


Multi-port versus single-port cholecystectomy: results of a multi-centre, randomised controlled trial (MUSIC trial)

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Abstract

Background Single-port laparoscopic surgery as an alternative to conventional laparoscopic cholecystectomy for benign disease has not yet been accepted as a standard procedure. The aim of the multi-port versus single-port cholecystectomy trial was to compare morbidity rates after single-access (SPC) and standard laparoscopy (MPC).

Methods This non-inferiority phase 3 trial was conducted at 20 hospital surgical departments in six countries. At each centre, patients were randomly assigned to undergo either

SPC or MPC. The primary outcome was overall morbidity within 60 days after surgery. Analysis was by intention to treat. The study was registered with ClinicalTrials.gov (NCT01104727).

Results The study was conducted between April 2011 and May 2015. A total of 600 patients were randomly assigned to receive either SPC ($n = 297$) or MPC ($n = 303$) and were eligible for data analysis. Postsurgical complications within 60 days were recorded in 13 patients (4.7 %) in the SPC group and in 16 (6.1 %) in the MPC group ($P = 0.468$); however,

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single-access procedures took longer [70 min (range 25–265) vs. 55 min (range 22–185); $P < 0.001$]. There were no significant differences in hospital length of stay or pain VAS scores between the two groups. An incisional hernia developed within 1 year in six patients in the SPC group and in three in the MPC group ($P = 0.331$). Patients were more satisfied with aesthetic results after SPC, whereas surgeons rated the aesthetic results higher after MPC. No difference in quality of life scores, as measured by the gastrointestinal quality of life index at 60 days after surgery, was observed between the two groups.

Conclusions In selected patients undergoing cholecystectomy for benign gallbladder disease, SPC is non-inferior to MPC in terms of safety but it entails a longer operative time. Possible concerns about a higher risk of incisional hernia following SPC do not appear to be justified. Patient satisfaction with aesthetic results was greater after SPC than after MPC.

Keywords Cholecystectomy · Single port surgery · Randomized controlled trial

In 1992 Pelosi first described the use of a single umbilical puncture for laparoscopic appendectomy [1], and in 1997 Navarra et al. published, as a short note, their results after single-incision laparoscopic cholecystectomy [2]. It is only more recently that the technique has begun to gain wider acceptance. Concerns over the safety issues with this new technique have been voiced by claims that its widespread adoption would lead to a significant increase in complications, especially bile duct injuries, as occurred during the early years of conventional laparoscopic cholecystectomy [3, 4]. More recently published studies have failed to demonstrate any major differences in clinical outcome after the single-incision laparoscopic technique versus standard multi-port laparoscopy [4–9]. Furthermore, there is increasing doubt about whether the new technique actually delivers the benefits of improved aesthetic results, reduced postoperative pain, earlier return to work, and greater patient satisfaction [10–12]. Also, it has been found that a larger peri-umbilical incision and consequent fascial defect may result in a higher rate of incisional hernia.

The aim of this randomised controlled trial (RCT) was to compare overall morbidity after single-incision laparoscopic technique versus standard multi-port laparoscopy for cholecystectomy in terms of skin incision-related morbidity, postoperative pain, and aesthetic results—the potential benefits advocated for single-port laparoscopic surgery.

Methods

We designed this multi-centre RCT under the endorsement of the Technology Committee of the European Association for Endoscopic Surgery (EAES). The project was approved

by the local ethical committee (COMITATO ETICO INTERAZIENDALE, A.O.U. CITTA' DELLA SALUTE E DELLA SCIENZA DI TORINO, University of Torino, Italy) of the principle study centre. The project was registered with ClinicalTrials.gov, U.S. International Clinical Trials Databank (U.S. National Institutes of Health), under ID-code NCT01104727, on behalf of the EAES. The study was designed to conform with CONSORT criteria.

Study population

The study population was patients with symptomatic cholelithiasis (gallstones <2 cm in diameter), gallbladder dyskinesia, or gallbladder polyps. Other inclusion criteria were: age 18–75 years, body mass index (BMI) <30 , ASA class I–III, absence of non-correctable coagulopathy, and no previous abdominal surgery above the umbilicus. Exclusion criteria were preoperative clinical findings of acute cholecystitis, suspected common bile duct stones or cancer, or previous surgery of the upper abdomen or of the umbilicus.

Patient recruitment

Consecutive eligible patients were recruited at the outpatient clinic of each participating centre by a designated physician. Patients granting informed consent were enrolled in the trial, allocated to one of the treatment groups by computerised randomisation via web-based software, and treated according to the study protocol. Patients unable or refusing to provide informed consent were treated according to current clinical guidelines. Surgeons designated as first operator had to demonstrate documented performance of at least 50 cholecystectomies and previous experience with single-port instruments in at least 15 cases.

Randomisation

Patient data were entered into a web-based database by a designated physician at each centre. Blind computerised randomisation (1:1 allocation ratio), stratified per single centre, was done by unchangeable number-generating software. To ensure that an approximately equal number of patients would be allocated to each arm of the study, each of the 20 centres composing the Consortium had to enrol 30 patients. Patients were allocated to undergo either conventional 4-port cholecystectomy (MPC) or single-port cholecystectomy (SPC).

Operative technique

MPC procedure

A 12-mm Hg pneumoperitoneum was created through either a 10-mm umbilical Hasson's port or a Veress needle,

and a 10-mm umbilical port was inserted; a second 10-mm and two 5-mm ports were then placed. Instrumentation included a straight or angulated laparoscope, laparoscopic graspers, monopolar hook, bipolar forceps, scissors, and a 10-mm clips applier. A plastic bag system for gallbladder extraction was used as needed. Fascia suturing of the 10- and 12-mm access sites was done with resorbable sutures, and the skin was closed with either metallic clips or interrupted sutures.

SPC procedure

A single skin incision was made inside the umbilicus. The subcutaneous tissue was dissected, the muscular fascia exposed and incised along the middle line (linea alba), taking care not to damage the muscular tissue. The peritoneum was identified and incised. A single-port device was inserted and anchored. Depending on which port was used, either straight or curved instruments, crossed or uncrossed handles, gallbladder retractors or transcholecystic sutures or any other technical solution could be employed to complete the procedure safely. After cholecystectomy was completed and the gallbladder removed with/without a plastic bag, the fascia was sutured. Before closure, the fascial defect and the skin incision were measured in maximum length with sterile callipers and each was photographed for documentation. The choice of closure technique was left to the surgeon and had to be specified in detail on the surgical report form. The skin incision was secured with either metallic clips or interrupted sutures.

Primary end point

Overall morbidity rate was defined as any surgery-related morbidity that occurred within 60 days after surgery. Morbidity was defined as the occurrence of any complication directly or indirectly related to surgery. Complications were classified according to Dindo [13].

Secondary end points

Operative time was recorded in minutes between skin incision and end of skin closure. Conversion rate from SPC to MPC was defined as the number of cases in which the procedure was converted from SPC to MPC for safety or technical reasons. Conversion rate to open surgery was defined as the number of cases in which the procedure was converted from SPC or MPC to laparotomy for safety or technical reasons. Postoperative pain was assessed by means of a self-report horizontal visual analogical scale (VAS) for pain recorded daily for the first week and then weekly up to 60 days after surgery. Paracetamol IV 3 times

a day was administered for the first 24 h and on demand thereafter. Tramadol was administered when pain control with paracetamol was judged insufficient. A single dose of ketorolac was given on request. Hospital length of stay was defined as the number of in-hospital days after surgery. All participating study centres applied the following standardised discharge criteria: normal intake of nutrition; normal mobility; absence of fever ($<38\text{ }^{\circ}\text{C}$); and stable haemoglobin level during postoperative day 1 ($<1\text{ g/dL}$). In cases of same-day discharge from hospital, patients were contacted by telephone the day after the operation. Follow-up examinations were scheduled at 30 and 60 days after surgery. Skin incision-related morbidity was defined as the occurrence of bleeding, infection, necrosis, skin retraction, incisional hernia, or suture dehiscence within 60 days after surgery.

Surgeon-evaluated aesthetic results were judged by three independent surgeons on the basis of a standardised methodology. The surgeons viewed two digital photographs (minimum resolution 800×600 pixels) of each patient in standing position taken before and then at 60 days after surgery. One was a close-up photo of the umbilical area and the other a large view of the abdomen. The results were scored on a 5-point Likert scale from 1 to 5 (1 indicates very poor, 2 poor, 3 satisfactory, 4 good, and 5 very good) in answer to the following questions:

1. How would you rate the overall aesthetic results of the abdomen after surgery?
2. How would you rate the scar size?
3. How would you rate the scar shape?
4. How would you rate the skin colour?
5. How would you rate the skin retraction?

Patient-evaluated aesthetic results were judged by the patients on the basis of the scores marked on a 5-point Likert scale administered at the follow-up visit 60 days after surgery in answer to the following questions:

1. How would you rate the overall aesthetic appearance of your body after surgery?
2. How would you rate the impact of the surgical scar/s on the appearance of your abdomen?
3. How would you rate the aesthetic appearance of the surgical scar/s?
4. How would you rate the impact of the surgical scar/s on your everyday life?

Quality of life was assessed with the gastrointestinal quality of life index (GIQLI) at the follow-up visit 60 days after surgery.

Long-term morbidity was defined as any surgery-related morbidity that occurred within 1 year after surgery. Incisional hernia was defined as any fascial defect revealed on

physical examination and confirmed by ultrasound within 1 year after surgery.

Sample size and power calculation

Assuming a baseline overall morbidity rate of 4 % in both the MPC and SPC groups (average morbidity rates drawn from the literature) and considering a clinically significant difference of 4 % (up to 8 % global) for SPC to be non-inferior, with a β -error of 0.2 and α -error of 0.05, a total of 600 patients were needed.

Data analysis

Intra- and postoperative data were entered in the web-based database at any time during the study by the recruiting surgeon. The photographic documentation was also uploaded into the computerised database. Patients' personal data were protected against unauthorised or accidental access. All analyses were carried out primarily on an intention-to-treat basis. Risk of bias was evaluated based on the CONSORT 2010 [14] statement.

Monitoring

Three experts in bilio-pancreatic and laparoscopic surgery were designated as members of multi-port versus single-port cholecystectomy (MUSIC) trial monitoring committee (Music TMC). They had access to the data during the entire course of the study and could recommend cessation of the trial if one arm was providing manifestly inferior results.

Statistical analysis

Categorical variables are described as frequencies and percentages and continuous variables as the median. The interquartile range (IQR) is given in brackets. The association between any categorical variable and treatment arm (MPC/SPC) was analysed using Fisher's exact test; the Mann-Whitney test was used for continuous variables. All reported *P* values were obtained by the two-sided exact method at the conventional 5 % significance level. Data were analysed as of June 2016 by R 3.2.3 (R Foundation for Statistical Computing, Vienna-A, <http://www.R-project.org>).

Results

Following Ethical Committee approval, enrolment was begun on 1 April, 2011 and closed on 7 July, 2015. All 20 centres but 1 involved in the study at the time of trial registration recruited patients. Six of these 19 centres

recruited an insufficient number of patients to complete the series according to local stratification (Table 1). By unanimous decision of the Consortium, the number of patients to be enrolled and randomised at the 13 other centres was raised to 40 in order to achieve the target of 600 patients (Fig. 1). The data from the patients recruited at the six centres were pooled as a miscellaneous group for sensitivity analysis by centre.

The indication for cholecystectomy was cholelithiasis in 578 patients, gallbladder polyps in 20, and gallbladder dyskinesia in 2. Table 2 presents the patients' characteristics, Table 3 the definitive diagnosis, and Table 4 the various device systems.

Data regarding skin and fascial incisions were reported in 278/297 patients. The median size of the skin incision was 25 mm (range 20–30). The median size of the fascial incision was 25 mm (range 20–30). Intraoperative complications were recorded in 25 patients in the MPC group (gallbladder perforation in 20, liver laceration in 3, and bleeding in 2) and in 21 patients in the SPC group (gallbladder perforation in 14, duodenal injury in 1, liver laceration in 1, and bleeding in 5) ($P = 0.647$). During SPC, an additional trocar was added in 18 procedures, and more than one trocar in 14 procedures, which were then recorded as conversion to laparoscopy. One procedure in the SPC group was converted to open surgery. Approximately equal amounts of analgesia were recorded for both groups (Table 5). The median VAS pain score was 2 in the MPC group (range 1–4) and 3 in the SPC group (range 1–4) ($P = 0.905$). The median hospital length of stay was 2 days in the MPC group (range 1–3) and 3 days in the SPC group (range 1–2) ($P = 0.808$). Postoperative complications during in-hospital stay were recorded in 3 patients in the MPC group (biliary leak in 1, pulmonary effusion in 1, and subcutaneous emphysema in 1) and in 5 in the SPC group (bleeding in 2, hyperthermia in 1, increase in inflammatory markers in 1, and acute hypertension in 1) ($P = 0.496$).

A total of 541/600 patients (90.2 %) completed follow-up at 60 days. Postoperative complications at 60 days occurred in 11 MPC group patients (biliary leak in 1, skin suture dehiscence in 4, fascial suture dehiscence in 2, hyperthermia in 1, pulmonary infection in 1, diarrhoea in 1, and subphrenic abscess in 1) and in 11 SPC group patients (biliary leak in 2, skin suture dehiscence in 2, fascial suture dehiscence in 5, intra-abdominal collection in 1, and persistent neck pain in 1) ($P = 1.000$). Postoperative complications within 60 days were recorded in 13 patients (4.7 %) in the MPC group and in 16 (6.1 %) in the SPC group, which demonstrated the non-inferiority of the SPC technique as compared to MPC in terms of morbidity ($P = 0.468$). Complications recorded in 541/600 patients

Table 1 Number of patients treated at each study centre

	MPC	SPC	Total
University of Torino, Turin, Italy	21	21	42
University of Torino (2nd centre), Turin, Italy	22	21	43
Humanitas, Rozzano, Italy	21	20	41
A.V. Vishnevsky, Moscow, Russia	20	21	41
Hadassah-Hebrew University Medical Centre, Jerusalem, Israel	20	21	41
University Hospital G. Martino, Messina, Italy	20	20	40
University of Insubria, Varese, Italy	21	21	42
University of Roma Tor Vergata, Rome, Italy	21	21	42
University of San Luigi Gonzaga, Orbassano (TO), Italy	20	19	39
Hospital Latisana, Italy	21	21	42
University of Graz, Austria	20	18	38
University of Bremen, Germany	23	18	41
Moscow Clinical Scientific Centre, Moscow, Russia	21	21	42
Esther Koplowitz Centre, Barcelona, Spain	16	12	28
Hospital Bolzano, Italy	12	10	22
Institute of Chemical Biology and Fundamental Medicine, Novosibirsk, Russia	1	5	6
Niguarda CàGranda Hospital, Milan, Italy	1	3	4
Bilim University of Istanbul, Turkey	2	2	4
University Hospital Vall d' Hebron, Barcelona, Spain	0	2	2
Total no./total no. of enrolled and randomised patients in each treatment arm	303	297	600

MPC multi-port cholecystectomy, SPC single-port cholecystectomy

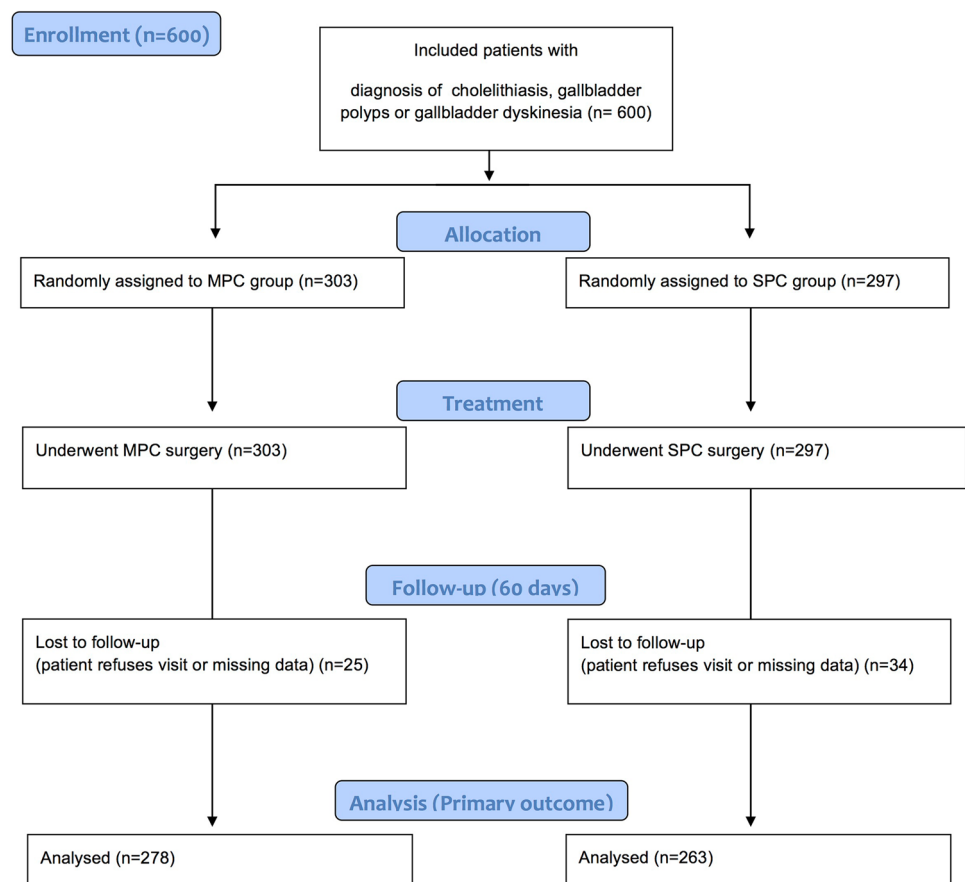
Fig. 1 CONSORT 2010 flow diagram

Table 2 Patients' characteristics

	MPC group					SPC group					<i>P</i> value
	Min	25th IQR	Median	75th IQR	Max	Min	25th IQR	Median	75th IQR	Max	
Age (years)	18	39	48	60	86	20	37	47	59	85	0.292
Weight (kg)	46	60	70	78	105	43	60	70	80	116	0.667
Height (cm)	142	162	167	172	197	126	160	167	175	195	0.873
BMI (kg/m ²)	18.0	22.8	24.6	27.1	38.5	17.2	22.7	24.9	27.7	40.1	0.598

MPC multi-port cholecystectomy, SPC single-port cholecystectomy, IQR interquartile range

Table 3 Definitive diagnosis of gallbladder disease

	MPC group	SPC group	Total
Cholelithiasis	285	278	563
Gallbladder polyps	9	11	20
Cholelithiasis + cholecystitis	4	4	8
Cholelithiasis + gallbladder empyema	2	1	3
Cholelithiasis + umbilical hernia	0	2	2
Gallbladder dyskinesia	2	0	2
Cystic duct obstruction	0	1	1
Choledocholithiasis	1	0	1

MPC multi-port cholecystectomy, SPC single-port cholecystectomy

Table 4 Number of single-port instruments by trademark name and manufacturer

Instrument (manufacturer)	No.
SILS Port [®] (Covidien)	74
XCone [®] (Karl Storz)	58
TriPort/Plus [®] (Olympus)	51
Octoport [®] (Dalimurg)	27
GelPoint [®] (Applied Medical)	21
Endocone [®] (Karl Storz)	21
SSL [®] (Ethicon)	19
S-Portal [®] (Karl Storz)	4
Key Port [®] (Richard Wolf)	1

were classified according to Dindo [13] (Table 6). No further surgery was required in any cases.

A total of 446/600 patients (74.3 %) completed follow-up at 1 year. Postoperative complications were recorded in 9 MPC group patients (biliary stenosis in 1, skin retraction in 2, keloid formation in 3, and incisional hernia in 3) and in 10 SPC group patients (biliary stenosis in 1, skin retraction in 2, keloid formation in 1, and incisional hernia in 6) ($P = 0.817$). Complications within 1 year after surgery were recorded in 22 patients (9.7 %) in each group ($P = 1.000$).

Data on patient-evaluated aesthetic results were available for 513/600 patients. The patients in the SPC group gave the aesthetic results a significantly higher score on all accounts (Table 7). Data on surgeon-evaluated aesthetic result were available for 289/600 patients. The surgeons gave significantly higher scores particularly for scar and skin retraction in the MPC group (Table 8). There were no significant differences between the two groups (505/600 patients) in quality of life scores as measured with the GIQLI at 60 days after surgery (Table 9).

Discussion

Although single-port laparoscopic surgery is not new [1, 2], its use has gained momentum over the last few years in part through the support of major surgical instrument manufacturers. This raises concerns about a possible industry-driven interest in promoting wider use of the technique. There is no doubt, however, that single-port surgery has several drawbacks particularly in relation to the lack of “triangulation” to which laparoscopic surgeons have grown accustomed in terms of both instruments and scope. Although this seems to have been overcome by the growing acceptability of in-line viewing, device manufacturers have focused their product research on developing and marketing a variety of curved instruments featuring

Table 5 Postoperative analgesic consumption

	Tramadol	Paracetamol	Paracetamol codein	Ketorolac
First 6 h				
Multi-port group	87	212	2	96
<i>P</i> value	0.109	0.298	1.000	0.365
Single-port group	103	195	2	83
6 h—1st day				
Multi-port group	39	222	7	70
<i>P</i> value	0.479	0.919	0.545	1.000
Single-port group	44	215	4	69
2nd day				
Multi-port group	6	119	6	27
<i>P</i> value	0.226	0.932	0.123	0.658
Single-port group	11	115	1	23
First week				
Multi-port group	7	68	2	13
<i>P</i> value	0.799	0.310	1.000	0.836
Single-port group	8	56	1	11

Table 6 Postoperative complications within 60 days graded according to Dindo–Clavien

	MPC	SPC
Grade I	9	10
Grade II	1	1
Grade IIIa	3	5
Grade IIIb	0	0
Grade IVa	0	0
Grade IVb	0	0
Grade V	0	0
<i>P</i> value = 0.865		
<i>MPC</i> multi-port cholecystectomy, <i>SPC</i> single-port cholecystectomy		

different characteristics with the aim of restoring standard triangulation as provided in a laparoscopic environment. Nevertheless, a recent study that measured ergonomic performance on a virtual-reality simulator designed for the purpose demonstrated that, after a short learning curve, only very experienced surgeons were able to perform the surgical tasks safely and effectively, while all the other surgeons found technique acquisition to be challenging [15].

For this reason, we chose as the main outcome the non-inferiority of SPC versus MPC in terms of overall post-operative morbidity at 60 days, and the results confirm this: no difference in severity of complications was observed. Hence, the hypothesis that SPC would be associated with a higher complications rate, but with greater overall satisfaction with clinical and aesthetic results, is not confirmed [6]. Few patients experienced complications, mostly minor, with 2 cases of biliary leak and 1 case of biliary stenosis

Table 7 Patient-evaluated scoring of aesthetic results in response to four question items

Score	Q1		Q2		Q3		Q4	
	MPC	SPC	MPC	SPC	MPC	SPC	MPC	SPC
1	1	0	7	1	3	0	12	8
2	1	3	5	5	5	3	3	6
3	30	10	42	14	32	11	26	13
4	106	55	96	60	94	67	97	68
5	131	176	119	164	135	163	131	149
<i>P</i> value	<0.001		<0.001		<0.001		0.025	

5-point Likert scale from 1 (poor) to 5 (very good)

1. How would you rate the overall aesthetic appearance of your body after surgery?
2. How would you rate the impact of surgical scar(s) on the image of your abdomen?
3. How would you rate the aesthetic appearance of the surgical scar(s)?
4. How would you rate the impact of the surgical scar(s) on your everyday life?

MPC multi-port cholecystectomy, *SPC* single-port cholecystectomy

recorded per group, all successfully treated by endoscopic retrograde cholangio-pancreatography (ERCP). Operative time was slightly but significantly longer in the SPC group, although this difference seems of marginal relevance for operating room organisation. An additional trocar was employed in very few cases, and in even fewer in which the procedure was converted to laparoscopy.

Moreover, it has been claimed that a larger peri-umbilical incision and consequent fascial defect would increase

Table 8 Surgeon-evaluated scoring of aesthetic results in response to five question items

Scores	Q1		Q2		Q3		Q4		Q5	
	MPC	SPC	MPC	SPC	MPC	SPC	MPC	SPC	MPC	SPC
1	0	0	0	0	0	0	0	0	0	0
2	3	2	2	1	2	3	0	0	6	2
3	10	19	8	19	8	25	27	32	14	36
4	78	68	77	68	80	61	69	59	75	55
5	56	53	60	54	57	53	51	51	52	49
<i>P</i> value	0.293		0.113		0.007		0.574		0.001	

5-point Likert scale from 1 (poor) to 5 (very good)

1 = How would you rate the overall aesthetic appearance of patient's abdomen after surgery?

2 = How would you rate the scar(s) size?

3 = How would you rate the scar(s) shape?

4 = How would you rate the skin colour?

5 = How would you rate the skin retraction?

MPC multi-port cholecystectomy, *SPC* single-port cholecystectomy

Table 9 Gastrointestinal quality of life index (GIQLI) scores

	MPC group					SPC group					<i>P</i> value
	Min	25th IQR	Median	75th IQR	Max	Min	25th IQR	Median	75th IQR	Max	
GIQLI_sum	25	114	122	128	140	44	117	123	129	144	0.124
GIQLI_phy	3	33	35	36	44	15	33	35	36	44	0.684
GIQLI_bow	6	21	23	24	24	8	21	23	24	24	0.246
GIQLI_emo	6	23	26	28	32	6	24	26	28	32	0.111
GIQLI_ugi	3	26	28	30	32	7	27	29	31	32	0.216
GIQLI_met	3	10	11	12	12	2	10	11	12	12	0.020

GIQLI subscale division

GIQLI_sum: all items, 1–36

GIQLI_phy (physical role): item 1, 18, 19, 20, 21, 22, 23, 24, 25, 26, 29

GIQLI_bow (large bowel function): item 6, 7, 30, 31, 34, 36

GIQLI_emo (emotional role): item 8, 10, 11, 12, 13, 14, 15, 16

GIQLI_ugi (upper GI tract function): item 4, 9, 17, 27, 28, 32, 33, 35

GIQLI_met (meteorism): item 3, 4, 5

MPC multi-port cholecystectomy, *SPC* single-port cholecystectomy, *IQR* interquartile range

the risk of incisional hernia [9]. This article presents the largest series with 1-year follow-up of patients enrolled in a single-blind, multi-centre, prospective, randomised, controlled trial of SPC versus standard MPC. Although this was true in our series, the incidence of incision hernia was so low in both groups that many more cases would be needed to achieve significance if confirmed. This reinforces the hypothesis that the finding of Marks et al. [9] was depending on an increased rate of incisional adverse events, in particular a higher rate of superficial wound complications in the single-port group. This was not confirmed in our series, three times larger, and in which possible local biases were more likely to be avoided due to the proportional distribution of patients among the different

centres. No other significant differences between the groups were observed in relation to the perioperative course, pain VAS scores, analgesic consumption, or QoL at 60 days as assessed by the GIQLI.

The basic rationale for the interest in single-port laparoscopy is that, because it may improve cosmesis and decrease postoperative pain, patient satisfaction would be greater than after standard laparoscopy. Our study shows that the majority of the patients in the single-port group were pleased with their aesthetic results, although it may be argued that other not investigated factors might have influenced their personal opinion. In contrast, the surgeon-evaluated aesthetic results were based on a comparative, standardised methodology in which the images were

viewed and objectively scored by three independent surgeons. In their opinion, the scar shape and skin retraction after MPC appeared aesthetically more acceptable.

There are several limitations to this study that must be discussed. First, approximately 25 % of patients were lost to follow-up at 1 year, which is higher than would be normally expected for a 12-month prospective study. Second, all surgeons participating in this trial had performed at least 15 previous SPC cases, but the ability to generalise outcomes from this study might not be applicable to those in the initial learning curve associated with this new technique. Finally, the follow-up of 12 months might be too short to determine the true differences between SPC and MPC in terms of risk for hernia development.

Conclusions

In selected patients undergoing cholecystectomy for benign gallbladder disease, a single-access technique is non-inferior to standard laparoscopy in terms of safety, but it entails a longer operative time. The short follow-up cannot exclude possible concerns about a higher risk of incisional hernia following SPC, although this was not demonstrated in the present study. Patients rated the aesthetic results after the single-access technique higher than after standard laparoscopy.

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Compliance with ethical standards

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