Br J Surg* 1997; **84**: 695 [PMID: 9171771 DOI: 10.1002/bjs.1800840536]

5 **Pisanu A**, Porceddu G, Reccia I, Saba A, Uccheddu A. Meta-analysis of studies comparing single-incision laparoscopic appendectomy and conventional multiport laparoscopic appendectomy. *J Surg Res* 2013; **183**: e49-e59 [PMID: 23582760 DOI: 10.1016/j.jss.2013.03.038]

6 **Trastulli S**, Cirocchi R, Desiderio J, Guarino S, Santoro A, Parisi A, Noya G, Boselli C. Systematic review and meta-analysis of randomized clinical trials comparing single-incision versus conventional laparoscopic cholecystectomy. *Br J Surg* 2013; **100**: 191-208 [PMID: 23161281 DOI: 10.1002/bjs.8937]

7 **Sajid MS**, Ladwa N, Kalra L, Hutson KK, Singh KK, Sayegh M. Single-incision laparoscopic cholecystectomy versus conventional laparoscopic cholecystectomy: meta-analysis and systematic review of randomized controlled trials. *World J Surg* 2012; **36**: 2644-2653 [PMID: 22855214 DOI: 10.1007/s00268-012-1719-5]

8 **Garg P**, Thakur JD, Garg M, Menon GR. Single-incision laparoscopic cholecystectomy vs. conventional laparoscopic cholecystectomy: a meta-analysis of randomized controlled trials. *J Gastrointest Surg* 2012; **16**: 1618-1628 [PMID: 22580841 DOI: 10.1007/s11605-012-1906-6]

9 **Markar SR**, Karthikesalingam A, Thrumurthy S, Muirhead L, Kinross J, Paraskeva P. Single-incision laparoscopic surgery (SILS) vs. conventional multiport cholecystectomy: systematic review and meta-analysis. *Surg Endosc* 2012; **26**: 1205-1213 [PMID: 22173546 DOI: 10.1007/s00464-011-2051-0]

10 **Geng L**, Sun C, Bai J. Single incision versus conventional laparoscopic cholecystectomy outcomes: a meta-analysis of randomized controlled trials. *PLoS One* 2013; **8**: e76530 [PMID: 24098522]

11 **Joseph M**, Phillips MR, Farrell TM, Rupp CC. Single incision laparoscopic cholecystectomy is associated with a higher bile duct injury rate: a review and a word of caution. *Ann Surg* 2012; **256**: 1-6 [PMID: 22664556 DOI: 10.1097/SLA.0b013e3182583fde]

12 **Flum DR**, Cheadle A, Prela C, Dellinger EP, Chan L. Bile duct injury during cholecystectomy and survival in medicare beneficiaries. *JAMA* 2003; **290**: 2168-2173 [PMID: 14570952 DOI: 10.1001/jama.290.16.2168]

13 **Hall TC**, Dennison AR, Bilku DK, Metcalfe MS, Garcea G. Single-incision laparoscopic cholecystectomy: a systematic review. *Arch Surg* 2012; **147**: 657-666 [PMID: 22802063 DOI: 10.1001/archsurg.2012.814]

14 **Tay CW**, Shen L, Hartman M, Iyer SG, Madhavan K, Chang SK. SILC for SILC: Single Institution Learning Curve for Single-Incision Laparoscopic Cholecystectomy. *Minim Invasive Surg* 2013; **2013**: 381628 [PMID: 23766898]

15 **Chow A**, Purkayastha S, Aziz O, Pefanis D, Paraskeva P. Single-incision laparoscopic surgery for cholecystectomy: a retrospective comparison with 4-port laparoscopic cholecystectomy. *Arch Surg* 2010; **145**: 1187-1191 [PMID: 21173293 DOI: 10.1001/archsurg.2010.267]

16 **Rasić Z**, Schwarz D, Nesek VA, Zoricić I, Sever M, Rasić D, Lojo N. Single incision laparoscopic cholecystectomy--a new advantage of gallbladder surgery. *Coll Antropol* 2010; **34**: 595-598 [PMID: 20698134]

17 **Song T**, Liao B, Liu J, Yin Y, Luo Q, Cheng N. Single-incision versus conventional laparoscopic cholecystectomy: a systematic review of available data. *Surg Laparosc Endosc Percutan Tech* 2012; **22**: e190-e196 [PMID: 22874697 DOI: 10.1097/SLE.0b013e318257000c]

18 **Kravetz AJ**, Iddings D, Basson MD, Kia MA. The learning curve with single-port cholecystectomy. *JSLS* 2009; **13**: 332-336 [PMID: 19793472]

19 **Shaikh HR**, Mahesri M, Abbas A. Single incision laparoscopic cholecystectomy: overcoming the learning curve. *Surg Endosc* 2011; **25**: S337

20 **Rivas H**, Varela E, Scott D. Single-incision laparoscopic cholecystectomy: initial evaluation of a large series of patients. *Surg Endosc* 2010; **24**: 1403-1412 [PMID: 20035355 DOI:

10.1007/s00464-009-0786-7]
21 **Blinman T**. Incisions do not simply sum. *Surg Endosc* 2010; **24**: 1746-1751 [PMID: 20054565 DOI: 10.1007/s00464-009-0854-z]
22 **Chang SK**, Wang YL, Shen L, Iyer SG, Shaik AB, Lomanto D. Interim report: a randomized controlled trial comparing postoperative pain in single-incision laparoscopic cholecystectomy and conventional laparoscopic cholecystectomy. *Asian J Endosc Surg* 2013; **6**: 14-20 [PMID: 22979900 DOI: 10.1111/j.1758-5910.2012.00154.x]
23 **Xiao S**, Hu S, Zhang G. Comparative study between transumbilical single port laparoscopic cholecystectomy and conventional laparoscopic cholecystectomy. *J Laparosc Surg* 2010; **15**: 501-504
24 **Chang SK**, Tay CW, Bicol RA, Lee YY, Madhavan K. A case-control study of single-incision versus standard laparoscopic cholecystectomy. *World J Surg* 2011; **35**: 289-293 [PMID: 21057790 DOI: 10.1007/s00268-010-0842-4]
25 **Aprea G**, Coppola Bottazzi E, Guida F, Masone S, Persico G. Laparoendoscopic single site (LESS) versus classic video-laparoscopic cholecystectomy: a randomized prospective study. *J Surg Res* 2011; **166**: e109-e112 [PMID: 21227454 DOI: 10.1016/j.jss.2010.11.885]
26 **Phillips MS**, Marks JM, Roberts K, Tacchino R, Onders R, DeNoto G, Rivas H, Islam A, Soper N, Gecelter G, Rubach E, Paraskeva P, Shah S. Intermediate results of a prospective randomized controlled trial of traditional four-port laparoscopic cholecystectomy versus single-incision laparoscopic cholecystectomy. *Surg Endosc* 2012; **26**: 1296-1303 [PMID: 22083331 DOI: 10.1007/s00464-011-2028-z]
27 **Tsimoyiannis EC**, Tsimogiannis KE, Pappas-Gogos G, Farantos C, Benetatos N, Mavridou P, Manataki A. Different pain scores in single transumbilical incision laparoscopic cholecystectomy versus classic laparoscopic cholecystectomy: a randomized controlled trial. *Surg Endosc* 2010; **24**: 1842-1848 [PMID: 20174950 DOI: 10.1007/s00464-010-0887-3]
28 **Zheng M**, Qin M, Zhao H. Laparoendoscopic single-site cholecystectomy: a randomized controlled study. *Minim Invasive Ther Allied Technol* 2012; **21**: 113-117 [PMID: 21574826 DOI: 10.3109/13645706.2011.577787]
29 **Ma J**, Cassera MA, Spaun GO, Hammill CW, Hansen PD, Aliabadi-Wahle S. Randomized controlled trial comparing single-port laparoscopic cholecystectomy and four-port laparoscopic cholecystectomy. *Ann Surg* 2011; **254**: 22-27 [PMID: 21494123 DOI: 10.1097/SLA.0b013e3182192f89]
30 **Lee PC**, Lo C, Lai PS, Chang JJ, Huang SJ, Lin MT, Lee PH. Randomized clinical trial of single-incision laparoscopic cholecystectomy versus minilaparoscopic cholecystectomy. *Br J Surg* 2010; **97**: 1007-1012 [PMID: 20632264]
31 **Cai XJ**, Zhu ZY, Liang X, Yu H, Wang YF, He JK, Li ZY. Single incision laparoscopic liver resection: a case report. *Chin Med J* (Engl) 2010; **123**: 2619-2620 [PMID: 21034639]
32 **Aikawa M**, Miyazawa M, Okamoto K, Toshimitsu Y, Okada K, Ueno Y, Yamaguchi S, Koyama I. Single-port laparoscopic hepatectomy: technique, safety, and feasibility in a clinical case series. *Surg Endosc* 2012; **26**: 1696-1701 [PMID: 22179479 DOI: 10.1007/s00464-011-2095-1]
33 **Gaujoux S**, Kingham TP, Jarnagin WR, D'Angelica MI, Allen PJ, Fong Y. Single-incision laparoscopic liver resection. *Surg Endosc* 2011; **25**: 1489-1494 [PMID: 20976489 DOI: 10.1007/s00464-010-1419-x]
34 **Sasaki K**, Watanabe G, Matsuda M, Hashimoto M, Harano T. Original method of transumbilical single-incision laparoscopic deroofing for liver cyst. *J Hepatobiliary Pancreat Sci* 2010; **17**: 733-734 [PMID: 20703853]
35 **Pan M**, Jiang Z, Cheng Y, Xu X, Zhang Z, Zhou C, He G, Xu T, Liu H, Gao Y. Single-incision laparoscopic hepatectomy for benign and malignant hepatopathy: initial experience in 8 Chinese patients. *Surg Innov* 2012; **19**: 446-451 [PMID: 22474017 DOI: 10.1177/1553350612438412]
36 **Kobayashi S**, Nagano H, Marubashi S, Wada H, Eguchi H, Takeda Y, Tanemura M, Sekimoto M, Doki Y, Mori M. A single-incision laparoscopic hepatectomy for hepatocellular carcinoma: initial experience in a Japanese patient. *Minim Invasive Ther Allied Technol* 2010; **19**: 367-371 [PMID: 20945973 DOI: 10.3109/13645706.2010.518731]
37 **Wang E**, Kow AW, Chan CY, Liau KH, Ho CK. Starting a laparoscopic hepatectomy programme. *Singapore Med J* 2009; **50**: 354-359 [PMID: 19421677]
38 **Azagra JS**, Goergen M, Brondello S, Calmes MO, Philippe P, Schmitz B. Laparoscopic liver sectionectomy 2 and 3 (LLS 2 and 3): towards the "gold standard". *J Hepatobiliary Pancreat Surg* 2009; **16**: 422-426 [PMID: 19466378 DOI: 10.1007/s00534-009-0117-3]
39 **Gigot JF**, Glineur D, Santiago Azagra J, Goergen M, Ceuterick M, Morino M, Etienne J, Marescaux J, Mutter D, van Krunckelsven L, Descottes B, Valleix D, Lachachi F, Bertrand C, Mansvelt B, Hubens G, Saey JP, Schockmel R. Laparoscopic liver resection for malignant liver tumors: preliminary results of a multicenter European study. *Ann Surg* 2002; **236**: 90-97 [PMID: 12131090 DOI: 10.1097/00000658-200207000-00014]
40 **Chang SK**, Lomanto D, Mayasari M. Single-port laparoscopic spleen preserving distal pancreatectomy. *Minim Invasive Surg* 2012; **2012**: 197429 [PMID: 22482047]
41 **Barbaros U**, Sümer A, Demirel T, Karakullukçu N, Batman B, Içscan Y, Sarıçam G, Serin K, Loh WL, Dinççağ A, Mercan S. Single incision laparoscopic pancreas resection for pancreatic metastasis of renal cell carcinoma. *JSLS* 2010; **14**: 566-570 [PMID: 21605524 DOI: 10.4293/108680810X12924466008448]
42 **Srikanth G**, Shetty N, Dubey D. Single incision laparoscopic distal pancreatectomy with splenectomy for neuroendocrine tumor of the tail of pancreas. *J Minim Access Surg* 2013; **9**: 132-135 [PMID: 24019693 DOI: 10.4103/0972-9941.115377]
43 **Haugvik SP**, Røsok BI, Waage A, Mathisen O, Edwin B. Single-incision versus conventional laparoscopic distal pancreatectomy: a single-institution case-control study. *Langenbecks Arch Surg* 2013; **398**: 1091-1096 [PMID: 24177746 DOI: 10.1007/s00423-013-1133-y]
44 **Marinis A**, Anastasopoulos G, Polymeneas G. A solid pseudopapillary tumor of the pancreas treated with laparoscopic distal pancreatectomy and splenectomy: a case report and review of the literature. *J Med Case Rep* 2010; **4**: 387 [PMID: 21114814 DOI: 10.1186/1752-1947-4-387]
45 **Kim SC**, Park KT, Hwang JW, Shin HC, Lee SS, Seo DW, Lee SK, Kim MH, Han DJ. Comparative analysis of clinical outcomes for laparoscopic distal pancreatic resection and open distal pancreatic resection at a single institution. *Surg Endosc* 2008; **22**: 2261-2268 [PMID: 18528619 DOI: 10.1007/s00464-008-9973-1]
46 **Kooby DA**, Chu CK. Laparoscopic management of pancreatic malignancies. *Surg Clin North Am* 2010; **90**: 427-446 [PMID: 20362796 DOI: 10.1016/j.suc.2009.12.011]
47 **Nigri GR**, Rosman AS, Petrucciani N, Fancellu A, Pisano M, Zorcolo L, Ramacciato G, Melis M. Metaanalysis of trials comparing minimally invasive and open distal pancreatectomies. *Surg Endosc* 2011; **25**: 1642-1651 [PMID: 21184115 DOI: 10.1007/s00464-010-1456-5]
48 **Lorenz U**, Maier M, Steger U, Töpfer C, Thiede A, Timm S. Analysis of closure of the pancreatic remnant after distal pancreatic resection. *HPB* (Oxford) 2007; **9**: 302-307 [PMID: 18345309 DOI: 10.1080/13651820701348621]
49 **Ridolfini MP**, Alfieri S, Gourgiotis S, Di Miceli D, Rotondi F, Quero G, Manghi R, Doglietto GB. Risk factors associated with pancreatic fistula after distal pancreatectomy, which technique of pancreatic stump closure is more beneficial? *World J Gastroenterol* 2007; **13**: 5096-5100 [PMID: 17876875]
50 **Sledzianowski JF**, Duffas JP, Muscari F, Suc B, Fourtanier F. Risk factors for mortality and intra-abdominal morbidity after distal pancreatectomy. *Surgery* 2005; **137**: 180-185 [PMID:

15674199 DOI: 10.1016/j.surg.2004.06.063]

51 **Bassi C**, Dervenis C, Butturini G, Fingerhut A, Yeo C, Izbicki J, Neoptolemos J, Sarr M, Traverso W, Buchler M. Postoperative pancreatic fistula: an international study group (ISGPF) definition. *Surgery* 2005; **138**: 8-13 [PMID: 16003309 DOI: 10.1016/j.surg.2005.05.001]

52 **Prasad A**, Mukherjee KA, Kaul S, Kaur M. Postoperative pain after cholecystectomy: Conventional laparoscopy versus single-incision laparoscopic surgery. *J Minim Access Surg* 2011; **7**: 24-27 [PMID: 21197238]

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