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ORIGINAL ARTICLE

Single port laparoscopic cholecystectomy: which technique, which surgeon, for which patient? A study of the implementation in a teaching hospital

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Abstract
Background Single port cholecystectomy is increasingly performed. This procedure can be challenging, and we lack factors predicting the operative difficulty.
Aims To assess the role of surgeon experience and identify possible predictive factors of intraoperative difficulties.
Patients and methods Sixty-one selected patients were prospectively enrolled between January 2008 and August 2010. Six surgeons were involved (3 seniors, 3 juniors). Anthropometrics of the patients, types of ports, exposure methods and intraoperative data were recorded. Pain was assessed with the visual analogic scale at postoperative day 1 (POD 1 VAS).
Results Fifty-eight patients with symptomatic gallstones and three with acute cholecystitis underwent single port cholecystectomy. The mean BMI, weight and height were 25.7 kg/m^2 (SD 4.45), 71.8 kg (SD 14.83) and 166 cm SD 0.07, respectively. Mean operative time was 68.4 min (SD 26.98). Anthropometrics had no influence on operative time. Senior surgeons performed more rapidly, but the difference was not significant. The overall mean POD 1 VAS was 2.26, (SD 1.81). The mean hospital stay was 2.22 days, (SD 0.9). No complications occurred. An additional exposure method was necessary in 19 procedures. This cluster presented a significantly higher operating time (81.5 min, SD 31.69 vs. 62.7, SD 22.74; $p = 0.01$) and POD 1 VAS (1.92 vs. 3; $p = 0.031$).
Conclusion Single trocar cholecystectomy can be implemented safely in teaching hospitals. Anthropometrics are not predictive of operative difficulties. The need for additional exposure systems affects the operative time and pain negatively, reflecting greater technical difficulties. Research to optimize instruments may help to solve these problems.

Keywords Single incision laparoscopic surgery · Single port · Cholecystectomy · Education · Trocars

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Introduction

The surgical community is facing the challenge of achieving optimal results with ever less invasive approaches.

Laparoscopic cholecystectomy is a paradigm of this dynamic process.

Technological improvements have led to a progressive contraction in the size and number of operating ports, hence reducing abdominal wall trauma and providing further benefits for the patients [1].

The switch from four to one single incision has constantly shown better outcomes in terms of postoperative pain and cosmetic results [2–4], and may reduce the risk of trocar-site-related complications such as incision hernia or infections [5].

Single port laparoscopic surgery is increasingly performed. It is deemed a safe and effective procedure, but has not yet passed the acid test because of operative difficulties, partly due to the lack of adapted instruments [6].

Since operating instruments come from a single port, there is a lack of triangulation with repeated conflicts between operating instruments as well as a lack of

proprioception due to the crossing of instruments with difficult exposure of organs and structures [7]. Surgeons have to get used to these new surgical constraints and may be starting a new learning curve.

Considering these drawbacks, it has been recommended that single port laparoscopic cholecystectomy should be reserved for selected cases such as lean patients without previous surgery and without signs of severe inflammation of the gallbladder [8].

Morbid obesity has been reported as a risk factor for conversion from laparoscopy to open cholecystectomy [9–11]. Furthermore, two large series confirm obesity as an additional challenge in single port cholecystectomy [7, 8].

The primary aim of our study was to analyze the impact of the surgeon's skill on single port cholecystectomy implemented in a teaching hospital. The secondary endpoint was to identify the potential predictive factors of operative difficulty in a strictly selected group of patients by analyzing anthropometric and clinical characteristics of the patient, the influence of different access ports and the need for additional retraction methods to obtain the "critical view of safety" [12].

Patients and methods

Between January 2008 and August 2010, sixty-one patients underwent laparoscopic single port cholecystectomy at our university hospital. Exclusion criteria were: body mass index (BMI) >40 kg/m^2, previous abdominal surgery, severe radiological or clinical signs of cholecystitis, and ASA score ≥III. Six surgeons were involved in the study: three senior surgeons with personal experience of more than 1,000 laparoscopic cholecystectomies and having a fixed position as consultant surgeons, and three junior surgeons with more than 100 but fewer than 200 operated patients having a temporary position in the hospital in order to complete their surgical education.

The operative approach

A 2-cm skin incision was performed intra-umbilically. A single access system was introduced into the abdominal cavity via a 2-cm incision of the muscular aponeurosis under visual control. The basic principles of cholecystectomy were strictly respected. The optical system was a 5-mm, 45-cm-long, 30° angle telescope (Karl Storz Endoskope, Tüttlingen, Germany). The dissection started with the retraction of the gallbladder and the identification of Calot's triangle with two instruments (grasper and hook). Once the cystic elements had been clearly identified and exposed, they were divided between two metal clips. In case of difficult exposure, roticulating graspers (Covidien®) or curved S-shaped instruments (Karl Storz, Tüttlingen, Germany) as well as different exposure systems (hepatic suspension with a percutaneous stitch, Endograb™ system, Virtual Ports Ltd.) were used according to the surgeon's preference and clinical presentation. The gallbladder was dissected in a "bottom to top" fashion using a monopolar hook and was retrieved after introduction into a bag (Memobag Rusch Teleflex Medical or Endo-catch® bag, Covidien®) along with the port.

Depending on the operating surgeon's choice and hospital supplies, five types of port (GELPORT® and GELPOINT®, Applied Medical, Rancho Santa Margarita, CA; TRIPORT®, Advanced Surgical Concepts, Wicklow, Ireland; SILS™, Covidien, North Haven, CT; X-CONE®, Karl Storz, Tüttlingen, Germany; one surgical-glove technique that involves the use of a small plastic wound retractor inserted transumbilically with an attached surgical glove to prevent CO_2 leakages with its fingers functioning as multiple ports for scopes and instruments) [13] were used in this study.

The following parameters were recorded: operating "skin to skin" time, blood loss, instrumentation (type of trocar, type of graspers, exposure systems), as well as the need for additional trocar(s) and/or exposure device(s).

Postoperative pain was evaluated on postoperative day 1 (POD1) using the visual analogic scale (VAS). The length of hospital stay was also noted.

To evaluate whether the size or the BMI of the patients could play a role in the difficulty of the procedure, we applied a BMI cutoff value to classify patients into two groups: above and below 26 kg/m^2. An arbitrary cutoff value of 170 cm height (mean size of French male patients) was also used.

Statistical analysis was performed using a standard software package SPSS 14.0 (SPSS, Inc., Chicago, IL). Descriptive statistics are expressed as absolute numbers or percentages. The Fischer's exact test was used for comparison of discrete variables. A p value of less than 0.05 was considered statistically significant.

Results

Fifty-eight patients with symptomatic gallstones and three patients admitted for acute mild cholecystitis (46 women and 15 men) successfully underwent single port cholecystectomy. Demographics and clinical data are summarized in Table 1.

Thirty-five procedures were performed by three senior surgeons and 26 by three junior surgeons. The overall mean operating time was 68.4 min (SD 26.98). Senior surgeons (S1–S3) showed a shorter mean operating time (68.14 min, SD 24.7) compared to their junior (J1–J3) counterparts (68.8 min, SD 30.24), but this difference was not

statistically significant ($p = 0.92$). The operative times of the two surgeons who carried out most procedures (S1 = 24 and J1 = 14 cholecystectomies) did not demonstrate any significant "learning curve" effect (Fig. 1). The body mass index mean operative times of 67.82 (SD 27.82) and 69.23 (SD 26.33) min in patients with BMI below or above 26 kg/m^2, respectively, or height mean operative time 68.43 (SD 27.77) min and 68.4 (SD 26.15) min in patients below or above 170 cm, respectively, had no significant impact on the operating time.

Table 1 Patient characteristics

Gender (F/M)	46/15
Age (years; mean, range)	47.54 (23–82)
BMI (kg/m^2 mean, range)	25.7 (17.9–38)
Weight (kg; mean, range)	71.8 (47–105)
Height (cm; mean, range)	166 (150–183)
BMI <26 kg/m^2 (*n* patients, range BMI)	35 (17.9–25.7)
BMI >26 kg/m^2 (*n* patients, range BMI)	26 (26–38)
Height <170 cm (*n* patients, range height)	39 (150–169)
Height >170 cm (*n* patients, range height)	22 (170–183)
Diagnosis	
Symptomatic gallstones	58
Cholecystitis	3

In 19 out of 61 procedures (31.14%), an additional exposure system was deemed necessary to obtain the critical view of safety. In eleven patients, liver suspension was achieved by passing a tape under the falciform ligament and by fixing its edges with transparietal stitches. In four patients, an internally anchored, self-standing retraction device, the ENDOGRAB^{TM} system (Virtual Ports Ltd., Israel), was employed. In four patients, an additional port was inserted: in two cases because of bleeding of the cystic artery, and in two cases because the length of the clip applier was not sufficient to reach the cystic duct from the umbilical port. These patients were 180 cm tall.

The 19 procedures requiring an additional exposure system had a statistically significant higher mean operating time (81.05 min, SD 31.69 vs. 62.7, SD 22.74; $p = 0.01$) and POD1 VAS (3 SD 2.02 vs. 1.92 SD 1.62; $p = 0.031$) (Fig. 2).

The type of access port did not influence either the operating time or postoperative pain (Table 2). Roticulating graspers and/or curved instruments were used in 17 patients without any measurable advantage (72.3 min, SD 28.18 vs. 71.6, SD 27; $p = 0.93$). An intraoperative cholangiogram was performed in two cases (3.27%). These two patients had a moderate alteration in their liver biochemistries preoperatively. Otherwise, they did not show any clinical history of stone migration as there was no dilatation of the common bile duct shown by the ultrasonographic examination.

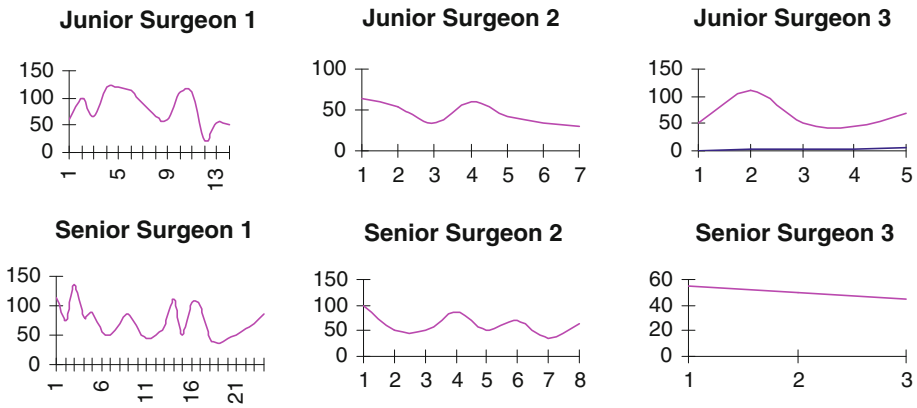

Fig. 1 Junior versus senior surgeons' operating times. *X* axis: consecutive number of procedures; *Y* axis: time (min). Statistical analysis between the two groups showed no significant difference ($p = 0.92$)

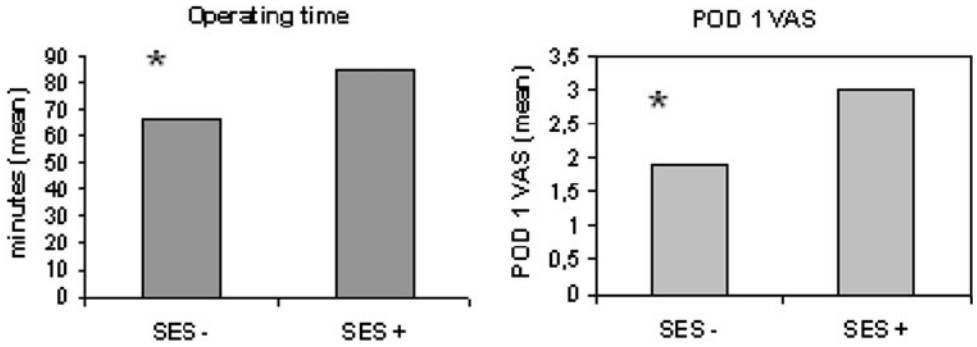

Fig. 2 Operating times and POD 1 VAS. SES+: 19 cases requiring supplementary exposure systems. SES−: 42 cases not requiring supplementary exposure systems. *Statistically significant ($p < 0.05$)

Table 2 Influence of trocar type on operating times and postoperative pain

	GELPORT®	TRIPORT®	SILS™	GLOVE	X-CONE®
Number of operations	15	7	25	11	3
Operating time mean (min)	81.3	72.8	66.88	50.63	71.66
VAS on POD 1 (mean, range)	2.13 (0–7)	1.42 (0–4)	2.52 (0–6)	2.63 (0–8)	1.33 (0–4)

In these cases, an IOC was performed to confirm the lack of remaining stones. The IOC did not influence the operating time: mean of 72.5 min (85–60). The postoperative outcome was uneventful in all patients. The overall mean POD1 VAS was 2.26 (SD 1.81).

The mean hospital stay was slightly higher in the group requiring additional assistance, but without a statistically significant difference (2.14 SD 0.87 vs. 2.42 SD 0.96; $p = 0.26$).

Discussion

The aim of modern surgery is to offer patients the best of care with the minimal impact on global wellness. Single port cholecystectomy is one of these new approaches and has been increasingly performed over the last 2 years. Few large series have been published yet [14–16], and the largest one (297 patients) is a multi-institutional review [13]. This procedure may be challenging even in expert hands, and predictive factors of intraoperative difficulties and subsequent outcome are lacking. Our series of 61 patients, which included consecutive unselected patients, showed results comparable to the published reports in terms of conversion rate and complications, but raises questions about some issues concerning the predictive factors of success. Weight and height could be regarded as important factors when considering the anatomical distance between the umbilicus and the liver. Indeed, a high BMI has been directly correlated with longer operating times in some series [7, 8, 15], whereas no relationship could be identified in other series [6, 16, 17]. In our series, anatomical factors were not discriminatory. Neither obesity (up to a BMI of 40) nor patient height was predictive of complications or longer operating times. Nevertheless, even though insignificant in the whole group of patients, one additional trocar was mandatory in the tallest patients (180 cm) of our series because our current clip applier was not long enough to reach the elements of Calot's triangle.

The learning curve was identified as a significant factor in the quality and outcome of laparoscopic cholecystectomy. The single port approach increases the technical complexity of the procedure and may require a new learning phase. In several studies, different cutoff parameters have been proposed as the point of flatness of the learning curve: 5 procedures [16], 10 [8, 15], 15 [16] or 20 [7]. In our experience, we consider that the learning curve can be overcome with about 15 procedures, after which a flattening of the learning curve was observed. A trend towards lower operating times was observed in the series of patients operated on by an experienced laparoscopic surgeon who carried out the largest number of interventions. A larger group of patients would likely demonstrate a learning curve, which is also related to a better understanding of the specific constraints of the single port approach and its related technological developments. This comprehension may also explain the slight difference observed between the junior and senior surgeons. The operating time was significantly influenced by the use of additional instruments or retracting devices. This probably reflected intraoperative difficulties that were not clearly identified as prognostic factors. The size and shape of the liver lobes were not analyzed but could certainly have an influence on the quality of exposure of Calot's triangle. Nevertheless, this increased difficulty does not alter the protocol of surgical practice defined in conventional laparoscopy. A typical example is the performance of intraoperative cholangiography. We performed this procedure twice in our series. This is interesting to demonstrate the feasibility of IOC in single port access surgery for the control of the common bile duct, its vacuity or the lack of injury if necessary.

This study has some limitations, such as a limited number of patients. In addition, the presence of several surgeons with various levels of expertise and the use of different access ports and exposure systems are all variables that do not facilitate a strong evaluation of the potentialities of a new surgical technique. However, the study reports the reality of the implementation of a new laparoscopic approach where ideal ports and instruments have still not been validated. The slight improvement in the operating times, even though not demonstrating a real learning curve, is probably not only related to the growing experience of the surgeon, but also to the improvements of the technology. A trend towards the use of flexible single port systems and the combination of straight and curved instruments was observed during the study. New internal retraction devices, such as the Endograb™ system, were not used regularly, and no conclusion can be drawn. Transcutaneous assistance for retraction, such as liver suspension, led to higher postoperative pain scores, which were statistically significant, and to prolonged hospital

stays in some patients. No objective reason was found for this increased pain. However, the long-lasting tension on the abdominal wall, the longer operating time or the hepatic suspension technique could account for it.

The major issue in single port cholecystectomy remains the difficulty of inserting several instruments through a small incision and getting a good "laparoscopic" triangulation. Conflicts between the hands of the operator and between the instruments in the peritoneal cavity are reduced by the use of curved instruments and roticulating scissors. Even though these new instruments improve the comfort and confidence of the surgeon, they objectively failed to improve the clinical outcome of the patients.

A positive observation of this study is that the implementation of single port cholecystectomy is possible without compromising the patient's safety in a university hospital, which gathers surgeons with various degrees of experience, some of them still in the learning stage. Nevertheless, this approach should not be performed as a first minimally invasive access by inexperienced surgeons since difficulties in identifying anatomical structures may be observed. We confirm that patient safety will not be altered if this single port access is safely carried out without any fear of adding laparoscopic ports in case of difficulty. Original ideas from younger surgeons will certainly help develop the approach as long as senior surgeons are present to channel their enthusiasm. Indeed, a novel technique must be safe and competitive in terms of outcome and not be prohibitively time-consuming. The operating time is one of the scoring parameters of a surgical technique, but it should not become an obsession. As we all know, safety comes first.

Conclusion

Single port cholecystectomy respects all the issues of safety and reproducibility in the hands of both experts and younger surgeons. One major criticism of this new approach is that it "makes an easy procedure difficult," which can therefore be associated with specific related complications and be considered as a step back in the early period of laparoscopic practice. Research to optimize the instruments, retraction and vision devices as well as training in this technique must be encouraged.

The lack of a significant learning curve must still be confirmed, as well as the preoperative workup required to select the best candidates for this surgery.

We would also like to emphasize that adding a supplementary device or port to maintain the safety acquired for laparoscopy is a matter of prudence and not a failure of an elegant technique. In this way surgery can meet patients' requests for enhanced cosmetic results. Pain evaluation should be carried out with a strictly randomized study as the results of the present study were unclear, so the question remains unanswered.

Conflict of interest The authors of the manuscript have no conflicts of interest or financial ties to disclose.

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