Int J Colorectal Dis (2015) 30:1445–1455
DOI 10.1007/s00384-015-2324-5

REVIEW

Conversion during laparoscopic colorectal resections: a complication or a drawback? A systematic review and meta-analysis of short-term outcomes

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Accepted: 9 July 2015 / Published online: 21 July 2015

Abstract
Purpose Several studies compared the outcomes of laparoscopically completed colorectal resections (LCR) to those requiring conversion to open surgery (COS). However, a comparative analysis between COS patients and patients undergoing planned open surgery (POS) would be useful to clarify if the conversion can be considered a simple drawback or a complication, being cause of additional postoperative morbidity. The aim of this study is to perform a meta-analysis of current evidences comparing postoperative outcomes of COS patients to POS patients.
Methods A systematic search of Medline, ISI Web of Knowledge, and Scopus was performed to identify studies reporting short-term outcomes of COS and POS patients. Primary outcomes were 30-day overall morbidity and length of postoperative hospital stay. Data were analyzed with fixed-effect modeling, and sensitivity analyses were performed to test the robustness of the results.
Results Twenty studies involving 30,656 patients undergoing POS and 1935 COS patients were selected. The mean conversion rate was 0.17. Similar 30-day overall morbidity and length of postoperative hospital stay were found in COS and POS patients. Wound infection (OR 1.43, 95 % CI 1.12 to 1.83, $p<0.01$) was higher in the COS group. Other results were robust. Outcomes were comparable for patients undergoing resection for different natures of the disease (benign vs. malignant) and at different sites (colon vs. rectum).
Conclusion Conversions from laparoscopic to open procedure during colorectal resection are not associated with a poorer postoperative outcome compared to patients undergoing planned open surgery, except for a higher risk of wound infection.

Keywords Laparoscopic colorectal resection · Conversion to open surgery · Short-term outcomes · Meta-analysis

Electronic supplementary material The online version of this article (doi:10.1007/s00384-015-2324-5) contains supplementary material, which is available to authorized users.

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Introduction

Conversion from laparoscopic to open procedure in colorectal surgery is reported with a widely variable rate (5.2 to 77 %) [1, 2]. Intention-to-treat analyses of randomized controlled trials (RCTs) considering procedures converted to open surgery (COS) for the laparoscopic group have shown that the minimally invasive approach is not inferior to the open approach [3–6]. Nevertheless, it is interesting to analyze the postoperative results in COS patients.

Several studies have compared the outcomes of COS procedures to laparoscopically completed colorectal resections (LCR), in some cases showing increased morbidity [7, 8], mortality [8], and length of hospital stay [9, 10]. However, the right yardstick for patients who require conversion during LCR should be patients undergoing planned open surgery (POS). A comparative analysis would clarify if the conversion has to be considered a simple drawback or a complication, causing additional postoperative morbidity. Evidence comparing these two groups of patients is controversial; some studies showed that COS patients may have a worse outcome in terms of postoperative course [3, 11, 12] and a poorer long-term oncologic outcome [13–15] than POS patients, while other studies showed no differences [16, 17] and one study found better outcome [18].

The aim of this study is to perform a meta-analysis of current evidence, evaluating the short-term outcomes of COS procedures compared to POS ones.

Material and methods

Search strategy and selection criteria

We searched Medline, SCOPUS, and Web of Science with no language, publication date, or publication status restrictions. The last search was run on September 9, 2014, using the following search terms: "laparoscop*," "pneumoperitoneum," "conver*," "colon*," "colectomy," "colorectal," "rectum," "rectal," "sigmoid," "hemicolectomy," "crohn," and "ulcerative colitis" (Appendix 1, see Supporting information). The reference list of the identified articles was also checked to identify other potentially relevant studies.

To be considered eligible, a study had to report data on perioperative outcomes in patients undergoing planned open surgery (POS group) and in patients converted to open surgery (COS group) after a failed laparoscopic attempt. Studies including patients undergoing emergency colorectal resections were excluded. Two reviewers (MDs) independently assessed the reports for eligibility at the title and abstract levels. Divergences were resolved by a third reviewer. The full text of selected reports was then retrieved for further analysis.

Data extraction and methodological quality appraisal

Two authors independently extracted data from included studies and filled an electronic database with the following information: first author and publication year, study design, surgeon experience, definition of the term conversion, rate and

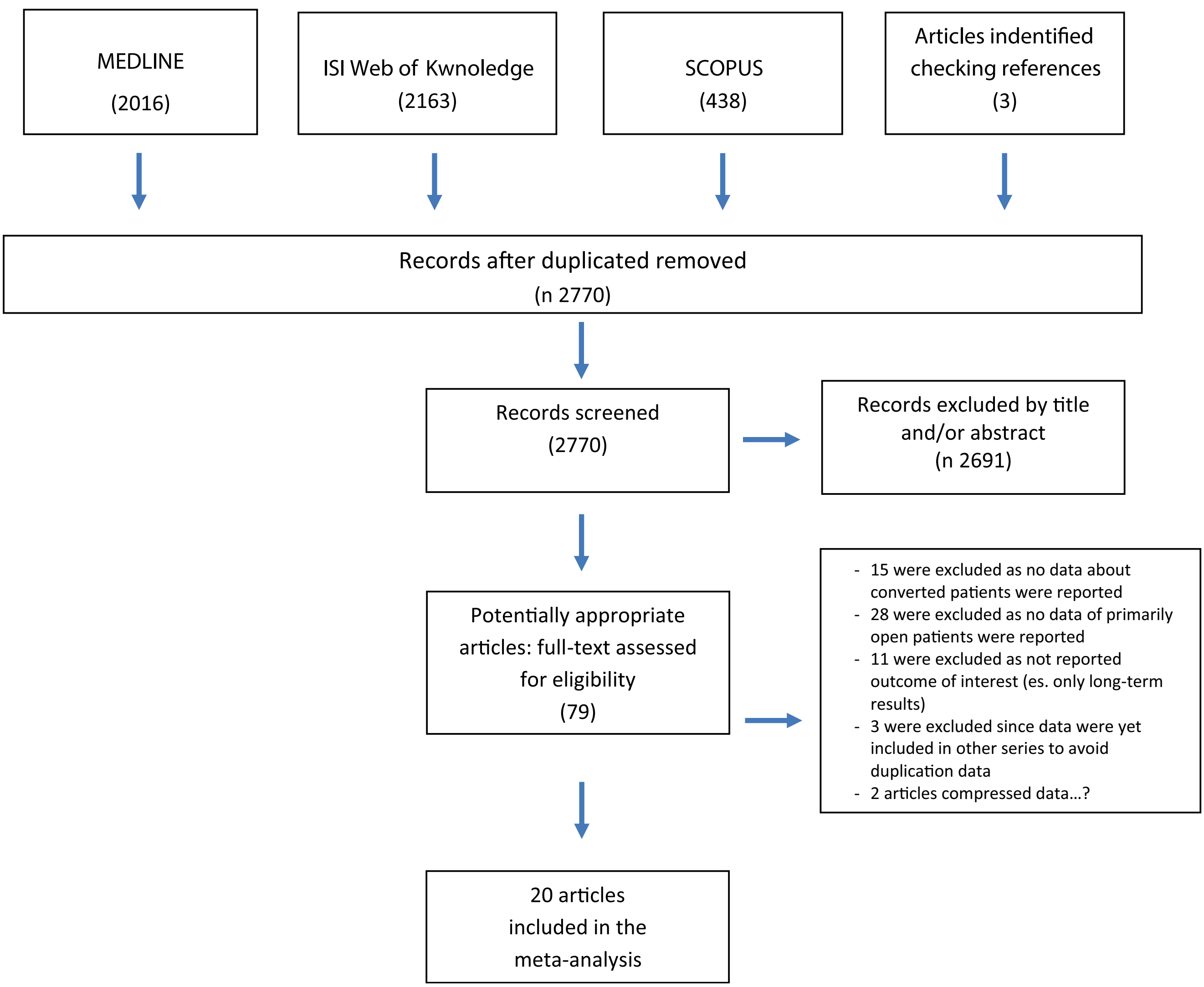

Fig. 1 Search strategy

reason of conversion, and characteristics of study population (age, gender, BMI, ASA index, nature of disease, type of resection, stage of disease).

The Newcastle–Ottawa scale (NOS) was used to assess the quality of a study on a scale of 9, with a greater score indicating better quality. Further assessment of the selection bias was made by considering if the COS and POS groups were comparable for six variables: age, gender, American Society Anesthesiology (ASA) index, body mass index (BMI), site of resection, and stage of disease. Thus, every study was considered to be at low (5–6), medium (3–4), or high risk (0–2) of selection bias, depending on the number of variables that were balanced. If a variable was missing, it was considered not to be balanced.

Outcome analysis

Primary outcomes were 30-day overall morbidity and length of postoperative hospital stay. Secondary outcomes were 30-day mortality, operating time, estimated blood loss, anastomotic leak, re-operation, postoperative bleeding, postoperative bowel obstruction, wound infection, pneumonia, sepsis, cardiovascular complications, and deep venous thrombosis. The odds ratio (OR) and 95 % confidence interval (95 % CI) were used as summary measures for discrete outcomes, while the weighted mean difference (WMD) and 95 % CI were used as summary measures for continuous outcomes. In the absence of statistical heterogeneity, the fixed-effect Mantel-Hænzel model was used. Otherwise, a random-effect DerSimonian and Laird model was used. The heterogeneity among the studies was tested by the Q statistic and quantified by the I^2 statistic. As a guide, I^2 values of <25 % indicated low heterogeneity, 25–50 % indicated moderate heterogeneity, and >50 % indicated high [19] heterogeneity. For dichotomous analyses with zero count cells, 0.5 was added to each cell. Subgroup analysis was planned to establish whether the type of disease (cancer) or type of resection (rectal, colonic) affected the results. The presence of a correlation between the year of the study and the conversion rate was assessed using Spearman's rho statistic.

Sensitivity analyses Additional analyses were performed to test if the results were robust to our methodological assumptions. When a fixed-effect model was used, the meta-analysis was repeated using a random-effect model. The influence of each individual study on the analysis was investigated by omitting each study in turn and re-estimating the summary effect and the heterogeneity.

To further explore whether the results were affected by potential confounding factors, a meta-regression analysis was performed. Study characteristics (year of publication, study design, surgeon experience, conversion rate), study

Table 1 Characteristics of included studies

Study	Multicenter	Type of resection	Disease	POS	LCR	COS	Conversion rate
Begos et al. [24]	No	Colon and rectum	ANY	34	50	17	0.34
Belizon et al. [11]	No	Colon	ANY	28	115	28	0.19
Bouvet et al.[25]	No	Colon and rectum	CANCER	57	53	38	0.42
Casillas et al. [16]	No	Colon	ANY	51	430	51	0.12
CLASICC trial [3]	Yes	Colon and rectum	CANCER	276	488	143	0.29
Curet et al. [22]	No	Colon	CANCER	18	25	7	0.28
Gonzalez et al. [18]	No	Colon and rectum	ANY	260	238	56	0.23
Hewett et al. [27]	Yes	Colon	CANCER	298	294	43	0.15
Kaiser et al. [26]	No	Colon	CANCER	20	29	13	0.46
Kang et al. [32]	Yes	Colon and rectum	ANY	5774	3171	602	0.16
Kolfschoten et al. [33]	Yes	Colon and rectum	CANCER	4287	3063	446	0.13
Laurent et al. [21]	No	Rectum	CANCER	233	238	36	0.15
Martinek et al. [28]	No	Colon and rectum	CANCER	226	243	17	0.07
Mroczkowski et al. [30]	Yes	Rectum	CANCER	16,308	1455	201	0.12
Pennincks et al. [31]	Yes	Rectum	CANCER	1896	764	88	0.12
Rickert et al. [34]	No	Rectum	CANCER	114	124	38	0.24
Rottoli et al. [29]	No	Colon and rectum	CANCER	155	62	31	0.10
Senagore et al. [23]	No	Colon and rectum	ANY	102	26	12	0.32
Slim et al. [12]	No	Colon and rectum	ANY	252	65	16	0.25
Strohlein et al. [15]	Yes	Rectum	CANCER	275	114	25	0.22

ANY resection both for benign and malignant disease, *POS* planned open surgery, *LCR* laparoscopic colorectal resections, *COS* converted to open surgery quality (NOS), and risk of selection bias were tested as potential effect modifiers. Publication bias was assessed by graphical inspection of the funnel plot to detect asymmetry. Symmetry of the funnel plot was also tested using Egger's linear regression method and Harbord's modified test. Statistical analyses were performed using STATA 12 statistical software (STATA Corp, College Station, Texas, USA). The study was realized according to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement [20].

Results

Study selection

The search of the Medline, Web of Science, and Scopus databases provided a total of 4617 citations. Three additional studies [3, 21, 22] were identified by checking the references. One thousand eight hundred forty-seven duplicated studies were found and removed. Of the 2770 remaining, 2691 studies were discarded because they clearly did not meet the inclusion criteria after reviewing the title or abstract. The full text of the remaining 79 articles was examined in more detail. After excluding 59 studies, 20 studies [11, 12, 15, 16, 18, 23–36] were included in the meta-analysis (Fig. 1). No relevant unpublished studies were found.

Study characteristics and quality assessment

The selected studies included 41,741 patients: 30,656 patients underwent POS, while 11,085 patients had an LCR. Of these, 1935 were converted to an open procedure. The mean conversion rate was 0.17, ranging from 0.07 to 0.46. The more recent the study, the lower the conversion rate was (Spearman's rho −0.68, p=0.002). However, reasons for conversion to open surgery (intraoperative findings vs. complication) remained constant over the years (Spearman's rho −0.1, p=0.64). Characteristics of included studies are shown in Table 1. The indication for surgery was colorectal cancer in 13 studies [3, 15, 21, 22, 25–31, 33, 34], while seven studies [11, 12, 16, 18, 23, 24, 32] analyzed resections both for malignant and benign disease. Five studies included only rectal resections [15, 21, 30, 31, 34] while five studies analyzed colonic resections only [11, 16, 22, 26, 27]. Table 2 shows the assessment of the risk

Table 2 Assessment of risk of bias within the studies

Study	Primary allocation to POS or LCR	Study time	Matching of patients	Newcastle–Ottawa scale	Characteristics balanced between COS and POS patients						
					Age	Gender	ASA	Res. type	Disease	Tumoral stage	Bias risk
Begos et al. [24]	Nonrandom	RETROSPECTIVE	No	8	Yes	Yes	Yes	No	Yes	No	M
Belizon et al. [11]	Nonrandom	PROSPECTIVE	Yes	8	Yes	Yes	Yes	No	Yes	Yes	L
Bouvet et al. [25]	Nonrandom	PROSPECTIVE	No	7	Yes	Yes	No	Yes	Yes	Yes	L
Casillas et al. [16]	Nonrandom	PROSPECTIVE	Yes	8	Yes	Yes	Yes	No	Yes	No	M
CLASICC trial [3]	Random	PROSPECTIVE	No	8	Yes	Yes	Yes	No	Yes	Yes	L
Curet et al. [22]	Random	PROSPECTIVE	No	7	Yes	Yes	No	Yes	Yes	Yes	L
Gonzalez et al. [18]	Nonrandom	RETROSPECTIVE	No	8	Yes	Yes	Yes	No	Yes	Yes	L
Hewett et al. [27]	Random	PROSPECTIVE	No	6	No	No	No	No	No	No	H
Kaiser et al. [26]	Random	PROSPECTIVE	No	7	Yes	Yes	No	No	Yes	Yes	M
Kang et al. [32]	Nonrandom	RETROSPECTIVE	No	7	Yes	Yes	Yes	No	Yes	No	M
Kolfschoten et al. [33]	Nonrandom	RETROSPECTIVE	Yes	7	Yes	No	Yes	Yes	No	Yes	M
Laurent et al. [21]	Nonrandom	RETROSPECTIVE	No	6	No	No	No	No	No	No	H
Martinek et al. [28]	Nonrandom	PROSPECTIVE	No	7	Yes	Yes	No	Yes	Yes	Yes	L
Mroczkowski et al. [30]	Nonrandom	RETROSPECTIVE	No	5	No	No	No	No	No	No	H
Penninckx et al. [31]	Nonrandom	RETROSPECTIVE	Yes	8	Yes	Yes	Yes	Yes	Yes	Yes	L
Rickert et al. [34]	Nonrandom	PROSPECTIVE	No	8	Yes	Yes	Yes	Yes	Yes	Yes	L
Rottoli et al. [29]	Nonrandom	PROSPECTIVE	Yes	8	Yes	Yes	Yes	Yes	Yes	Yes	L
Senagore et al. [23]	Nonrandom	PROSPECTIVE	No	7	Yes	No	No	No	No	No	H
Slim et al. [12]	Nonrandom	RETROSPECTIVE	No	8	Yes	No	Yes	No	No	No	H
Strohlein et al. [15]	Nonrandom	PROSPECTIVE	No	7	Yes	No	No	Yes	No	Yes	M

POS planned open surgery, *COS* converted open surgery, *ASA* American society of anesthesiology index, *L* low (5–6 characteristics balanced), *M* medium (3–4 characteristics balanced), *H* high (0-2 characteristics balanced)

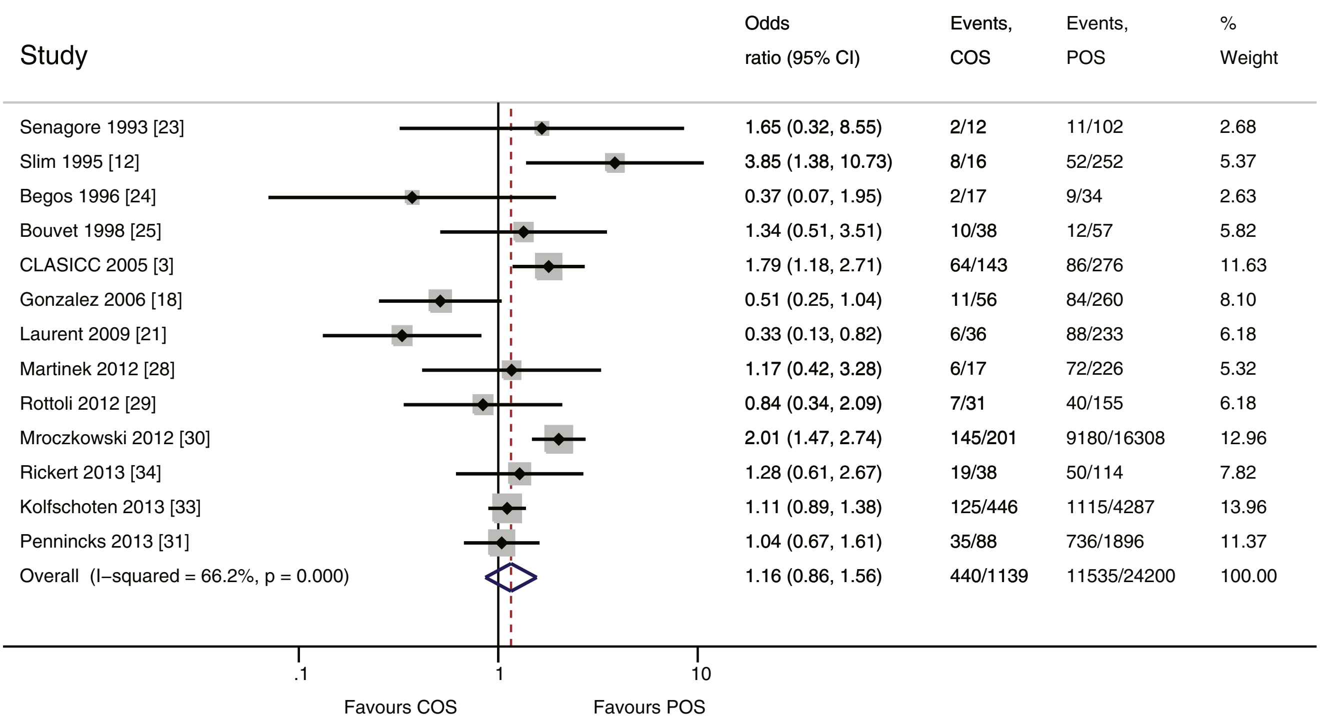

Fig. 2 Forest plot comparing 30-day overall morbidity for planned open surgery (POS) vs. laparoscopic resections converted to open surgery (COS). A random-effect model was used for the analysis. An odds ratio above 1 indicates a higher morbidity in the COS group

Table 3 Definition of conversion

Study	Definition of conversion
Begos et al. [24]	Incision larger than required for specimen retrieval
Belizon et al. [11]	Abortion of laparoscopic approach and the performance of a conventional abdominal incision OR incision>6 cm
Bouvet et al. [25]	Need to convert a laparoscopic colectomy in an open colectomy
Casillas et al. [16]	Incision <10 cm or operating through the incision if <10 cm
CLASICC trial [3]	Vertical incision greater than planned
Curet et al. [22]	Laparotomy
Gonzalez et al. [18]	Extending one of the incisions to perform any step of the procedure other than the anastomosis or specimen removal, or performing a formal laparotomy to complete the operation. In the case of hand-assisted laparoscopic surgery (HALS), extending incision of the hand port used originally to fit the surgeon's hand to perform any part of the operation was considered a conversion
Hewett et al. [27]	Making a larger skin incision than was originally planned at the commencement of the operation
Kaiser et al. [26]	n.d.
Kang et al. [32]	n.d.
Kolfschoten et al. [33]	Procedure started with the intention to resect the tumor using laparoscopic resection but completed as open resection
Laurent et al. [21]	Conventional midline laparotomy or incision greater than needed for specimen retrieval
Martinek et al. [28]	Unplanned laparotomy or wound enlargement above the necessity for specimen removal
Mroczkowski et al. [30]	Procedures started in laparoscopic manner and ended in open manner
Pennincks et al. [31]	n.d.
Rickert et al. [34]	Incision (laparotomy or Pfannenstiel) larger than minilaparotomy
Rottoli et al. [29]	Laparotomy created for any purpose other than specimen extraction
Senagore et al. [23]	n.d.
Slim et al. [12]	Abandonment laparoscopic procedure and midline laparotomy incision
Strohlein et al. [15]	n.d.

n.d. conversion not defined

of bias. The definition of the term “conversion” in the selected studies is reported in Table 3.

Outcome analysis

All studies provided information on *30-day mortality*, and the Forest plot showed no difference between COS and POS (OR, 1.1; 95 % CI, 0.83 to 1.46). The incidence of overall postoperative *30-day morbidity* was reported in 13 studies [3, 12, 18, 21, 23–25, 28–31, 33, 34]. The results were similar in the two groups (OR, 1.16; 95 % CI, 0.86 to 1.56) although a significant heterogeneity was found (Q, 35.5; p=0; I^2=66.2 %) (Fig. 2). Conversion to open surgery was associated with a higher incidence of postoperative *pneumonia* (OR, 1.54; 95 %

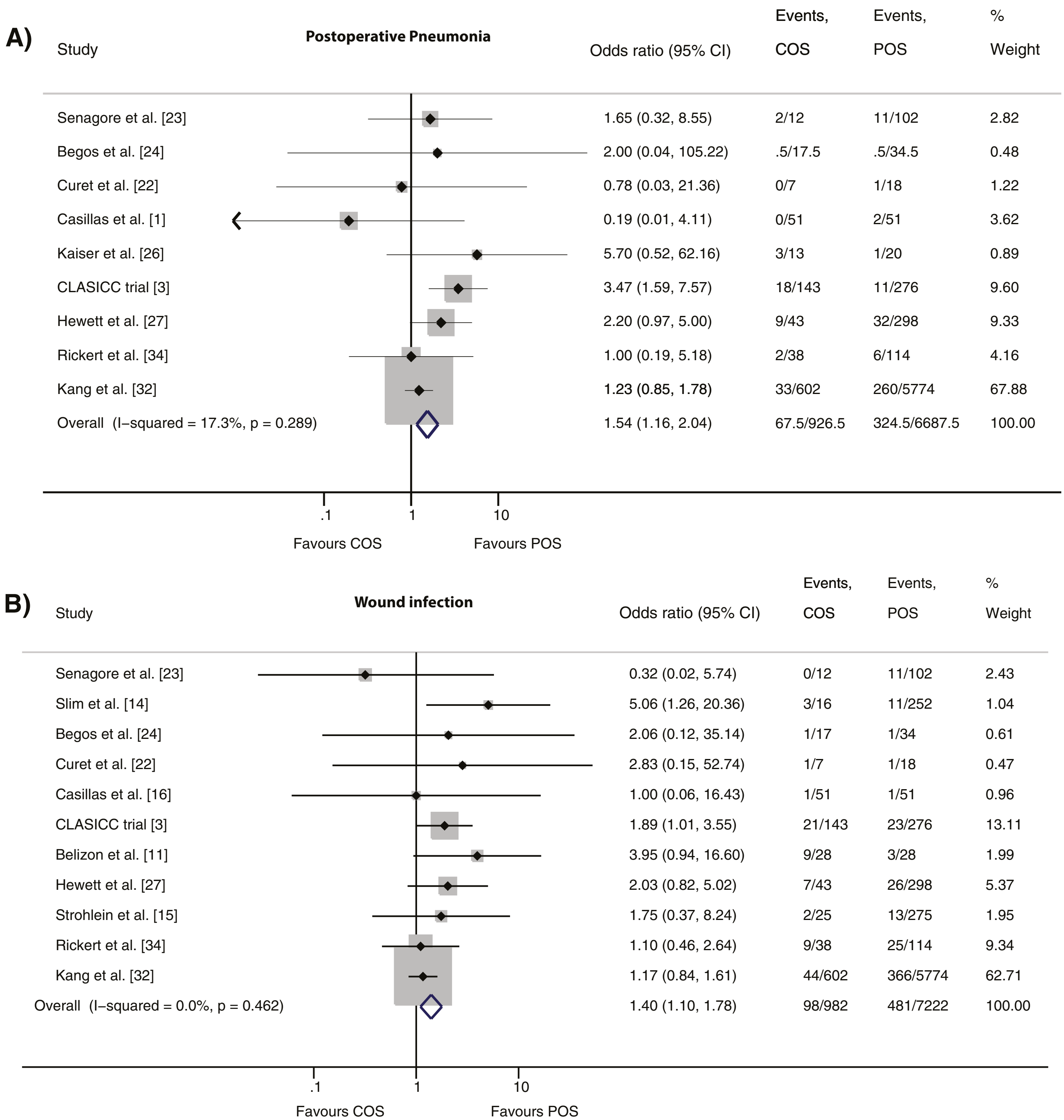

Fig. 3 Forest plot comparing incidence of postoperative pneumonia (**a**) and wound infection (**b**) after planned open surgery (POS) vs. laparoscopic resections converted to open surgery (COS). A fixed-effect model was used for the analyses. An odds ratio above 1 indicate a higher incidence in the COS group

CI, 1.16 to 2.04) as reported in nine studies [3, 16, 22–24, 26, 27, 32, 34] (Fig. 3a). Furthermore, the rate of *wound infection* was compared in 11 studies [3, 11, 12, 15, 16, 22–24, 27, 32, 34], and it was found to be higher in COS group (OR, 1.43; 95 % CI, 1.12 to 1.83) (Fig. 3b). The *length of hospital stay* was reported in 14 studies [3, 12, 15, 16, 18, 24–28, 31, 32, 34] (Fig. 4) with no difference between COS and POS (WMD, −0.12; 95 % CI, −1.14 to 0.89; significant heterogeneity Q, 65.10; p=0, I^2=96.9 %) as for *anastomotic leak* rate (OR, 1.08; 95 % CI, 0.88 to 1.33) that was recorded in seven studies [3, 11, 15, 24, 29, 32, 34]. *Operating time* [11, 12, 16, 18, 22, 24–26, 28, 34, 37] was longer in the COS group (WMD, 57.59; 95 % CI, 44.55 to 70.63), while no difference was found in *blood loss* (WMD, 36.34: 95 % CI, −122.79 to 195.48), reported in five studies [18, 22, 23, 26, 28]. Among other secondary outcomes investigated, no differences were found in rates of *re-operation*, *postoperative bleeding*, *postoperative obstruction*, *sepsis*, *cardiac complication*, and *deep venous thrombosis* (Table 4). Subgroup analysis confirmed the results when studies were considered according to the nature of disease and site of resection (Table 5).

Sensitivity analysis and publication bias

The results obtained using a fixed-effect model were confirmed by repeating the analysis using a random-effect model (Table 4). The influence analysis showed that after exclusion of the studies by Hewett et al. [27] (OR, 1.64; 95 % CI, 0.92 to 2.91) or Guillou at al. [3] (OR, 1.35; 95 % CI, 0.98 to 1.86), there was no more difference in the risk of pneumonia. Meta-regression analysis showed that the results were not influenced by the quality of the study, the selection bias, or other study characteristics (Table 6). The funnel plot showed symmetry (Fig. 5), which was confirmed by Egger's and Harbord's modified tests (p>0.6 for all tests).

Discussion

Several studies have compared the outcomes of COS procedures to laparoscopic completed colorectal resections. However, the right term for comparison of patients who required COS should be patients undergoing POS. Surgeons should answer the question, "W*ould the patient's outcome have changed if the operation had been planned primarily as an open case?*" In addition, when informing the patient about the procedure, a failed laparoscopic attempt should be presented not simply as a drawback, but as a complication, if the conversion is associated with a poorer postoperative outcome than POS.

The main finding of the study is that the postoperative course of COS patients does not differ from that of POS patients, except for a higher risk of wound infection. No difference was found in 30-day overall morbidity between COS and POS patients. Previously, two studies found a higher

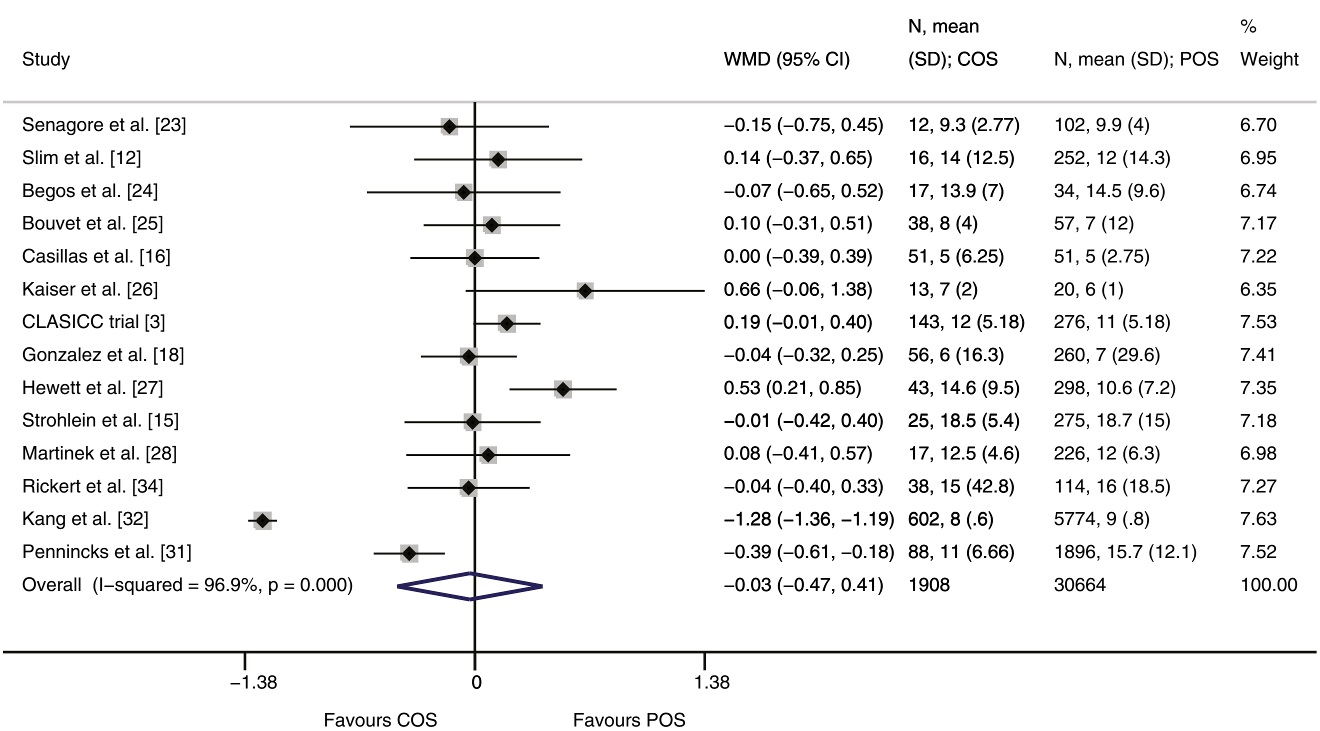

Fig. 4 Forest plot comparing length of hospital stay after planned open surgery (POS) vs. laparoscopic resections converted to open surgery (COS). A random-effect model was used for the analysis. A positive weighted mean difference (WMD) indicates longer hospital stay in the COS group

Table 4 Summary of outcomes of included studies: planned open surgery vs. converted open surgery

Outcome	Number of data sets	Summary effect	Model	Heterogeneity	Random-effect model analysis
30-day mortality	20	OR=1.102 [0.830–1.463] p=0.50	FE	Q=7.6 p=0.99	OR=1.144 [0.856–1.528] p=0.363
30-day morbidity	13	OR=1.159 [0.862–1.558] p=0.31	RE	Q=35.53 p=0.00 I^2=66.2 %	
Wound infection	11	OR=1.4 [1.1–1.783] p=0.006	FE	Q=9.75 p=0.462	OR=1.428 [1.116–1.828] p=0.005
Anastomotic leak	7	OR=1.081 [0.877–1.331] p=0.467	FE	Q=5.30 p=0.505	OR=1.095 [0.887–1.353] p=0.397
Pneumonia	9	OR=1.536 [1.156–2.041] p=0.003	FE	Q=9.66 p=0.209	OR=1.729 [1.090–2.73] p=0.02
Cardiac complications	4	OR=0.829 [0.508–1.352] p=0.453	FE	Q=0.90 p=0.827	OR=0.830 [0.505–1.363] p=0.453
Postoperative bleeding	4	OR=0.355 [0.076–1.669] p=0.190	FE	Q=0.02 p=0.999	OR=0.354 [0.076–1.637] p=0.184
Deep venous thrombosis	4	OR=0.622 [0.212–1.818] p=0.385	FE	Q=0.19 p=0.979	OR=0.638 [0.215–1.887] p=0.416
Sepsis	4	OR=1.091 [0.394–3.024] p=0.866	FE	Q=2.86 p=0.414	OR=1.534 [0.455–5.174] p=0.490
Operating time (min)	12	WMD=57.593 [44.550–70.637] p=0.00	RE	Q=83.45 p=0.00 I^2=86.8 %	
Re-operation	5	OR=0.909 [0.706–1.171] p=0.460	FE	Q=3.00 p=0.558	OR=0.910 [0.705–1.175] p=0.470
Postoperative obstruction	4	OR=2.466 [0.470–12.950] p=0.286	FE	Q=0.10 p=0.949	OR=2.458 [0.453–13.346] p=0.297
Length of hospital stay	14	WMD=−0.124 [−1.144–0.895] p=0.811	RE	Q=65.10 p=0.00 I^2=96.9 %	
Blood loss (ml)	5	WMD=36.34 [−122.79–195.48] p=0.654	RE	Q=58.85 p=0.00 I^2=92.3 %	

Weighted mean difference (WMD) for continuous variables and odds ratio (OR) for complications, all with 95 % confidence interval

Positive WMD and OR above 1 favor planned open surgery (POS)

FE fixed-effect model, *RE* random-effect model, *Q* Cochrane index

Table 5 Subgroup analysis on mortality, overall morbidity and length of hospital stay according to site of resection and indication for surgery

Outcome	Number of data sets	Summary effect	Model	Heterogeneity
SUBGROUP disease CANCER				
30-day mortality	13	OR=1.21 [0.871–1.697] p=0.25	FE	Q=4.07 p=0.982
30-day morbidity	9	OR=1.212 [0.905–1.622] p=0.197	RE	**Q=22.48 p=0.004 I^2=64.4 %**
Length of hospital stay	8	WMD=0.226 [−1.740–2.191] p=0.82	RE	**Q=51.87 p=0.01 I^2=86.5**
SUBGROUP type of resection COLON				
30-day mortality	5	OR=2.492 [0.564–10.998] p=0.22	FE	Q=0.58 p=0.96
30-day morbidity	-	–	–	–
Length of hospital stay	3	WMD=1.30 [−0.429–3.029] p=0.14	RE	Q=5.04 p=0.08
SUBGROUP type of resection RECTUM				
30-day mortality	5	OR=1.102 [0.830–1.463] p=0.79	FE	Q=0.75 p=0.945
30-day morbidity	13	1.065 0.567 2.000 p=0.36	RE	**Q=16.64 p=0.001 I^2=82.4 %**
Length of hospital stay	4	WMD=−2.519 [−6.454–1.417] p=0.21	RE	**Q=8.03 p=0.01 I^2=75.1 %**

Bold emphasis is to highlight that the statistical heterogeneity (Q test) was significant

FE fixed-effect model, *RE* random-effect model, *OR* odds ratio, *WMD* weighted mean difference, *Q* Cochrane index

Table 6 Effect of potential effect modifiers on main outcomes

	Outcome			
	Mortality	Morbidity	Hospital stay	Wound infection
Δduration (COS–POS)	0.005 p=0.31	0.001 p=0.75	0.0032009 p=0.34	0.001 p=0.83
Learning curve	0.642 p=0.52	0.221 p=0.77	−0.0915573 p=0.67	0.363 p=0.72
Disease (cancer/benign)	0.322 p=0.34	0.113 p=0.80	0.3974207 p=0.14	0.084 p=0.82
Type of resection (colon/rectum)	−0.159 p=0.59	0.079 p=0.83	−0.2289881 p=0.17	−0.183 p=0.41
Matching (yes/no)	−0.013 p=0.96	−0.164 p=0.68	−0.190211 p=0.62	0.673 p=0.35
Study time (prospective/retrospective)	0.484 p=0.17	0.250 p=0.50	0.5376222 p=0.12	0.224 p=0.51
Newcastle–Ottawa scale	0.057 p=0.76	−0.050 p=0.78	−0.0915573 p=0.67	0.149 p=0.58
Numbers of variables matched	0.030 p=0.76	0.034 p=0.68	0.0667436 p=0.39	0.059 p=0.57
Primary allocation (randomized/not randomized)	0.630 p=0.12		0.6104352 p=0.14	0.399 p=0.22
Conversion rate	0.960 p=0.74	0.062 p=0.97	1.370128 p=0.30	1.40 p=0.75
Year of the study	−0.049 p=0.16	−0.017 p=0.54	−0.0237594 p=0.24	−0.023 p=0.06

COS converted to open surgery, *POS* planned open surgery

morbidity in the COS group [3, 12], but Slim et al. [12] reported data from an early laparoscopic experience. Consistent with this result, there was no difference in the length of postoperative hospital stay. Moreover, our analysis did not show any difference in the risk of anastomotic complication after conversion, in contrast to findings by Belizon et al. [11] and Slim et al. [12]. As expected, the operating time was longer in the COS group, which could explain the higher risk of pneumonia in these patients [3] revealed in our analysis. However, this result was not robust, since it depended on the singular inclusion of two [3, 27]. In particular, the study by Hewett et al. [27] has high risk of selection bias. Thus, we think that no conclusion should be drawn about the risk of pneumonia in COS patients. Despite the conversion rate decreasing in more recent studies, the outcomes of COS patients were substantially comparable to those of POS patients over the years. Consistent with this result, surgeon experience and the reason for conversion (findings vs. intraoperative complications) did not worsen postoperative outcomes in COS patients. This could be because most of the intraoperative complications that occurred could be repaired without having a significant impact on the postoperative course.

Some methodological aspects and limitations of this study should be considered. An inherent risk of selection bias is present in this analysis. The COS group is a negatively selected group, as patients requiring conversion are usually older, have more comorbidities, or have an advanced stage of disease [38, 39]. Additionally, in a nonrandomized setting, patients could have been selected for POS in view of the same characteristics. Each of these aspects alone could cause a poorer postoperative outcome, independently from the procedure (POS or COS).

In addition to the study quality (NOS), we assessed the presence of a selection bias by considering if the groups (POS and COS) were comparable for six variables (age, gender, ASA index, BMI, site of resection, stage of disease), which are risk factors for conversion and could act as confounding factors [38, 39]. The meta-regression analysis showed that the results did not change according to the NOS score, the number of variables balanced, and the status of each of these variables (balanced vs. not balanced). Another potential confounding factor is the number of previous surgeries. Unfortunately, this factor could not be considered in this assessment, since it was not reported in most of the studies. However, this and other unknown confounding factors are more likely to have been a cause of higher morbidity in the COS group than in our analysis, which does not show a substantial difference of morbidity.

The design of the included studies was heterogeneous (Table 1). We should point out that in this comparison, RCTs lose their advantages. Although POS and LCR groups are fully comparable because of randomization, the COS group is not comparable to the POS group as a result of the negative selection (Table 2). In view of the unpredictability of the conversion event [40], an observational study remains as the only

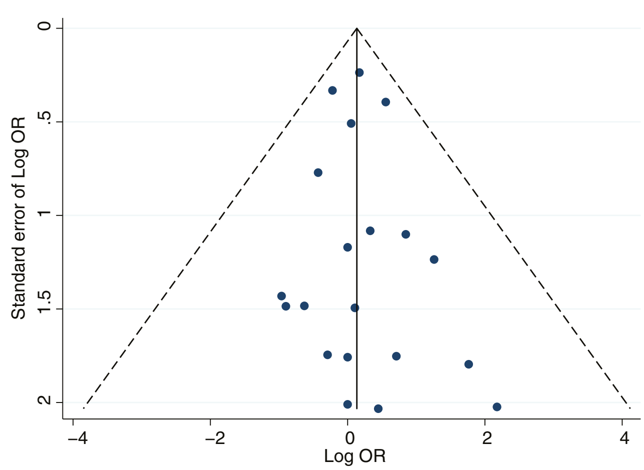

Fig. 5 Funnel plot. The standard error (SE) of the logarithm of the odds ratio (OR) is plotted against the logarithm of the OR (outcome 30-day mortality)

conceivable evidence to study this topic. Compared to retrospective studies, prospective ones have a lower risk of measurement bias. However, sensitivity analysis showed that the results were comparable for prospective and retrospective studies. Study populations were heterogeneous according to the nature of disease (benign vs. malignant), the site of the disease (colon vs. rectum), and consequently, the type of operation. Subgroup analyses revealed comparable outcomes for these categories of patients.

Inter-study heterogeneity was present in the analysis of overall morbidity. This is a composite outcome, and a varying definition of the composition could account for this heterogeneity. This hypothesis is supported by the fact that no statistical heterogeneity was present in the analysis of each single outcome of morbidity. The definition of conversion varied across the studies, as there is still no consensus on this term. Nevertheless, the varying definition of conversion did not correspond with significant heterogeneity of the outcomes. This suggests that in most of the studies, the definition differed mainly on a formal level.

Intention-to-treat analyses of RCTs have shown that a minimally invasive approach is not inferior to the open approach when COS procedures are considered in the laparoscopic group [3–6]. This evidence might support a surgeon's choice to attempt a minimally invasive colorectal resection when a laparoscopic operation is feasible and there are no obvious contraindications. We believe that our results further support this strategy, adding valuable information that the postoperative course of converted patients does not differ from that of patients undergoing POS, except for a higher risk of wound infection.

Conflict of interest The authors declare that they have no competing interests.

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