

## Retrospective Cohort Study

# Single-port laparoscopic cholecystectomy vs standard laparoscopic cholecystectomy: A non-randomized, age-matched single center trial

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## Abstract

**AIM:** To compare the safety of single-port laparoscopic cholecystectomies with standard four-port cholecystectomies.

**METHODS:** Between January 2011 and December 2012 data were gathered from 100 consecutive patients who received a single-port cholecystectomy. Patient baseline characteristics of all 100 single-port cholecystectomies were collected (body mass index, age, etc.) in a database. This group was compared with 100 age-matched patients who underwent a conventional laparoscopic cholecystectomy in the same period. Retrospectively, pre- and postoperative data were added. The two groups were compared to each other using independent *t*-tests and  $\chi^2$ -tests, *P* values below 0.05 were considered significantly different.

**RESULTS:** No differences were found between both groups regarding baseline characteristics. Operating time was significantly shorter in the total single-port group (42 min vs 62 min, *P* < 0.05); in procedures performed by surgeons the same trend was seen (45 min vs 59 min, *P* < 0.05). Perioperative complications between both groups were equal (3 in the single-port group vs 5 in the multiport group; *P* = 0.42). Although not significant less postoperative complications were seen in the single-port group compared with the multiport group (3 vs 9; *P* = 0.07). No statistically significant differences were found between both groups

with regard to length of hospital stay, readmissions and mortality.

**CONCLUSION:** Single-port laparoscopic cholecystectomy has the potential to be a safe technique with a low complication rate, short in-hospital stay and comparable operating time. Single-port cholecystectomy provides the patient an almost non-visible scar while preserving optimal quality of surgery. Further prospective studies are needed to prove the safety of the single-port technique.

**Key words:** Single-port; Minimal invasive; Laparoscopy; Safety; Feasibility; Cholecystectomy

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**Core tip:** Single-port cholecystectomies can be performed safe when performed by experienced surgeons. Low complication and conversion rates are seen, similar to standard multiport laparoscopic cholecystectomies. Single-port cholecystectomies can be performed in similar or even shorter operating times compared to the standard procedure. Single-port cholecystectomies can provide the patient an almost non-visible scar while preserving optimal quality of surgery.

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## INTRODUCTION

Laparoscopic cholecystectomy is the standard operative procedure for patients with symptomatic cholelithiasis<sup>[1]</sup>. Introduced in 1985, laparoscopic cholecystectomy, has been an important development in general surgery<sup>[2,3]</sup>. Its introduction resulted in surgical procedures with reduced blood loss, enhanced recovery and less major wound complications. Single incision laparoscopic surgery techniques were introduced in the 1990s<sup>[4]</sup>. When performing this particular type of laparoscopic surgery only one incision is made, usually through the umbilicus. In general, smaller and fewer incisions result in less pain, accelerate postoperative recovery and improve cosmetic result<sup>[3,5,6]</sup>.

After its introduction, standard multiport cholecystectomy was for a long time under debate and frequently contradicted, a situation in which nowadays single-port cholecystectomy finds it-self in. Some studies report higher percentages of bile duct injuries, more blood loss and longer operating time when performing single-port cholecystectomy<sup>[7,8]</sup>. In contrast, although other

studies suggest that single site laparoscopic surgery is a safe and adequate procedure, single site surgery for cholecystectomy for uncomplicated cholecystolithiasis is still subject of debate<sup>[9-11]</sup>.

In 2011, single-port laparoscopic (SPL) also known as laparo-endoscopic single site surgery was introduced at the Jeroen Bosch Hospital, 's-Hertogenbosch, The Netherlands. Since its introduction more than 100 patients received a laparoscopic cholecystectomy with only one umbilical incision. The aim of this study is to compare short as well as long term surgical outcome parameters, such as safety and patient-outcome, between SPL cholecystectomy and standard four port laparoscopic cholecystectomy (SLC).

## MATERIALS AND METHODS

### Patients

Between January 2011 and December 2012 all patients who received a SPL cholecystectomy at the Jeroen Bosch Teaching Hospital ('s-Hertogenbosch, The Netherlands) were included in a prospective database in which relevant patient data and surgical outcome parameters were recorded. Also, all patients who received a SLC in the same study period were identified. After an introduction period ( $n = 36$ ) of the SPL technique, 100 consecutive patients who were operated upon using the SPL technique were matched by age with a group of 100 patients which received a SLC in the same period.

Preoperative data included: age, gender, body mass index (BMI), indication of surgery, previous abdominal surgery, comorbidity and American Society of Anesthesiologists classification. Peroperative data included: operating time (defined as time from first skin incision to completion of closure), need for extra trocar, conversion to open cholecystectomy, first operator (surgeon or resident supervised by surgeon) and peroperative complications. Peroperative bloodloss of more than 200 mL was registered as a complication. Postoperative data included: duration of stay in hospital (including the day of operation), complications (during hospitalisation), reoperation, readmission to the hospital (within 30 d after discharge) and mortality.

Above normal postoperative pain was defined as pain resulting in prolongation of hospital admission with at least one day, without finding a cause of pain.

Hernia cicatricialis was defined as complaints around the umbilical incision caused by herniation of the abdominal wall. Patients were routinely seen 2-6 wk after surgery at the outpatient department and checked on complaints of the incision. All patients were checked in the medical files if they returned to the hospital with complaints of the umbilical incision.

### SPL

SPL cholecystectomy is performed under general anaesthesia. Patients are positioned in a supine position with both legs in holders. The surgeon is positioned

**Table 1 Patient characteristics**

	SPL	SLC	P value
Gender (% female)	80	75	0.397
Age (mean, SD)	45 (15)	46 (15)	0.787
BMI (median, range)	25 (17-40)	28 (19-46)	< 0.001 <sup>b</sup>
ASA (%)			0.239
I + II	98	96	
III	1	2	
Indication (%)			0.557
Symptomatic cholelithiasis	80	77	
Cholecystitis	13	18	
Biliary pancreatitis	3	1	
Gallbladder polyp	3	4	
Cyst gallbladder	1	0	

<sup>b</sup>Statistical significant. SPL: Single-port laparoscopic cholecystectomy; SLC: Standard laparoscopic cholecystectomy; BMI: Body mass index; ASA: American Society of Anesthesiologists classification.

between the legs of the patient ("French" position) and the first assistant is at the left side of the patient. Through an umbilical incision a 4-access multiport trocar (TriPort+, Olympus surgical) is introduced. Patients are placed in an anti-Trendelenburg position and left lateral tilt. Additional support holders are preoperative placed. The gallbladder is lifted cranially to the liver using a straight laparoscopic clamp. The procedure is the same as the multiport procedure. Before ligation of the cystic duct and artery a critical view of safety is achieved. Ligation is performed using a 5 mm clip applier. If no critical view of safety can be achieved an extra trocar will be placed or the procedure is converted to an open procedure. Conversion means that the single-port or standard procedure was converted to an open cholecystectomy. Total number of placement of extra trocar(s) was registered.

### SLC

The standard four-port technique is performed under general anaesthesia. Patients are positioned in a supine position. The surgeon and assistant are positioned at the left side of the patient. A 10 mm trocar is placed periumbilically by open approach and three 5 mm ports are placed in the upper right abdomen under laparoscopic vision. A critical view of safety is achieved before ligation of the cystic duct and artery. When it is not possible to achieve the critical view of safety, the procedure is converted to an open procedure.

### Statistical analysis

Data was collected and statistically analyzed using SPSS (IBM Corp. Released 2010. IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp.).

Continuous variables (means) were analyzed using independent *t*-test. Categorical (ordinal and nominal) variables were analyzed using  $\chi^2$ -test. *P* values were two tailed. Statistical significance was accepted for *P* values of < 0.05.

## RESULTS

In the period January 2011 to December 2012, a total of 795 cholecystectomies were performed of whom 136 patients were treated with the SPL technique. In total 27 of the 795 procedures were converted to an open procedure. All patients' characteristics of the included 100 consecutive patients who underwent a SPL technique and who, matched by age, underwent a four-port technique are noted in Table 1. A significant difference in mean BMI between both groups is observed (25.6 for the SPL group vs 28.9 for the SLC group; *P* < 0.05). BMI ranged in the SPL group from 17 to 40 and in the SLC group from 19 to 46.

In the SPL group three operations were performed by residents vs 29 in the SLC group. The operating time in the whole SPL group (*n* = 100) was significant shorter compared with the total SLC group (*n* = 100) (mean operating time was 46 min vs 62 min, *P* < 0.001). The mean operating time together performed by surgeons was 51 min (SD 24; *n* = 168) whereas the mean operating time for residents for both techniques was 69 min (SD 22; *n* = 32). Operating times in procedures performed by surgeons were significantly shorter in the SPL group, *i.e.*, mean operating time in SPL procedures performed by surgeons (*n* = 97) was 45 min compared to a mean operating time of 59 min in the SLC group (*n* = 71, *P* < 0.05).

A significant correlation (*r* = 0.22; *P* = 0.002) between BMI and operating time was found using the Spearman's rho test (*n* = 200); subgroup analysis showed a significant correlation in the SPL group (*r* = 0.21; *P* = 0.037), but the SLC group did not show a significant correlation (*r* = 0.03; *P* = 0.787). This suggests more influence of BMI on operating times in SPL cholecystectomies. To exclude the effect of the learning curve in analysing the effect of BMI on the operating time, the procedures performed by surgeons were analysed as a subgroup. Regarding all procedures performed by surgeons a significant correlation was found (*r* = 0.24; *P* = 0.003; *n* = 168). Subgroup analysis of procedures performed by surgeons show significant correlation between BMI and operating time in the SPL group (*r* = 0.23; *P* = 0.029; *n* = 97) and no correlation in the SLC group (*r* = 0.108; *P* = 0.385; *n* = 71). No correlation was seen between BMI and placement of extra trocars.

One conversion was observed in the SPL group because of inadequate critical view of safety (vs zero in the SLC group, *P* = 0.331). Additional ports were placed in seven patients (one extra trocar in six patients and two extra trocars in one patient) in the SPL group vs two patients in the SLC group (both one extra trocar, *P* = 0.122). In this group (extra trocar; *n* = 9) the median BMI was 28 (range 18-31) vs 26 (range 17-46) in patients (*n* = 191) without the need of placing an extra trocar (*P* = 0.862). Peroperative complications were seen in three patients in the SPL group (one

**Table 2 Operation characteristics**

	SPL	SLC	P value
Operating time in min (mean, SD)	46 (20)	62 (26)	< 0.001 <sup>b</sup>
Peroperative complications (%)	3	5	0.417
Conversions (%)	1	0	0.331
Adding extra ports (%)	7	2	0.122

<sup>b</sup>Statistical significant. SPL: Single-port laparoscopic cholecystectomy; SLC: Standard laparoscopic cholecystectomy.

**Table 3 Number of postoperative complications**

	SPL	SLC
Bile leakage	1	1
Surgical	0	1
Cardial	0	0
Pulmonary	2	2
Urogenital	0	0
Pain	0	3
Other	0	2

SPL: Single-port laparoscopic cholecystectomy; SLC: Standard laparoscopic cholecystectomy.

peroperative bleeding, two pneumothoraces) vs five patients in the SLC group (all five had a peroperative bleeding;  $P = 0.417$ ). All peroperative characteristics are listed in Table 2.

No patients were admitted to the intensive care and no mortality was seen. A slight difference in postoperative complications in favour of the SPL group in comparison with the SLC group was seen. Three patients of the SPL group suffered from postoperative complications vs nine in the SLC group ( $P = 0.071$ ). Postoperative complications are listed in Table 3 (the two complications noted as "other" are biliary colics and neurological dysfunction of one leg; the surgical complication was a superficial wound infection). No significant difference between both groups was found in length of stay in the hospital including the day of operation. Three patients of the SPL group were readmitted vs four patients in the SLC group ( $P = 0.700$ ). After a median follow up period of 4 wk (range 1-91 wk) one patient was presented with a hernia cicatricialis in the SPL group vs three in the SLC group ( $P = 0.312$ ). For all postoperative data see Table 4.

## DISCUSSION

Nowadays, multiport laparoscopic cholecystectomy is worldwide the standard operative procedure for symptomatic cholelithiasis and chronic cholecystitis. This study shows that the single-port procedure (SPL) could be a safe and feasible procedure, performed in a comparable or even shorter operating time. In this age matched control study a similar or even lower percentage of SPL-operated patients suffered from per- and/or postoperative complications compared with data

**Table 4 Postoperative characteristics**

	SPL	SLC	P value
Complications (%)	3	9	0.071
IC admission (%)	0	0	
Length of stay (in days, mean)	1	2	0.239
Readmission (%)	3	4	0.70
Mortality (%)	0	0	

SPL: Single-port laparoscopic cholecystectomy; SLC: Standard laparoscopic cholecystectomy.

found in literature<sup>[12-15]</sup>.

This study was not designed for or aimed to identify superiority for either one of the techniques. This study shows SPL to be non-inferior to SLC.

In 92% of the patients a SPL cholecystectomy could be performed safely without placement of extra trocars or conversions, whereas only eight patients had a conversion ( $n = 1$ ) or additional port placed ( $n = 7$ ). It is noteworthy to mention that patients in the group who received an additional port still had fewer incisions compared with the multiport procedure.

Furthermore, no increase of biliary or other surgical complications in the single-port group compared with the multiport group was observed. In the beginning of the SPL cholecystectomies surgeons placed a transcutaneous suture for retraction of the gallbladder, causing a pneumothorax in some patients. For this reason after around 45 procedures (including the first 36 procedures performed before this analysis) this suture was not used anymore. This explains the two pneumothoraces seen in the SPL group.

In a meta-analysis published by Trastulli *et al*<sup>[7]</sup> a significant higher procedural failure was found for the SPL technique compared with the SLC technique, ranging from 0% to 67%. It was also mentioned that the SPL technique led to a significantly higher blood loss. This was possibly due to loss of triangulation that makes the use of instruments for suction and diathermy difficult, resulting in less accurate haemostasis. A possible explanation for the findings of Trastulli *et al*<sup>[7]</sup> could be the fact that in the included studies the SPL procedures were performed during the surgeon's learning curve.

In contrast to the conclusion of the study of Ma *et al*<sup>[16]</sup> this study shows a shorter operating time in the SPL group and comparable complication rates. Culp *et al*<sup>[17]</sup> performed a retrospective study and found slightly longer operating times in the SPL group but also a shorter length of stay in the SPL group with comparable complication rates. We did not find a significant shorter length of stay, but we did see shorter operating times in the SPL group. The learning curve could be an explanation of the longer operating times seen in the study of Culp *et al*<sup>[17]</sup>.

No differences were found in postoperative pain, but no validated tests were taken to score postoperative



pain. Single-port laparoscopy is developed to minimize surgical trauma and thereby reduce postoperative pain. Our results suggest less postoperative pain in the SPL group. A study performed by Justo-Janeiro *et al.*<sup>[18]</sup> showed no advantages in postoperative pain for SPL cholecystectomies, however they conclude that more clinical trials are needed. Another shows better postoperative pain scores for a technique comparable to single-port laparoscopy<sup>[19]</sup>. A study of Sodergren *et al.*<sup>[20]</sup> showed better postoperative pain results and better body image and cosmesis in SPL cholecystectomies.

Despite the fact that the SPL procedure is more challenging to learn for surgeons, no difference in perioperative complications were found when compared with the multi-port procedure. In literature a learning curve of around 10-15 patients is described for single site laparoscopic cholecystectomy for surgeons with laparoscopic skills. Operating time for SPL procedures became comparable to the SLC operating time when a surgeon performed 10-15 procedures<sup>[11]</sup>. Another study mentioned a learning curve of 25 patients for surgeons proficient with SLC<sup>[21]</sup>. In this study the first 36 patients who received a SPL cholecystectomy were excluded, preventing effects of the learning curve.

Last year a Cochrane review concerning fewer than four ports cholecystectomies was published<sup>[22]</sup>. This review concluded a lack evidence of the benefits of fewer than four ports cholecystectomies. Last years several studies are published regarding the benefits of single-port surgery, to prove its safety and usefulness. One of the benefits of SPL cholecystectomies is better body image<sup>[20,23]</sup>. As shown by Fransen *et al.*<sup>[24]</sup> the public opinion is in favour for single-port laparoscopy, *i.e.*, when complications risks remain similar, 80% of patients prefers SPL to SLC. Another benefit of the SPL technique is the possible decrease in postoperative pain, however no large clinical trials have proved this advantage yet<sup>[20]</sup>. Liang *et al.*<sup>[25]</sup> showed some advantages of single-port appendectomies compared to standard laparoscopic appendectomies, like less postoperative complications and returning sooner to oral feeding.

Unfortunately, the study described in this article is limited due to selection bias (higher mean BMI in the SLC group) and bias-by-surgeon. Experienced laparoscopic surgeons performed the majority of the SPL cholecystectomies. Supervised residents performed only three procedures, whereas residents performed 29 SLC procedures. Both sources of bias probably influenced the study outcomes, however the study was designed to investigate safety and feasibility. This reality-based study showed no increase of perioperative complications as result of SPL surgery.

Longer operating time is most frequently mentioned as a disadvantage of performing the single-port technique<sup>[16,17,26,27]</sup>. A significant shorter operating time was seen in the total SPL group in this study, operating times are most likely influenced by the experience of the surgeon and possibly the BMI of the patient. Residents

performed only three SPL procedures. SLC procedures performed by surgeons showed longer operating times (median operating time for surgeons in the SPL group was 40 min, in the SLC group 51 min). Longer operating times seen in the SLC group could be explained by the higher BMI seen in this group. When analysing all 200 patients included a significant correlation between BMI and operating time is seen (higher BMI results in longer operating time). The same effect is seen in subgroup analysis for the SPL group, however no significant correlation is seen between BMI and operating time in the SLC group. A possible explanation could be that the experience of the surgeon has more influence on the operating time than BMI, more SLC procedures were performed by residents, this could be the cause of no correlation seen between BMI and operating time in the SLC group. However analysis of procedures performed by surgeons show a correlation between operating times and BMI for SPL procedures and not for SLC procedures. This suggests longer operating times in patients with a higher BMI in SPL procedures. Baseline characteristics were significantly different regarding the BMI of the patients comparing the two groups; no conclusions should be made based on this study regarding the effect of BMI on operating times. Nevertheless, in our clinic no limitations regarding BMI are of issue for SPL procedures.

Median follow-up for all patients was four weeks. After cholecystectomy patients regularly are seen only once. Patients suffering from complication or due to other reasons (*i.e.*, malignant disease or trauma) were followed for a longer period. This short follow-up period of four weeks could influence the amount of hernias measured.

Nowadays the single-port technique is not only used for cholecystectomies or other procedures in benign diseases but in malignant resections as well<sup>[28-30]</sup>. In our hospital more procedures are performed using the single-port technique in the last years, for example hemicolectomies, sigmoidresections and abdominoperineal resections. In procedures in which the patient will receive a stoma, the single-port device can be placed at the location of the stoma for the best cosmetic result. Surgeons and patients are satisfied with the results. In future these results will be analysed as well.

SPL has the potential to be a safe technique with a low complication rate, short hospital stay and comparable operating time to multiport laparoscopic cholecystectomies. A major advance of SPL cholecystectomy in contrast with other techniques is that it can provide the patient a non-visible scar with preserving optimal quality of surgery. Randomized controlled trials are needed to confirm these advantages of SPL cholecystectomies.

## COMMENTS

### Background

Single-port procedures are developed to further minimize trauma and provide faster postoperative recovery with a better cosmetic result.

## Research frontiers

With this study the safety and feasibility of single-port cholecystectomies is studied. Results of single-port cholecystectomies are compared to standard multiport laparoscopic cholecystectomies, regarding per- and postoperative data.

## Innovations and breakthroughs

Previous studies showed single-port laparoscopic (SPL) cholecystectomy to be a safe and feasible technique, but also showed longer operating times and higher conversion rates. The results show faster operating time for the single-port technique with comparable conversions rates and comparable complications. No significant difference was found for the length of stay, but the length of stay was slightly shorter in the single-port group.

## Applications

This study shows that SPL cholecystectomies can be performed safe in hands of experienced surgeons. Probably single-port laparoscopy can be performed safe in other laparoscopic procedures as well. Providing patients an almost non-visible scar while preserving high surgical quality.

## Terminology

Single-port laparoscopy is a laparoscopic technique in which through one transumbilical incision the laparoscopic instruments are introduced in the intra-abdominal cavity. Using the single-port technique minimizes surgical trauma and fastens postoperative recovery.

## Peer-review

This is a good study.

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