CIR ESP. 2015;93(5):307–319

CIRUGÍA ESPAÑOLA

www.elsevier.es/cirugia

Original article

Single-Port Colectomy vs Multi-Port Laparoscopic Colectomy. Systematic Review and Meta-Analysis of More Than 2800 Procedures☆

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ARTICLE INFO

Article history:
Received 23 September 2014
Accepted 10 November 2014
Available online 14 April 2015

Keywords:
Colon
SILS
Laparoscopy

ABSTRACT

Objective: Multiport laparoscopic surgery in colon pathology has been demonstrated as a safe and effective technique. Interest in reducing aggressiveness has led to other procedures being described, such as SILS. The aim of this meta-analysis is to evaluate feasibility and security of SILS technique in colonic surgery.
Material and methods: A meta-analysis of 27 observational studies and one prospective randomised trial has been conducted by the use of random-effects models.
Results: A total amount of 2870 procedures was analysed: 1119 SILS and 1751 MLC. We did not find statistically significant differences between SILS and MLC in age (WMD 0.28 [−1.13, 1.68]; P=.70), BMI (WMD −0.63 [−1.34, 0.08]; P=.08), ASA score (WMD −0.02 [−0.08, 0.04]; P=.51), length of incision (WMD −1.90 [−3.95, 0.14]; P=.07), operating time (WMD −2.69 (−18.33, 12.95]; P=.74), complications (OR=0.89 [0.69, 1.15]; P=.37), conversion to laparotomy (OR=0.59 [0.33, 1.04]; P=.07), mortality (OR=0.91 [0.36, 2.34]; P=.85) or number of lymph nodes harvested (WMD 0.13 [−2.52, 2.78]; P=.92). The blood loss was significantly lower in the SILS group (WMD −42.68 [−76.79, −8.57]; P=.01) and the length of hospital stay was also significantly lower in the SILS group (WMD −0.73 [−1.18, −0.28]; P=.001).
Conclusion: Single-port laparoscopic colectomy is a safe and effective technique with additional subtle benefits compared to multiport laparoscopic colectomy. However, further prospective randomised studies are needed before single-port colectomy can be considered an alternative to multiport laparoscopic surgery of the colon.

☆ Please cite this article as: Luján JA, Soriano MT, Abrisqueta J, Pérez D, Parrilla P. Colectomía mediante puerto único vs. colectomía mediante laparoscopia multipuerto. Revisión sistemática y metaanálisis de más de 2.800 procedimientos. Cir Esp. 2015;93:307–319.

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Colectomía mediante puerto único vs. colectomía mediante laparoscopia multipuerto. Revisión sistemática y metaanálisis de más de 2.800 procedimientos

R E S U M E N

Objetivos: La cirugía laparoscópica multipuerto (CLM) ha demostrado su seguridad y efectividad en la cirugía del colon. Con la intención de reducir la agresividad surgen otras técnicas como la cirugía por puerto único (SILS). El objetivo de este metaanálisis es evaluar la seguridad y la viabilidad de la técnica SILS en la cirugía del colon.

Material y métodos: Se realiza un metaanálisis de 27 estudios observacionales y uno prospectivo aleatorizado mediante el modelo de efectos aleatorios.

Resultados: Se han analizado 2.870 procedimientos: 1.119 SILS y 1.751 CLM. No se han encontrado diferencias estadísticamente significativas en la edad (DMP 0,28 [−1,13, 1,68]; p = 0,70), IMC (DMP −0,63 [−1,34, 0,08]), ASA (DMP −0,02 [−0,08, 0,04]; p = 0,51), longitud de incisión (DMP −1,90 [−3,95, 0,14]; p = 0,07), tiempo operatorio (DMP −2,69 [−18,33, 12,95]; p = 0,74), complicaciones (OR = 0,89 [0,69, 1,15]]; p = 0,37), conversión a laparotomía (OR = 0,59 [0,33, 1,04]; p = 0,07), mortalidad (OR = 0,91 [0,36, 2,34]; p = 0,85) o número de ganglios obtenidos (DMP 0,13 [−2,52, 2,78]; p = 0,92). La pérdida de sangre (DMP −42,68 [−76,79, −8,57]; p = 0,01) y la estancia hospitalaria (DMP −0,73 [−1,18, −0,28]; p = 0,001) son significativamente menores en el grupo SILS.

Conclusiones: La cirugía colorrectal mediante SILS es segura y efectiva, con ligeros beneficios respecto a la CLM. Sin embargo, se necesitan más estudios aleatorizados antes de que la SILS se pueda considerar una alternativa a la CLM.

Palabras clave:
Colon
SILS
Laparoscopia

Introduction

Multiport laparoscopic colectomy (MLC) is a safe and effective technique, a fact that has been confirmed by many prospective randomised studies that have shown a lower level of blood loss, a better postoperative recovery, a shorter length of hospital stay, and similar oncological results when compared to open colectomy.[1–4] With the aim of reducing aggressiveness and improving MLC results, other procedures have been described, such as mini-laparoscopic surgery, natural orifice transluminal endoscopic surgery (NOTES)[5] and single-incision laparoscopic surgery (SILS). Due to its similarity to MLC, only SILS has been adopted by a wide group of surgeons, mainly in appendectomy and cholecystectomy, as well as in more complex procedures, such as colectomy, showing the safety and effectiveness of the intervention.[6,7] In comparison with MLC, SILS could offer potential benefits like better aesthetics, less trauma to the abdominal wall, and a reduction in postoperative pain. However, some disadvantages are that it requires a learning curve, adequate technology, a longer operating time, it is difficult to expose and visualise and it may potentially compromise the oncological results of the malignant disease. This is why some surgeons question whether it is possible for SILS colectomy to offer tangible benefits in comparison with MLC, due to the lack of sufficient scientific evidence to that effect. Although there is an increasing number of studies reporting on SILS colectomy results, few of them compare SILS to MLC, making it necessary to rigorously evaluate the safety, the efficacy, and the oncological results in colorectal cancer before SILS methodology is used in a widespread manner.

The main purpose of this article is to review the published literature on SILS colectomy, using meta-analysis to evaluate comparative studies between MLC and SILS in colorectal disease.

Method

This meta-analysis was prepared following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA).[8]

Search Strategy

We have conducted a systematic search of the major databases, including MEDLINE and PUBMED, articles, clinical trials, reviews and works related to single-port laparoscopic colorectal surgery. The date of the last search was April 30, 2014. Only articles in English and Spanish have been included; papers in other languages have been excluded. The key words searched were: ‘‘single incision’’, ‘‘single port’’, ‘‘single access’’, ‘‘colectomy’’, ‘‘colorectal surgery.’’ Abstracts have been independently scrutinised by 2 authors (JL and MTS) to determine the eligibility for inclusion in the study. Disagreements were solved by means of a third author. The references mentioned in the selected articles have been analysed to identify possible relevant studies.

Criteria of Selection and Eligibility of the Studies

The articles were selected if the abstract contained information about patients treated via SILS for colorectal diseases, benign and malignant. Prospective randomised and non-randomised studies have been included, as well as comparative case–control and cohort studies. Articles related to natural orifice transluminal endoscopic surgery (NOTES), meta-analyses, reviews, editorials, case series, expert opinions and letters to the director have been excluded, as well as articles referring to series of patients with ≤15 SILS procedures. Multicentric studies containing units and hospitals data, already included in the studies, have also been excluded to avoid duplicating patients.

Data Extraction Process

Three authors (JL, MTS, and JA) obtained the following data from each study, and then entered them in a database: year of publication, type of study, number of patients treated with each technique, demographic characteristics of the study population (age, gender, ASA score, body mass index [BMI], indication for surgery [benign pathology, malignant pathology, or both], type of surgical procedure, average operating time in minutes [min], blood loss measured in millilitres [ml], conversion to open surgery, length of the incision in centimetres [cm], postoperative complications, average length of hospital stay in days, and mortality. In the studies where oncological procedures have been conducted, the number of lymph nodes harvested was also obtained. The data analysed come exclusively from the published articles. No author was contacted to complete the information.

The parameters analysed in the meta-analysis were: BMI, ASA score, length of the incision, blood loss, operating time, postoperative complications, length of hospital stay, number of lymph nodes, and mortality.

A postoperative complication was defined as a complication that developed within 30 days of the intervention as a direct result of the surgery. The complications were classified by degree of severity, according to the Clavien–Dindo scale.[9]

The conversion to open surgery was defined as the performance of a laparotomy in both SILS and MLC.

Assessment of the Methodological Quality and of Bias

The quality of the articles included in this meta-analysis was assessed according to the revised and modified Scottish Intercollegiate Guidelines Network,[10,11] where the maximum punctuation is 20. A score of <8 equals poor quality; a score between 8 and 14 equals intermediate quality, and a score ≥15 equals very good quality.

Statistical Analysis

All the data were extracted from the selected articles, tables, and figures, and then entered into an SPSS spreadsheet (SPSS version 19, Inc., Chicago, IL, USA). The odds ratio (OR) was calculated for binary and qualitative variables according to the random effects method of Mantel–Haenszel. OR is the probability of an event occurring in a group in relation with the probability of that event occurring in another group. This ratio was calculated for the studies that informed the occurrences and non-occurrences of events. The studies where the event did not occur in any of the groups were excluded. An OR<1 was favourable to the SILS group and the OR point estimation of $P<.05$ was considered to be statistically significant if 95% of the confidence interval (CI) did not include the value 1. The weighted mean difference (WMD) was used for the quantitative variables in the studies that included the mean and the standard deviation. Those studies that did not contain that information were excluded. A WMD<0 was favourable to the SILS group and was considered statistically significant with $P<.05$, if 95% of the CI did not include the value 0.

The degree of heterogeneity among studies was also analysed (the variation in the results among them), by means of τ^2, χ^2 (Cochrane Q) and I^2, where τ^2 values >1.00, χ^2 values associated to $P<.01$ and I^2 values >50 were indicators of heterogeneity.

Statistical analysis was performed with the statistical software Review Manager (REVMAN), version 5.0 (The Nordic Cochrane Centre, Copenhagen, The Cochrane Collaboration, 2008).

Results

Bibliographic Search

From January, 2008 to April, 2014, we collected 267 articles using the inclusion criteria for the search. After the exclusion criteria was used, we obtained 28 comparative articles to be included in the meta-analysis[12–39]: 27 comparative studies, and one prospective randomised study[29] (Fig. 1).

Characteristics of the Studies

According to the modified Scottish Intercollegiate Guidelines Network classification,[10,11] the average quality of the methodology used in the articles included in the meta-analysis was 13.21±1.87 with a range of (9–16). This means they are intermediate to good quality studies. The 28 studies of this meta-analysis included 2870 patients: 1119 treated via SILS and 1751 via MLC. Out of 28 studies, 11 compared malignant disease[17,19,21–23,29,32,35,37–39]; 2 compared benign diseases,[25,33] and 15 compared benign and malignant diseases.[12–16,18,20,24,26–28,30,31,34,36] The type of colectomy more frequently performed was the right hemicolectomy. Table 1 shows the demographic characteristics of all the procedures included. Table 2 shows the data collected individually from each study included in the meta-analysis.

Body Mass Index

The meta-analysis did not show statistically significant differences between both groups, with a WMD: −0.63 (−1.34, 0.08); P=.08 (Fig. 2).

Age

The meta-analysis estimation did not show statistically significant differences between both groups. WMD: 0.28 (−1.13, 1.68); P=.70 (Fig. 3).

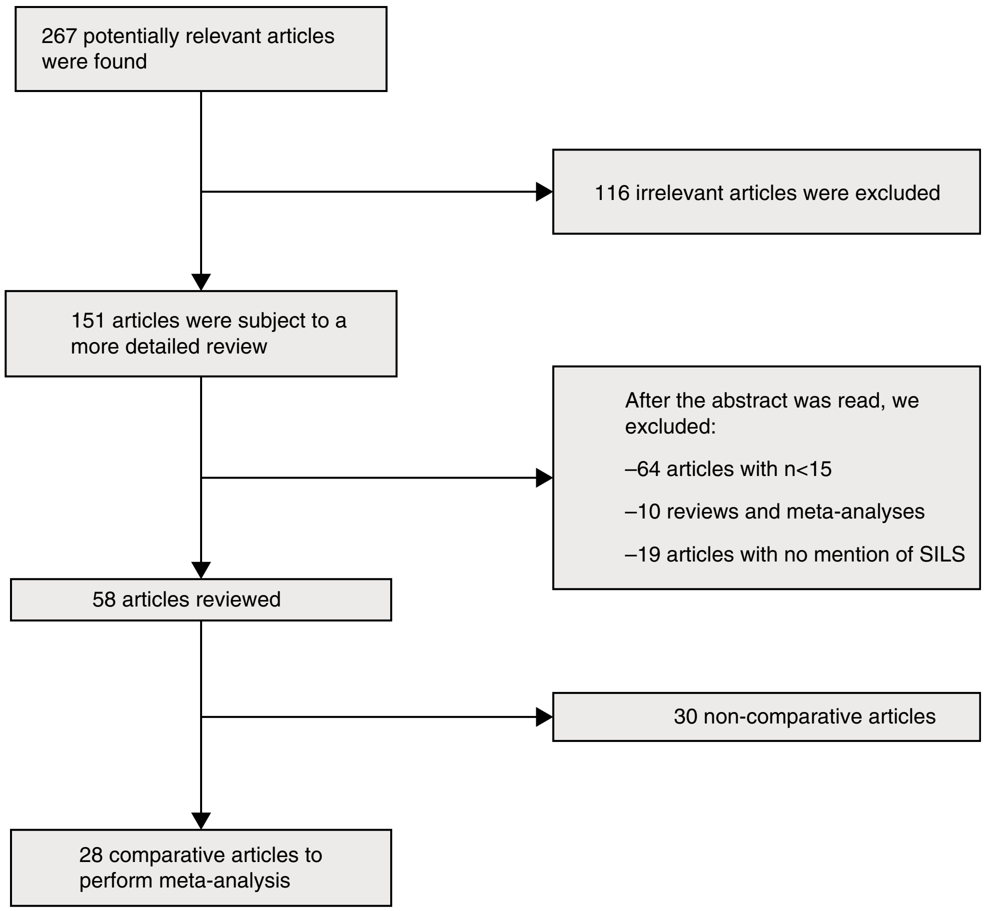

Fig. 1 – Flow chart of the systematic review of the literature.

ASA Score

The ASA score was informed in 22 studies. Thirteen articles were included in the meta-analysis after the mean and SD were calculated in studies where it was possible to do so.[14,17,19,22,23,25,27,29,30,33,35,37,39] The meta-analysis did not show statistically significant differences between both groups. WMD: −0.02 (−0.08, 0.04); *P*=.51 (Fig. 4).

Length of Incision

The meta-analysis did not show statistically significant differences for both groups. WMD: −1.90 (−3.95, 0.14); *P*=.07 (Fig. 5).

Conversion

Out of 1119 SILS procedures, conversion to laparotomy was necessary in 15 (1.34%) patients. Out of 1751 MLC cases, conversion to open surgery was necessary in 45 (2.56%) patients. No statistically significant differences were shown with OR=0.59 (0.33, 1.04); *P*=.07 (Fig. 6).

Operating Time

The meta-analysis estimation did not show statistically significant differences between both groups. WMD: −2.69 (−18.33, 12.95); *P*=.74 (Fig. 7).

Blood Loss

The meta-analysis showed a significantly lower blood loss in the SILS group. WMD: −42.68 (−76.79, −8.57); *P*=.01 (Fig. 8).

Postoperative Complications

Postoperative complications were reported in all studies but one.[23] There were 199 (17.78%) postoperative complications in the SILS group and 311 (17.76%) in the MLC group. Table 3 shows complications according to the Clavien–Dindo classification.[9] The most frequent complications in both groups were graded type I, excluding studies that did not contribute enough data to grade the complications. There were no differences in the postoperative complications with OR=0.89 (0.69, 1.15); *P*=.37 (Fig. 9).

Postoperative Pain

Postoperative pain was reported in 6 articles.[13,17,19,21,25,33] No statistical study was conducted due to the variability in the type of analgesia and the pain scale grading. Only 2 studies found significant differences: one with less pain in SILS colectomy during the first and second postoperative days, with no repercussions in the length of hospital stay[33]; and the other, with less pain in MLC colectomy,[21] which is attributed to a longer length of umbilical incision in SILS, and to the fact

Table 1 – Demographic Characteristics of Studies Included.

Study	Year	No.		Gender		Age		BMI		ASA Score		Indication	Procedure	
		SILS	MLC	SILS	MLC	SILS	MLC	SILS	MLC	SILS	MLC		SILS	MLC
Adair	2010	17	17	M5/F12	M5/F12	66.6±10	66.7±13	26.2±4.3	25.2±5	–	–	Bo	LARHC	LARHC
Chen	2010	18	21	M10/F8	M14/F7	69.44	66.19	23.34	23.92	–	–	Bo	LARHC	LARHC
Gandhi	2010	24	24	M12/F12	M12/F12	54.1±8.6	56±11.1	28.5±7.2	28.5±6	2.3±0.6	2.3±0.5	Bo	Various	Various
Waters	2010	16	27	M4/F6	M15/F12	65 (39–82)	67 (40–91)	29 (20–41)	29 (18–45)	–	–	Bo	LARHC	LARHC
Champagne	2011	29	29	M10/F19	M10/F19	61.2	63.5	27.4	28.8	–	–	Bo	Various	Various
Fujii	2011	23	23	M10/F13	M13/F10	63.9±9.9	65.2±9.6	21.6±2.9	22.9±4.5	1.52±0.51	1.61±0.5	M	Various	Various
Gaujoux	2011	25	50	M8/F17	M22/F28	56 (32–69)	55 (38–61)	22.6 (21.2–24.7)	22.6 (20–25)	–	–	Bo	Various	Various
Kim	2011	73	106	–	–	67 (35–87)	63 (27–88)	22.7±4	25.6±20.7	2±0.69	1.93±0.68	M	Various	Various
Lee	2011	46	46	M17/F29	M21/F25	58 (16–84)	61 (16–85)	24 (16–42)	25 (16–36)	–	–	Bo	Various	Various
Lu	2011	27	68	M16/F11	M36/F32	60.26±15.69	64.29±15.06	–	–	–	–	M	Various	Various
McNally	2011	27	46	M13/F14	M21/F25	67 (26–86)	73 (48–92)	27 (18.3–39.9)	26 (16.6–71.4)	2.44±0.62	2.5±0.62	M	Various	Various
Papaconstantinou	2011	26	26	M11/F15	M11/F15	65±13	66±12	28±5	28±5	2.54±0.51	2.54±0.51	M	Various	Various
Ramos-Valadez	2011	20	20	M11/F9	M11/F9	59±10	56.4±12.6	25.9±3.9	29.6±5.4	–	–	Bo	Sigm	Sigm
Rickjen	2011	20	20	M6/F14	M6/F14	31.6±10.8	31.7±10.7	21.5±2.6	21.2±2.5	1.7±0.57	1.85±0.49	Be	IR	IR
Champagne	2012	165	165	M58/F107	M65/F99	58	57.6	27	27.4	–	–	Bo	Various	Various
Chew	2012	40	104	M22/F18	M60/F44	63 (41–48)	67 (23–88)	22.3 (16.1–34.9)	23.1 (14–36.6)	1.93±0.35	1.9±0.45	Bo	LARHC	LARHC
Costedio	2012	24	24	M9/F15	M10/F14	43.2±12.5	42.3±12.7	24.8±4.8	25.3±4.3	–	–	Bo	Total	Total
Huscher	2012	16	16	M6/F10	M9/F7	70±11	70±13	–	–	1.94±0.68	2.13±0.81	M	Various	Various
Kanakala	2012	40	78	M22/F18	M49/F29	54.1 (17–86)	64.8 (23–84)	26.2 (18–37)	28 (21–45)	2.23±0.62	2.18±0.68	Bo	Various	Various
Osborne	2012	55	327	M27/F28	–	63±13	–	26 (17–41)	–	–	–	Bo	HAR	HAR
Park	2012	37	54	M21/F16	M26/F28	63.8±10.4	59.9±10.6	24.7±2.8	23.9±3.2	–	–	M	Sigm	Sigm
Vasilakis	2012	20	20	M12/F8	M12/F8	58.3±10.7	57.9±10.8	28.5±4.9	29±5.2	2.35±0.49	2.35±0.49	Be	Sigm	Sigm
Velthuis	2012	50	50	M21/F29	M22/F28	73±13.2	71±11.8	25 (20–32)	25 (20–36)	–	–	Bo	LARHC	LARHC
Woo Lim	2012	40	123	M21/F19	M62/F61	62.8±10.5	64.4±11.2	22.7±3.6	23.7±3.4	1.78±0.42	1.8±0.49	M	Various	Various
Keshava	2013	75	74	M35/F40	M36/F38	68 (18–99)	74 (34–96)	27 (19–42)	27.3 (20–45.1)	–	–	Bo	LARHC	LARHC
Pedraza	2013	50	50	M25/F25	M23/F27	64.6±12.4	66.3±12.9	27.2±5.7	31±8.1	2.5±0.7	2.7±0.6	M	Various	Various
Rosati	2013	50	50	M17/F33	M26/F24	65 (36–88)[a]	65 (44–87)[a]	–	–	–	–	M	LARHC	LARHC
Yun	2013	66	93	M33/F33	M55/F38	61±11	59±11	23.82±2.81	24.23±2.7	1.65±0.54	1.7±0.55	M	LARHC	LARHC

Bo: both; Be: benign; LARHC: laparoscopically assisted right hemicolectomy; HAR: anterior resection; M: malignant; IR: ileocolic resection; Sigm: sigmoidectomy.

[a] Mean.

Table 2 – Variables Collected From the Studies Included.

Study	Year	No.		Length of incision (cm)		Operating time (min)		Conversion		Blood loss (ml)		Lymph nodes		Complications		Length of hospital stay (days)		Mortality	
		SILS	MLC	SILS	MLC	SILS	MLC	SILS	MLC	SILS	MLC	SILS	MLC	SILS	MLC	SILS	MLC	SILS	MLC
Adair	2010	17	17	3.8	5.1	139±29.7	134±32.3	0	0			20.1±11.3	18.6±4.1	5	4	3.9±3.7	4.1±2.2	1	0
Chen	2010	18	21	4 (3–6)	4 (3–6)	175 (145–280)	165 (120–340)	1	0	75 (20–700)	50 (20–300)	19.5 (3–42)	19 (15–57)	3	2	5 (3–15)	5 (3–38)		
Gandhi	2010	24	24	3.3±1.1	6.6±2.1	143.2±37.2	112.8±44.8	0	0	62.5±37.6	90.6±60.6	24.6±12.3	18.6±5.7	2	0	2.7±0.8	3.3±1.1	1	0
Waters	2010	16	27	2.5–4.5	2.5–4.5	106 (71–223)	100 (65–215)	0	0	54 (25–120)	90 (25–300)	18 (13–22)	16 (10–21)	3	4	5 (2–24)	6 (2–28)	0	1
Champagne	2011	29	29	3.80	4.50	103.80	134.40	1	1			19.4	21.6	5	7	3.70	3.90		
Fujii	2011	23	23	3.3±1.2	5.5±2.4	174±37	179±40	0	1	9±9	109±391	19.9±5.2	23.3±11.5	3	5	8.2±3.4	12.7±12.9		
Gaujoux	2011	25	50			130 (110–185)	180 (110–200)	0	1	100 (50–150)	90 (50–100)			1	8	6 (6–7)	7 (6–9)	0	0
Kim	2011	73	106			274 (105–405)	254 (80–470)	1	3	282 (105–405)	418 (100–2.600)	29.3±16	23.2±15.4	23	39	9.60	15.50	0	1
Lee	2011	46	46	5.1±1.8	6.4±2.4	135±21	134±39							11	12	4.6±1.6	4.3±0.8		
Lu	2011	27	68	4.07±1.18	4.77±1.19	180 (150–205)	185 (155–230)			35 (30–50)	50 (30–80)			2	3	7 (5–8)	7 (6–9)		
McNally	2011	27	46			114 (59–268)	135 (45–314)	0	6	50 (5–100)	50 (5–250)	15 (3–32)	17 (0–35)	5	16	3 (2–17)	5 (2–11)	0	2
Papaconstantinou	2011	26	26			144±24	144±51	0	1	57±40	87±70	18±6	17±12			3.6±1.6	5±2.2		
Ramos-Valadez	2011	20	20			159.2±29.9	162.1±40.3	0	0	58.3±34.3	98.8±52.1	20.3±3.8	18.3±6.8	2	2	3.2±1	3.8±2.1		
Rickjen	2011	20	20	3.8 (2.5–5)		137.4±28.4	166.4±37.5	1	2					4	4	9±3.4	9.2±5.9		
Champagne	2012	165	165			135.4±45	133.2±56	4	8	47.20	63.50			43	48	4.3±1.6	4.6±1.4	1	0
Chew	2012	40	104	5 (3–12)	6 (3–25)	95 (45–180)	100 (55–190)	2	7			19 (10–43)	18 (6–54)	9	21	5 (4–15)	5 (3–109)	0	1
Costedio	2012	24	24			125.9±39.3	230±117.4	0	2	95.8±65	241.7±135.5			11	19	6.08±4.2	6.3±3.05	0	0
Huscher	2012	16	16			147±61	129±46			200		18±6	16±5	3	5	6±3	7±2	0	0
Kanakala	2012	40	78			162	170	0	0			22.9 (11–41)	13.8 (0–28)	3	10	4 (2–11)	4 (2–20)	0	1
Osborne	2012	55	327			79±37	113±44	0	3			18 (2–34)	14 (5–53)	12	27	1 (1–8)	3 (1–24)		
Park	2012	37	54	3.3±0.9	9.1±1.4	118.1±41.5	140±42.2	0	0	92	131	14.6±6.8	23.4±11.4	3	6	5.5±2.3	7.7±4.2		
Vasilakis	2012	20	20	4.9±1.9	5.1±1.9	175, 5±40.2	178.7±50.7	2	1	74.5±55.3	81.3±54.9			1	3	3.9±1.6	5.5±2	0	0
Velthuis	2012	50	50			97 (60–148)	112 (70–225)	0	0			14 (10–28)	12.5 (10–34)	17	17	6 (2–41)	6 (2–103)	1	2
Woo Lim	2012	40	123	4.6±0.7	4.4±0.9	225.5±48.3	144.6±32.6	1	1	109.2±80.3	96±58.4	25.3±11.9	28.3±13.2	5	18	7.7±1.1	7.8±2.8	0	0
Keshava	2013	75	74	4.3 (3–6)	5 (4–9)			1	1			17.00	17.00	8	13	5 (3–43)	8 (4–33)	1	0
Pedraza	2013	50	50			127.9±37.6	126.7±63.3	0	1	64.4±64.7	87.2±89.8	21.4±8.4	19.2±7.6	7	4	4.5±3.7	4±1.7		
Rosati	2013	50	50			160 (115–210)[a]	152 (110–215)[a]	0	1			21 (13–34)[a]	22 (8–38)[a]	4	11	6 (4–16)[a]	8 (4–34)[a]	0	1
Yun	2013	66	93			131±27	143±54	1	5			24±11	27±13	6	14	8±4	9±5		

min: minutes; ml: millilitres.

[a] Mean.

Table 3 – Complications According to Clavien–Dindo.

Degree	SILS	MLC
I	59	71
II	32	55
IIIa	6	11
IIIb	16	40
IVa	3	3
IVb	1	0

that in the MLC, the specimen is extracted by means of McBurney's incision, which is less painful.

Hospital Stay

The meta-analysis showed that the length of hospital stay was also significantly lower in the SILS group. WMD: −0.73 (−1.18, −0.28); *P*=.001 (Fig. 10).

Mortality

Out of 1119 SILS cases, there were 5 (0.44%) deaths. Out of 1751 MLC interventions, 9 (0.51%) patients died. No statistically significant differences were shown with OR=0.91 (0.36, 2.34); *P*=.85 (Fig. 11).

Isolated Lymph Nodes

The meta-analysis did not show statistically significant differences. WMD: 0.13 (−2.52, 2.78); *P*=.92 (Fig. 12).

Discussion

Colon surgery via SILS, as well as in other diseases, is a surgeon's attempt to diminish surgery aggressiveness by reducing the number of ports of entry. The aim is to diminish

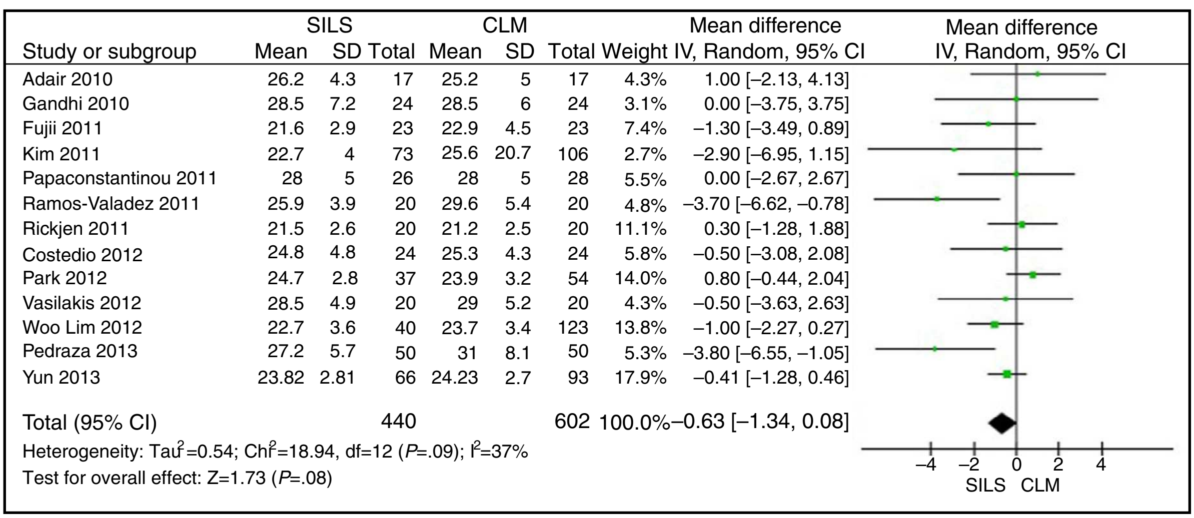

Fig. 2 – Analysis of body mass index.

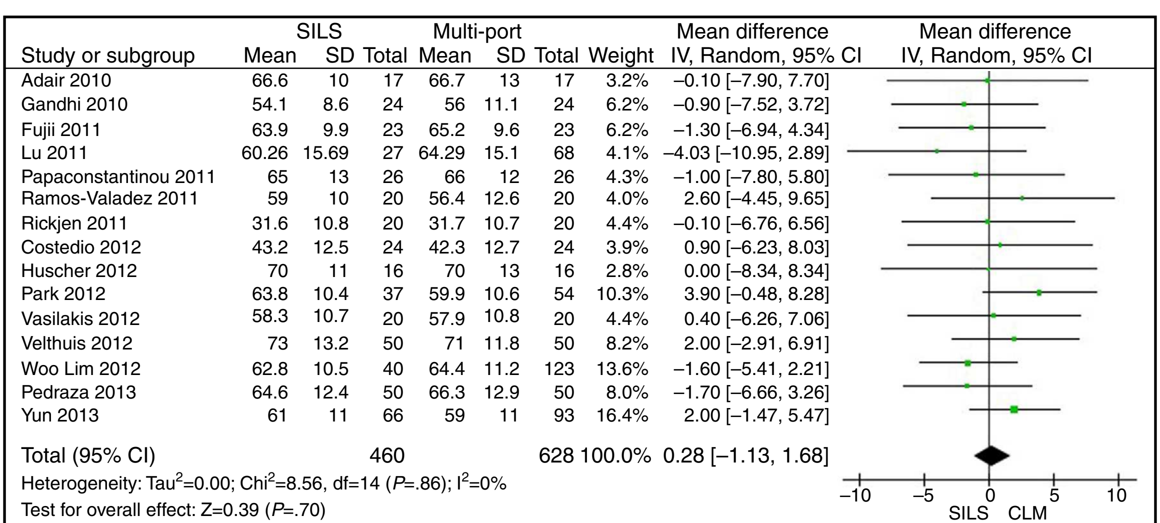

Fig. 3 – Analysis of age.

Study or subgroup	SILS Mean	SILS SD	SILS Total	CLM Mean	CLM SD	CLM Total	Weight	Mean difference IV, Random, 95% CI
Gandhi 2010	2.3	0.6	24	2.3	0.5	24	4.0%	0.00 [−0.31, 0.31]
Fujii 2011	1.52	0.51	23	1.61	0.5	23	4.6%	−0.09 [−0.38, 0.20]
Kim 2011	2	0.69	73	1.93	0.68	106	9.4%	0.07 [−0.13, 0.27]
McNally 2011	2.44	0.62	27	2.5	0.62	46	4.6%	−0.06 [−0.35, 0.23]
Papaconstantinou 2011	2.54	0.51	26	2.54	0.51	26	5.1%	0.00 [−0.28, 0.28]
Rickjen 2011	1.7	0.57	20	1.85	0.49	20	3.6%	−0.15 [−0.48, 0.18]
Chew 2012	1.93	0.35	40	1.9	0.45	104	20.5%	0.03 [−0.11, 0.17]
Huscher 2012	1.94	0.68	16	2.13	0.81	16	1.5%	−0.19 [−0.71, 0.33]
Kanakala 2012	2.23	0.62	40	2.18	0.68	78	6.6%	0.05 [−0.19, 0.29]
Vasilakis 2012	2.35	0.49	20	2.35	0.49	20	4.3%	0.00 [−0.30, 0.30]
Woo Lim 2012	1.78	0.42	40	1.8	0.49	123	16.2%	−0.02 [−0.18, 0.14]
Pedraza 2013	2.5	0.7	50	2.7	0.6	50	6.1%	−0.20 [−0.46, 0.06]
Yun 2013	1.65	0.54	66	1.7	0.55	93	13.4%	−0.05 [−0.22, 0.12]
Total (95% CI)			465			729	100.0%	−0.02 [−0.08, 0.04]

Heterogeneity: $Tau^2=0.00$; $Chi^2=4.94$, df=12 (*P*=.96); $I^2=0\%$
Test for overall effect: Z=0.66 (*P*=.51)

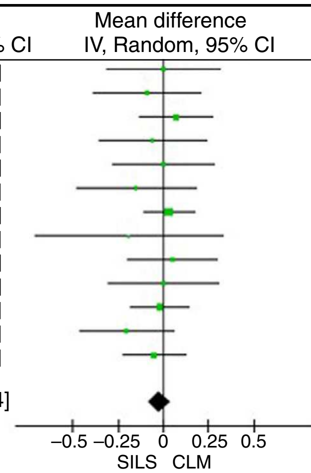

Fig. 4 – Analysis of ASA score.

Study or subgroup	SILS Mean	SILS SD	SILS Total	Multi-port Mean	Multi-port SD	Multi-port Total	Weight	Mean difference IV, Random, 95% cl
Gandhi 2010	3.3	1.1	24	6.6	2.1	24	14.2%	−3.30 [−4.25, −2.35]
Fujii 2011	3.3	1.2	23	5.5	2.4	23	14.0%	−2.20 [−3.30,−1.10]
Lee 2011	5.1	1.8	46	6.4	2.4	46	14.3%	−1.30 [−2.17,−0.43]
Lu 2011	4.07	1.18	27	4.77	1.19	68	14.5%	−0.70 [−1.23,−0.17]
Park 2012	3.3	0.9	37	9.1	1.4	54	14.5%	−5.80 [−6.27,−5.33]
Vasilakis 2012	4.9	1.9	20	5.1	1.9	20	13.9%	−0.20 [−1.38, 0.98]
Woo Lim 2012	4.6	0.7	40	4.4	0.9	123	14.6%	0.20 [−0.07, 0.47]
Total (95% CI)			217			358	100.0%	−1.90 [−3.95, 0.14]

Heterogeneity: $Tau^2=7.46$; $Chi^2=495.41$, df=6 (*P*<.00001); $I^2=99\%$
Test for overall effect: Z=1.82 (*P*=.07)

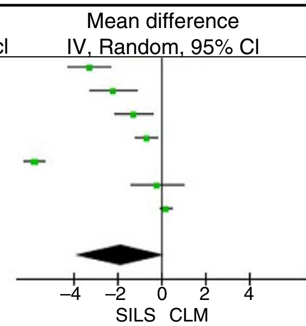

Fig. 5 – Analysis of length of incision.

Study or subgroup	SILS Events	SILS Total	Multi-port Events	Multi-port Total	Weight	Odds ratio F-M, Random, 95% CI
Chen 2010	1	18	0	21	3.1%	3.69 [0.14, 96.22]
Champagne 2011	1	29	1	29	4.1%	1.00 [0.06, 16.79]
Fujii 2011	0	23	1	23	3.1%	0.32 [0.01, 8.25]
Gaujoux 2011	0	25	1	50	3.1%	0.65 [0.03, 16.46]
Kim 2011	1	73	3	106	6.2%	0.48 [0.05, 4.68]
McNally 2011	0	27	6	46	3.8%	0.11 [0.01, 2.09]
Papaconstantinou 2011	0	26	1	26	3.1%	0.32 [0.01, 8.24]
Rickjen 2011	1	20	2	20	5.3%	0.47 [0.04, 5.69]
Champagne 2012	4	156	8	165	21.9%	0.52 [0.15, 1.75]
Chew 2012	3	40	7	104	12.5%	0.73 [0.14, 3.67]
Costedio 2012	0	24	2	24	3.4%	0.18 [0.01, 4.04]
Osborne 2012	0	55	3	327	3.7%	0.84 [0.04, 16.39]
Vasilakis 2012	2	20	1	20	5.3%	2.11 [0.18, 25.35]
Woo Lim 2012	1	40	1	123	4.2%	3.13 [0.19, 51.19]
Keshava 2013	1	75	1	74	4.2%	0.99 [0.06, 16.07]
Pedraza 2013	0	50	1	50	3.1%	0.33 [0.01, 8.21]
Rosati 2013	0	50	1	50	3.1%	0.33 [0.01, 8.21]
Yun 2013	1	66	5	93	6.9%	0.27 [0.03, 2.37]
Total (95% CI)		817		1351	100.0%	0.59 (0.33, 1.04)
Tota events	15		45			

Heterogeneity: $Tau^2=0.00$; $Chi^2=6.94$, df=17 (*P*=.98); $I^2=0\%$
Test for overall effect: Z=1.84 (*P*=.07)

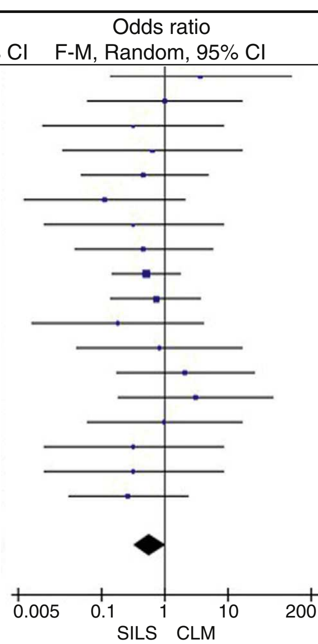

Fig. 6 – Analysis of conversion.

Study or subgroup	SILS Mean	SILS SD	SILS Total	Multi-port Mean	Multi-port SD	Multi-port Total	Weight	Mean difference IV, Random, 95% CI
Adair 2010	139	29.7	17	134	32.3	17	6.4%	5.00 [–15.86, 25.86]
Gandhi 2010	143.2	37.2	24	112.8	44.8	24	6.2%	30.40 [7.10, 53.70]
Fujii 2011	174	37	23	179	40	23	6.3%	–5.00 [–27.27, 17.27]
Lee 2011	135	31	46	134	39	46	6.8%	1.00 [–13.40, 15.40]
Papaconstantinou 2011	144	24	26	144	51	26	6.3%	0.00 [–21.67, 21.67]
Ramos-Valadez 2011	159.2	29.9	20	162.1	40.3	20	6.3%	–2.90 [–24.89, 19.09]
Rickjen 2011	137.4	28.4	20	166.4	37.5	20	6.4%	–29.00 [–49.62, –8.38]
Champagne 2012	135.4	45	156	133.2	56	165	6.9%	2.20 [–8.88, 13.28]
Costedio 2012	125.9	39.3	24	230	117.4	24	4.2%	–104.10 [–153.63, –54.57]
Huscher 2012	147	61	16	129	46	16	5.1%	18.00 [–19.44, 55.44]
Osborne 2012	79	37	55	113	44	327	6.9%	–34.00 [–44.88, –23.12]
Park 2012	118.1	41.5	37	140	42.2	54	6.6%	–21.90 [–39.38, –4.42]
Vasilakis 2012	175.5	40.2	20	178.7	50.7	20	5.8%	–3.20 [–31.56, 25.16]
Woo Lim 2012	225.5	48.3	40	144.6	32.6	123	6.7%	80.90 [64.86, 96.94]
Pedraza 2013	127.9	37.6	50	126.7	63.3	50	6.4%	1.20 [–19.21, 21.61]
Yun 2013	131	27	66	143	54	93	6.9%	–12.00 [–24.76, 0.76]
Total (95% CI)			640			1048	100.0%	–2.69 [–18.33, 12.95]

Heterogeneity: Tau^2=887.10; Chi^2=175.89, df=15 (P<.00001); I^2=91%

Test for overall effect: Z=0.34 (P=.74)

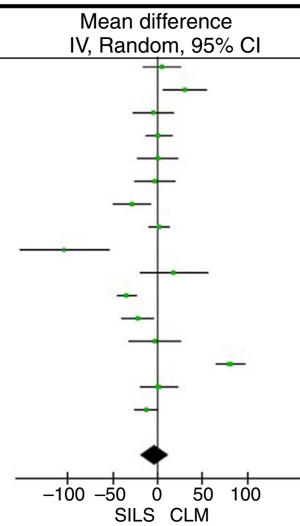

Fig. 7 – Analysis of operating time.

Study or subgroup	SILS Mean	SILS SD	SILS Total	Multi-port Mean	Multi-port SD	Multi-port Total	Weight	Mean difference IV, Random, 95% CI
Gandhi 2010	62.5	37.6	24	90.6	60.6	24	12.9%	–28.10 [–56.63, 0.43]
Fujii 2011	9	9	23	109	39.1	23	13.7%	–100.00 [–116.40, –83.60]
Papaconstantinou 2011	57	40	26	87	70	26	12.7%	–30.00 [–60.99, 0.99]
Ramos-Valadez 2011	58.3	34.3	20	98.8	52.1	20	13.0%	–40.50 [–67.84, –13.16]
Costedio 2012	95.8	65	24	241.7	135.5	24	9.8%	–145.90 [–206.02, –85.78]
Vasilakis 2012	74.5	55.3	20	81.3	54.9	20	12.4%	–6.80 [–40.95, 27.35]
Woo Lim 2012	109.2	80.3	40	96	58.4	123	13.0%	13.20 [–13.74, 40.14]
Pedraza 2013	64.4	64.7	50	87.2	89.8	50	12.7%	–22.80 [–53.48, 7.88]
Total (95% CI)			227			310	100.0%	–42.68 [–76.79, –8.57]

Heterogeneity: Tau^2=2144.13; Chi^2=80.13, df=7 (P<.00001); I^2=91%

Test for overall effect: Z=2.45 (P=.01)

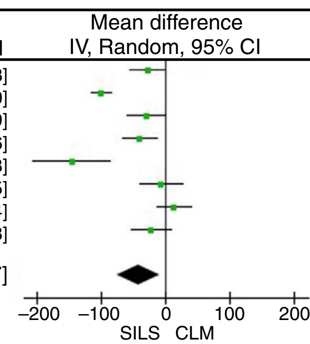

Fig. 8 – Analysis of blood loss.

postoperative pain, reduce complications, improve the time of recovery, and obtain a better aesthetic result, without jeopardising the safety and efficiency of the surgery. The vast majority of these advantages are based on cohort series studies, non-randomised comparative studies, sometimes with contradictory results which may raise more questions than answers. This meta-analysis has intended to answer whether SILS offers benefits as compared to MLC, using the best of the evidence available at present.

Operating time is similar in both groups, although longer in some MLC cases. It is difficult to explain how the operating time could be shorter in SILS colectomy. One possible explanation to this is that MLC procedures, most of the times, are performed by surgeons in training, while SILS are exclusively performed by surgeons with experience in laparoscopic procedures.[18,34] Another argument could be the very nature of the patient selection, as with patients with a stoma, which is generally placed at the end of the intervention, since it could be time-saving as the stoma orifice is already made and protected by a wound retractor, so there is no need to close the fascia or the skin in the additional ports, as in the MLC.[18] These two arguments, patient selection and the surgeon's expertise, could also be the cause of the increased blood loss in MLC patients.

Among the potential benefits of SILS over MLC is the shorter length of incision, which could contribute to an improvement in the aesthetics of the procedure and a reduction in postoperative pain. In this meta-analysis, the length of the incision was similar in both procedures. This could be so because in the laparoscopic colectomy, the length of the incision is not determined by the access path, whether it is SILS or MLC, but by the specimen size, the obesity and the depth of the abdominal wall, the mobility and thickness of the mesentery and omentum, and the amount of stool in the colon.

On the other hand, the advantage of better aesthetics attributed to SILS could be relevant for patients who underwent SILS cholecystectomy, but it is not clear, and it would probably be an irrelevant advantage for colon cancer patients.

The length of hospital stay was shorter in the SILS colectomy group. Discharge from hospital depends on the recovery programme implemented by each institution, on the operating time, the complexity of the surgery, and the

Study or subgroup	SILS Events	SILS Total	Multi-port Events	Multi-port Total	Weight	Odds ratio F-M, Random, 95% CI
Adair 2010	5	17	4	17	2.5%	1.35 [0.29, 6.26]
Chen 2010	3	18	2	21	1.7%	1.90 [0.28, 12.87]
Gandhi 2010	2	24	0	24	0.7%	5.44 [0.25, 119.63]
Waters 2010	3	16	4	27	2.2%	1.33 [0.26, 6.87]
Champagne 2011	5	29	7	29	3.3%	0.65 [0.18, 2.37]
Fujii 2011	3	23	5	23	2.4%	0.54 [0.11, 2.59]
Gaujoux 2011	1	25	8	50	1.4%	0.22 [0.03, 1.86]
Kim 2011	23	73	39	106	8.9%	0.79 [0.42, 1.49]
Lee 2011	11	46	12	46	5.4%	0.89 [0.35, 2.29]
Lu 2011	2	27	3	68	1.8%	1.73 [0.27, 11.00]
McNally 2011	5	27	16	46	4.0%	0.43 [0.14, 1.34]
Papaconstantinou 2011	0	0	0	0		Not estimable
Ramos-Valadez 2011	2	20	2	20	1.4%	1.00 [0.13, 7.89]
Rickjen 2011	4	20	4	20	2.4%	1.00 [0.21, 4.71]
Champagne 2012	43	156	48	165	11.4%	0.93 [0.57, 1.51]
Chew 2012	9	40	21	104	5.9%	1.15 [0.47, 2.78]
Costedio 2012	11	24	19	24	3.4%	0.22 [0.06, 0.79]
Huscher 2012	3	16	5	16	2.2%	0.51 [0.10, 2.62]
Kanakala 2012	3	40	10	78	3.1%	0.55 [0.14, 2.13]
Osborne 2012	14	55	27	327	7.6%	3.79 [1.84, 7.82]
Park 2012	3	37	6	54	2.7%	0.71 [0.16, 3.02]
Vasilakis 2012	1	20	3	20	1.1%	0.30 [0.03, 3.15]
Velthuis 2012	17	50	17	50	6.5%	1.00 [0.44, 2.29]
Woo Lim 2012	5	40	18	123	4.5%	0.83 [0.29, 2.41]
Keshava 2013	8	75	13	74	5.4%	0.56 [0.22, 1.44]
Pedraza 2013	7	50	4	50	3.3%	1.87 [0.51, 6.85]
Rosati 2013	0	0	0	0		Not estimable
Yun 2013	6	66	14	93	4.9%	0.56 [0.20, 1.55]
Total (95% CI)		1034		1675	100.0%	0.89 [0.69, 1.15]
Total events	199		311			

Heterogeneity: Tau^2=0.09; Chi^2=32.24, df=25 (P=.15); I^2=22%

Test for overall effect: Z=0.89 (P=.37)

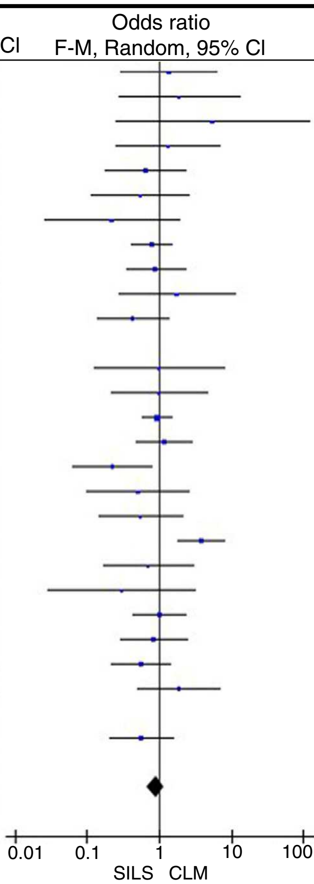

Fig. 9 – Analysis of postoperative complications.

Study or subgroup	SILS Mean	SILS SD	SILS Total	Multi-port Mean	Multi-port SD	Multi-port Total	Weight	Mean difference IV, Random, 95% CI
Adair 2010	3.9	3.7	17	4.1	2.2	17	3.5%	–0.20 [–2.25, 1.85]
Gandhi 2010	2.7	0.8	24	3.3	1.1	24	10.4%	–0.60 [–1.14, –0.06]
Fujii 2011	8.2	3.4	23	12.7	2.9	23	4.1%	–4.50 [–6.33, –2.67]
Lee 2011	4.6	1.6	46	4.3	0.8	46	10.6%	0.30 [–0.22, 0.82]
Papaconstantinou 2011	3.6	1.6	26	5	2.2	26	7.4%	–1.40 [–2.45, –0.35]
Ramos-Valadez 2011	3.2	1	20	3.8	2.1	20	7.6%	–0.60 [–1.62, 0.42]
Rickjen 2011	9	3.4	20	9.2	5.9	20	1.9%	–0.20 [–3.18, 2.78]
Champagne 2012	4.3	1.6	156	4.6	1.4	165	11.6%	–0.30 [–0.63, 0.03]
Costedio 2012	6.08	4.2	20	6.3	3.05	24	3.1%	–0.22 [–2.43, 1.99]
Huscher 2012	6	3	16	7	2	16	4.3%	–1.00 [–2.77, 0.77]
Park 2012	5.5	2.3	37	7.7	4.2	54	5.9%	–2.20 [–3.54, –0.86]
Vasilakis 2012	3.9	1.6	20	5.5	2	20	7.0%	–1.60 [–2.72, –0.48]
Woo Lim 2012	7.7	1.1	40	7.8	2.8	123	10.1%	–0.10 [–0.70, 0.50]
Pedraza 2013	4.5	3.7	50	4	1.7	50	7.0%	0.50 [–0.63, 1.63]
Yun 2013	8	4	66	9	5	93	5.6%	–1.00 [–2.40, 0.40]
Total (95% CI)			581			721	100.0%	–0.73 [–1.18, –0.28]

Heterogeneity: Tau^2=0.43; Chi^2=46.84, df=14 (P<.0001); I^2=70%

Test for overall effect: Z=3.18 (P=.001)

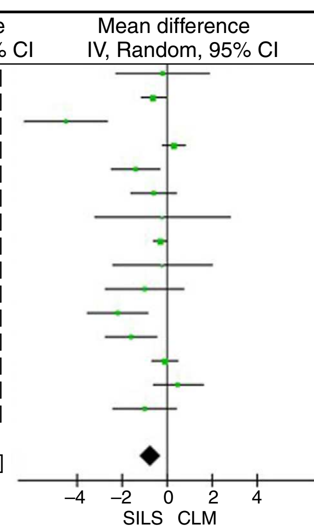

Fig. 10 – Analysis of length in hospital stay.

morbidity associated to it. All of these parameters are very difficult to assess in non-prospective randomised studies. In a Cochrane review, comparing "fast track" surgery vs conventional postoperative care in colorectal surgery, the length of hospital stay was found to be shorter in health care centres that provided fast-track recovery programmes.[40] Therefore, it is a variable that strongly depends on the centre that performs the study and, although this meta-analysis showed a statistically significant shorter length of hospital stay, results have to be taken with caution.

Study or subgroup	SILS Events	SILS Total	Multi-port Events	Multi-port Total	Weight	Odds ratio F-M, Random, 95% CI
Adair 2010	1	17	0	17	8.2%	3.18 [0.12, 83.76]
Gandhi 2010	1	24	0	24	8.3%	3.13 [0.12, 80.68]
Waters 2011	0	16	1	27	8.3%	0.54 [0.02, 13.93]
Kim 2011	0	73	1	106	8.5%	0.48 [0.02, 11.91]
McNally 2011	0	27	2	46	9.3%	0.32 [0.01, 7.00]
Champagne 2012	1	156	0	165	8.5%	3.19 [0.13, 78.97]
Chew 2012	0	40	1	104	8.5%	0.85 [0.03, 21.34]
Kanakala 2012	0	40	1	78	8.5%	0.64 [0.03, 16.01]
Velthuis 2012	1	50	2	50	14.9%	0.49 [0.04, 5.58]
Keshava 2013	1	75	0	74	8.5%	3.00 [0.12, 74.84]
Rosati 2013	0	50	1	50	8.5%	0.33 [0.01, 8.21]
Total (95% CI)		568		741	100.0%	0.91 [0.36, 2.34]
Total events	5		9			

Heterogeneity: Tau^2=0.00; Chi^2=3.61, df=10 (P<.96); I^2=0%

Test for overall effect: Z=0.19 (P=.85)

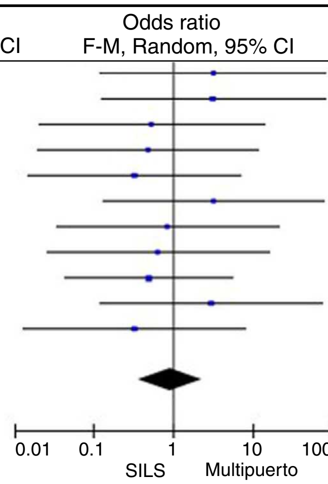

Fig. 11 – Analysis of mortality.

Study or subgroup	SILS Mean	SILS SD	SILS Total	Multi-port Mean	Multi-port SD	Multi-port Total	Weight	Mean difference IV, Random, 95% CI
Adair 2010	20.1	11.3	17	18.6	4.1	17	7.8%	1.50 [−4.21, 7.21]
Gandhi 2010	24.6	12.3	24	18.6	5.7	24	8.0%	6.00 [0.58, 11.42]
Fujii 2011	19.9	5.2	23	23.3	11.5	23	8.3%	−3.40 [−8.56, 1.76]
Kim 2011	29.3	16	73	23.2	15.4	106	8.8%	6.10 [1.40, 10.80]
Papaconstantinou 2011	18	6	26	17	12	26	8.3%	1.00 [−4.16, 6.16]
Ramos-Valadez 2011	20.3	3.8	20	18.3	6.8	20	10.1%	2.00 [−1.41, 5.41]
Huscher 2012	18	6	16	16	5	16	9.7%	2.00 [−1.83, 5.83]
Park 2012	14.6	6.8	37	23.4	11.4	54	9.8%	−8.80 [−12.55, −5.05]
Woo Lim 2012	25.3	11.9	40	28.3	13.2	123	9.1%	−3.00 [−7.36, 1.36]
Pedraza 2013	21.4	8.4	50	19.2	7.6	50	10.4%	2.20 [−0.94, 5.34]
Yun 2013	24	11	66	27	13	93	9.8%	−3.00 [−6.74, 0.74]
Total (95% CI)			392			552	100.0%	0.13 [−2.52, 2.78]

Heterogeneity: Tau^2=15.07; Chi^2=42.97, df=10 (P<.00001); I^2=77%

Test for overall effect: Z=0.10 (P=.92)

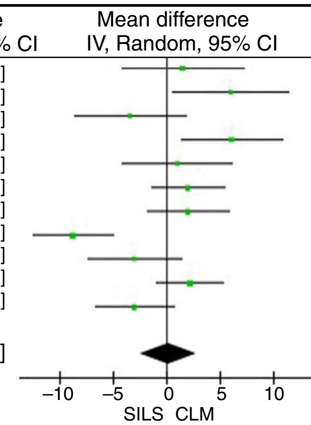

Fig. 12 – Analysis of the number of isolated lymph nodes.

The majority of studies show that SILS colectomy is a safe technique when compared to MLC. In this meta-analysis, the complications have been similar in both surgical techniques. This shows the technique is safe. In the vast majority of the studies, the selected SILS patients had a low BMI. In addition, the surgeons performing the interventions were skilled in laparoscopic surgery. It is unknown whether the safety and effectiveness will remain the same when operating on patients with more complex health profiles and a higher BMI. Moreover, regarding BMI, the results obtained by meta-analysis show that patients intervened via SILS technique have lower BMIs. It leads to think that there is a selection bias, although the results obtained are not statistically significant. On the other hand, one of the theoretical advantages of the SILS interventions is that there are fewer complications related to trocar ports of entry. MLC requires 4–6 ports. Each port represents a potential risk of bleeding, hernia, or intraperitoneal organ lesions. SILS reduces invasiveness since it only performs a single incision, and this could consequently reduce complication rates. However, there are no conclusive clinical studies that show the actual incidence of these complications, among other things, due to the low incidence of complications related to trocars.

In patients with colon cancer, the number of isolated lymph nodes is relevant for staging, determining a prognosis, and defining therapeutic implications. At present, there are no prospective randomised studies or cohort studies to determine oncological results with SILS, in the long run. In 3 studies (2 retrospective studies,[23,39] and one prospective randomised study[29]), the oncological results in adenocarcinoma of colon are compared in the short run, in both techniques: SILS colectomy and MLC. It is shown that in expert hands it is feasible to achieve a correct oncological resection with SILS, although there is no scientific evidence that proves the benefits via this intervention and no study has been able to show SILS colectomy advantages so far.[29] In this meta-analysis, the oncological parameters available in the short run, as the number of isolated lymph nodes, have been the same in both groups: with a mean of 19.22 isolated lymph nodes in SILS colectomy, and 18.55 in MLC. Literature suggests that, for a correct oncological study, there should be a minimum of 12 isolated lymph nodes in colectomies performed for cancer.[41] This leads to believe that SILS colectomy is as effective in oncology as MLC, provided the principles of laparoscopic resection of colorectal cancer are maintained: to perform an early ligation of the vascular pedicle, to avoid manipulating the tumour, and to protect the surgical wound for the specimen extraction.

This meta-analysis includes more studies and a larger amount of patients than other meta-analyses conducted before. The results indicated in those meta-analyses are surprising, in some respects: larger number of isolated lymph nodes during oncological resection performed by SILS, giving SILS colectomy a major improvement when compared to MLC.[42] The authors are aware that this meta-analysis has some methodological limitations. Thus, in the design of the comparative studies, only one study was prospective randomised[29] and the rest were observational studies. This may reduce the quality of the results.

The meta-analyses based on good quality observational studies generally produce estimates similar to those of meta-analyses based on prospective randomised studies,[43] which is why observational studies should not be excluded from meta-analyses, as it was demonstrated by the meta-analyses conducted with non-randomised comparative studies of laparoscopic resection of colorectal cancer.[44] Other biases in this meta-analysis is that in the majority of SILS colectomy studies, the intervention was conducted by surgeons with experience in laparoscopic surgery, while MLC is performed by surgeons in the process of being trained in laparoscopic colectomy. In addition, SILS studies select patients with lower BMIs, as obese and morbidly obese patients are a difficult population to be treated via SILS due to potential additional traction requirements. For this reason, the results obtained in this meta-analysis should be taken with caution.

In conclusion, based on the results of this meta-analysis, SILS is a safe and effective technique, with additional subtle benefits in comparison with MLC. Development in this area should continue, and prospective randomised studies are needed to be able to consider single-port laparoscopic colectomy an alternative to multi-port laparoscopic colectomy, as the evidence available at present is not enough to determine whether this practice should be a standard in laparoscopic colectomy.

Authors' Contributions

J. Luján: study design, data collection, draft of the manuscript; M.T. Soriano: data collection, draft of the manuscript; J. Abrisqueta: data collection, draft of the manuscript, statistical analysis; D. Pérez: data collection, statistical analysis; P. Parrilla: data collection, draft and review of the manuscript.

Conflict of Interests

The authors declare that there are no conflicts of interests.

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