Minimally Invasive Therapy. 2012; Early Online, 1–6

informa
healthcare

ORIGINAL ARTICLE

Internal retraction in single-port laparoscopic cholecystectomy: Initial experience and learning curve

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Abstract

Introduction: We report our experience and learning curve in single-port laparoscopic cholecystectomy (SPLC) using an internal anchored retraction system. **Methods:** Usefulness of the retraction system was analysed in 18 SPLC. The first eight, the following ten SPLC and 20 consecutive four-port laparoscopic cholecystectomies (4PLC) were compared. Duration of operation, burns on nontarget tissue and gallbladder perforations were assessed by reviewing videotapes recorded during the procedures. **Results**: Use of the retraction system failed in three out of five patients (60%) with intraoperative signs of chronic inflammation and in one out of 13 (7.1%) without such signs ($p = 0.0441$). Median operation time was 90 (45–120) in the first eight and 55 (40–180) minutes in the following ten SPLC ($p = 0.0361$). Whereas the first eight SPLC lasted longer compared to 4PLC (70 (40–140) minutes, $p = 0.0435$) the difference disappeared after eight procedures ($p = 0.2076$). Median number of burns to nontarget tissue was seven (1–16) in the first eight and one (0–8) in the following ten SPLC ($p = 0.0049$). There was no difference in perforation of the gallbladder. **Discussion:** Internal retraction enables a safe exposure of the Calot triangle avoiding bile spillage in cholecystectomies without intraoperative signs of inflammation. Familiarisation with SPLC was rapidly achieved. Operation time and dexterity were equal to 4PLC after eight SPLC.

Key words: *Single port, single access, single incision, cholecystectomy, learning curve*

Introduction

In the effort to reduce the operative trauma and to improve the cosmetic results of routine procedures such as laparoscopic cholecystectomy, possible advantages of three compelling minimally invasive techniques are currently debated. Besides minilaparoscopic cholecystectomy (1) and natural orifice surgery (NOTES), using mainly the transvaginal approach, single-port - also called single-access, single-site or single-incision - surgery has gained attention. The first published randomized controlled trials (RCT) on single-port (SPLC) versus conventional four-port laparoscopic cholecystectomy (4PLC) have shown less pain and improved patient satisfaction with cosmesis in SPLC (2,3). However, these results were not reproduced in the third RCT (4) and the results of ongoing more powerful RCTs are impatiently awaited. The widespread use of SPLC has been questioned due to the high costs of the procedure, increased duration of operation, increased risk of perforation of the gallbladder, difficult retraction due to loss of triangulation and possibly increased rate of bile duct injury due to the difficult learning curve (5,6).

As in SPLC the numbers of available trocars in the access devices are limited; different methods of fundus retraction have been proposed. Most commonly the fundus is retracted by transabdominal stay sutures. As those sutures pass through the gallbladder, spillage of bile is almost inevitable. However, bile spillage has been associated with increased postoperative pain (7).

At our institution we have introduced SPLC using a commercially available internal anchored retraction system (Endograb®, Virtual Ports Ltd., Caesarea, Israel) thus avoiding intraoperative bile spillage.

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ISSN 1364-5706 print/ISSN 1365-2931 online © 2012 Informa Healthcare
DOI: 10.3109/13645706.2012.728530

This study aims to both analyze the efficacy of this retraction system and to describe the learning curve in SPLC.

Material and methods

To assess the successful use of the internal retraction system, we analyzed the first 18 SPLC performed. The learning curve for SPLC was analysed comparing the first eight with the following ten SPLC procedures. Furthermore both groups were compared with the last 20 4PLC of the same surgeon.

Surgical technique

A straight transumbilical 20 mm skin and fascia incision was performed and a single-port device (SILS® PT12, Covidien Inc., Norwalk, CA, USA) was introduced. This port provides four openings: One for gas insufflation and three that can accommodate trocars ranging in size from 5 to 12 mm. After introduction of a 5-mm 45° long scope the fundus of the gallbladder was grasped and the Endograb® internally anchored retraction system was placed at the gallbladder corpus and the peritoneum parietal (Figure 1). The infundibulum was laterally retracted using a bending grasper (Endograsp roticulator®, Covidien Inc., Norwalk, CA, USA). Subsequently good exposure of the Calot triangle was achieved. The dissection was done using a monopolar dissection hook. The cystic artery and duct were first dissected and then separately clipped. The gallbladder was pushed upright and dissected free from the liver by means of the monopolar hook. Once the gallbladder was free from the adjacent tissues, one 5 mm trocar was exchanged for a 10 mm trocar which was inserted through the single-port access device. The gallbladder was extracted using an endobag. The umbilical fascia was closed using an absorbable running suture.

Figure 1. Fundus retraction with Endograb®: The internal retraction system consists of two connected anchors. One is attached to

In 4PLC instead of a single transumbilical incision a 12 mm paraumbilical skin incision was performed and a 12 mm Hasson-type blunt trocar was introduced. A 10 mm 45° long scope was introduced. Now additional 5 mm trocars were placed under optical control subxyphoidal on the left side of the falciforme ligament and in the right lateral upper abdomen. These trocars were used for endograspers to retain the fundus and the infundibulum of the gallbladder. A further 10 mm reusable trocar was placed in the left middle abdomen. This trocar was used for dissection instruments, swabs and the endobag. The gallbladder dissection and extraction was identical to SPLC.

Surgeon's experience and learning curve assessment

All 18 SPLC procedures were performed between January 2010 and May 2011 by the same surgeon who has introduced SPLC in our institution. Before starting with SPLC the operating surgeon had performed 91 4PLC and 243 laparoscopic procedures in total. To determine the learning curve in SPLC the first eight and the consecutive ten procedures were compared. Additionally SPLC procedures were compared with the 20 4PLC performed by the same surgeon between October 2009 and December 2010. To determine the learning curve, operation time, burns of nontarget liver tissue, gallbladder perforation and safe dissection of the Calot triangle were assessed.

Data collection

Patient characteristics, indication and procedure details were prospectively collected in a database (Excel® Version 12.0, 2007, Microsoft Switzerland, Wallisellen, Switzerland). Clinical intraoperative signs of inflammation, duration of operation, identification of the cystic artery and perforations of the gallbladder were described systematically in the operation report. All SPLC procedures were videotaped and stored in the electronical clinical information system. The number of liver burns as well as, again, the perforation of the gallbladder was controlled on the videotapes. Difficulty of performance was classified according to Nassar (8).

Statistical analysis

Descriptive statistics and analysis of significant differences were performed using GraphPad® Prism

Table I. Patient demographics and comparison of SPLC and 4PLC.

	SPLC (n = 18)	4PLC (n = 20)	p
Age (years)	47 (30–76)	47 (30–81)	0.9757
Gender (men/female)	4/14	9/11	0.1818
BMI (kg/m2)	22.4 (21.5–33.1)	26.9 (19.3–33.8)	0.0796
Indication			
Symptomatic cholecystolithiasis	17	20	0.4737
Gallbladder polyps	1		
History of acute cholecystitis	1	3	0.602
Duration of surgery (minutes)	75 (40–180)	70 (40–140)	0.6247
Difficulty of performance (Nassar)	1 (1–3)	1 (1–3)	0.7271
Safe identification of cystic artery	14	18	0.3945
Perforation of gallbladder	4	4	1.0
Length of hospital stay	2 (1–6)	2 (2–6)	0.0980

version 5.00 for Windows (GraphPad Software, San Diego CA, USA). Proportions between groups were compared using a two-tailed Mann-Witney test assuming a nonparametric distribution. Categorical variables were compared using a two-sided Fisher's exact test. The level of significance was set at 0.05.

Results

Patients in the SPLC and 4PLC were not different in age, gender and BMI. Distribution of indications and patients with a history of acute cholecystitis that was treated by antibiotics previously was equal in both groups. The difficulty of performance was not different in SPLC versus 4PLC (Table I).

Internal retraction

The use of the internal retraction system failed in four out of 18 cases (22.2 %). It failed significantly more frequently in patients with intraoperative clinical signs of chronic inflammation. The system could not be mounted or slipped off in three out of five (60%) SPLC patients with intraoperative signs of inflammation such as a thickened gallbladder, but only in one out of 13 (7.1%) without such signs (p = 0.0441). In those patients one (n = 2) or two (n = 1) additional 5 mm trocars had to be inserted. The patient that needed two additional trocars had a history of conservatively treated acute cholecystitis five weeks before surgery. One case was converted to open cholecystectomy due to difficult exposure of a very short cystic duct. This anatomical difficulty was not expected in a patient with symptomatic cholecystolithiasis before surgery. However, when comparing cases with chronic cholecystitis in histology or no histological signs of chronic inflammation no difference could be found in terms of failure of internal retraction (4/14 versus 0/4; p = 0.5538).

Learning curve in SPLC

The median duration of operation dropped significantly after the first eight SPLC (Table II). The median duration of operation in the last 20 4PLC of the same surgeon was 70 (40–140) minutes. This is significantly shorter compared with the first eight SPLC (p = 0.0435). Yet, in the following ten SPLC the duration of operation reached the median operative time of 4PLC (p = 0.2076) (Figure 2).

The median number of burns with electrocautery to nontarget liver tissue was reduced after eight SPLC (p = 0.0049) (Table II, Figures 3 and 4). The number of perforations of the gallbladder during surgery was not different in the first eight SPLC and the following ten SPLC (Table II). The perforation rate in 4PLC was equal to the initial eight SPLC (p = 0.3340) and to the ten consecutive SPLC (p = 0.5577). No

Table II. Comparison of first eight SPLC with following ten SPLC.

	First 8 SPLC	Following 10 SPLC	p
Duration of operation (minutes)	90 (45–120)	55 (40–180)	**0.0361**
Number of burns to nontarget liver tissue	7 (1–16)	1 (0–8)	**0.0049**
Perforation of gallbladder	3	1	0.2745

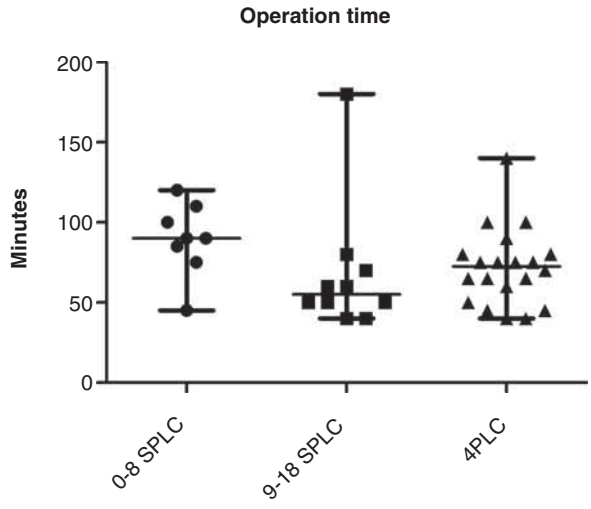


Figure 2. Operation time: Median operation time was 90 (45–120) in the first eight versus 55 (40–180) minutes in the consecutive ten SPLC ($p = 0.0361$). In 4PLC median operation time was 70 (40–140) minutes which is shorter than in the first eight SPLC ($p = 0.0435$) but equal to the consecutive ten SPLC ($p = 0.2076$).

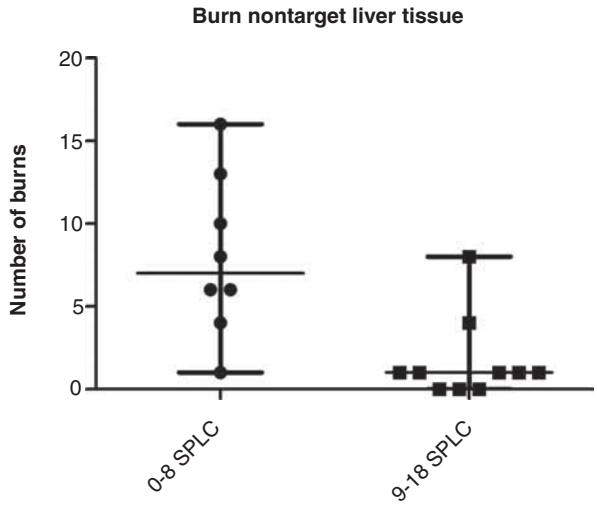


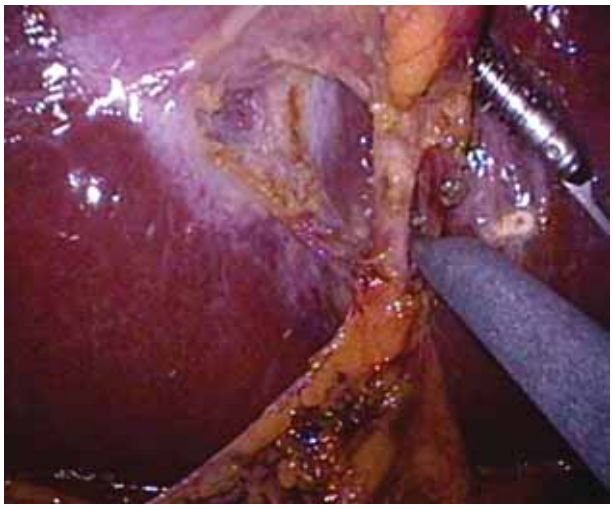
Figure 3. Burn non-target liver tissue: The median number of burns to non-target liver tissue was seven (1–16) in the first eight and 1 (0–8) in the consecutive 10 SPLC ($p = 0.0049$).

differences in safe identification of the cystic artery and length of stay were identified between SPLC and 4PLC (Table I).

Discussion

This study addresses several current hurdles in the implementation of SPLC into surgical routine. First of all in an attempt to avoid bile spillage which occurs in suture retraction of the gallbladder fundus the use of an alternative commercially available internal retraction system (Endograb®) is evaluated. Furthermore the learning curve of a moderately experienced laparoscopic surgeon is assessed in terms of duration of operation as well as dexterity and safety surrogate markers.

Since in SPLC the number of available trocars for retraction is limited and due to the loss of triangulation, retraction of the gallbladder fundus from the umbilical access can be difficult. Different methods of retraction have been proposed (9). Only if the single access device offers four or more working channels the fundus can be retracted by a curved endograsper. For statical fundus retraction in this case the connection of the grasper to a flexible retractor locked in position has been described (10). However, most commonly transabdominal stay sutures are used. Thus this approach leads inevitably to bile spillage as the sutures perforate the gallbladder. Bile spillage has been shown to be a risk factor of postoperative pain (7) and is believed to increase tumor seeding in case of an incidentally encountered gallbladder cancer (11). Moreover, exposure using stay sutures is difficult to achieve in comparison to standard laparoscopy (12). Alternatively transabdominal endoloops have been used to retract the fundus without perforating it. However, only a limited exposure can be achieved using this method. Magnetic anchoring und guidance systems (MAGS) have been developed. Nevertheless those systems are still limited by exponential decrease in magnetic coupling strength as a function of distance. The use of MAGS is therefore restricted to thin patients (13). In this study the Endograb® internal retractor was employed. This system avoids perforation of the gallbladder and allows good exposure as retention force is high. The only evaluation of this system in SPLC derives from a Jerusalem group associated with the manufacturer of the product. Comparing endoloop and Endograb® retraction they rated the latter to be superior in a series of a total of 20 SPLC procedures. However, they report a long median operation time of 136 (78–230) minutes (9). In our experience the use of Endograb® was successful allowing a good and safe exposure of the Calot triangle in most cases. Failure of the internal retraction occurred with the exception of one case only in patients with thickened gallbladder wall corresponding to an important chronic cholecystitis representing a significant risk factor for Endograb® failure. We therefore recommend not to use Endograb® if intraoperatively the gallbladder wall appears inflamed and thickened. In this case the costs of the device can be economized and one additional trocar should be introduced straight away to prevent a lack of progress resulting



in long duration of operation. In three out of 18 patients (17%) in which SPLC was intended additional 5 mm trocars had to be introduced due to the need of additional retraction devices for safe exposure of Calot's triangle. For safety reasons we advocate the use of additional trocars whenever needed to obtain a clear view of Calot's triangle. However, it is possible that additional trocars will increase postoperative pain in SPLC (12,14). A decrease in need of conversion and additional ports can be expected with increasing experience (15). Yet, laparoscopic cholecystectomy performed by highly experienced surgeons does not reflect the daily practice in most hospitals as it is a typical teaching procedure. Data concerning the learning curve in SPLC are scarce. Most of the published series were operated by experienced senior laparoscopic surgeons. The learning curve is described to be achieved after five to 20 procedures by senior surgeons (15–19). One study showed significant decrease in duration of operation after 20 cases in fellowship-trained surgeons whereas no typical learning curve was found in highly-experienced laparoscopic surgeons (20). This study describes, to our knowledge for the first time, the initial experience of a 5th year chief resident with moderate experience in laparoscopic surgery. As distinct from other published reports the learning curve was not only assessed in terms of the operation time but also using safety and dexterity surrogate markers such as as burns to non-target tissue and perforations of the gallbladder. Those markers have been used and validated in virtual reality training before (21). Yet, burns on nontarget liver tissue are related to the anatomy of the liver and the specific pathological status of the gallbladder. Presuming a non-uniform distribution of patients with difficult anatomy the reliability of this dexterity surrogate might be limited. Both the duration of operation and number of burns on nontarget liver tissue improved significantly already after the initial eight procedures. No differences in perforations of the gallbladder and identification of the cystic artery have been observed over time and in comparison to 4PLC. Median operation time has rapidly reached the level of 4PLC thus mandating rapid familiarisation with the single-port technique.

In conclusion internal retraction using Endograb® enables a safe exposure of the Calot triangle avoiding bile spillage. Its use though is limited to gallbladders without intraoperative signs of inflammation. Improvement of the pull forces of the retraction system would be desirable. The results of this study contradict the raised concerns of prolonged duration of surgery and long learning curve in SPLC. In contrary, familiarisation with SPLC was rapidly achieved by a moderately experienced surgeon. Operation time was not increased compared to 4PLC. The dexterity in SPLC was no longer impaired after eight SPLC procedures.

Declaration of interest: The authors declare that they have no competing interests. No financial support was received for this study.

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