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Laparoscopic *versus* Open Total Mesorectal Excision for Resectable Rectal Cancer: An Updated Meta-analysis of Randomized Controlled Trials

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Abstract

Aim: This meta-analysis was conducted to evaluate the safety and efficacy of laparoscopic (LPS) *versus* open surgery for resectable rectal cancer.

Methods: We analyzed and compared oncological outcomes, safety outcomes, and recovery outcomes between LPS surgery and open surgery. Meta-analyses were conducted using RevMan 5.3 software. Dichotomous variables were analyzed by risk ratio with 95% confidence intervals, and continuous variables were analyzed as mean differences.

Results: A total of 16 randomized controlled trials were identified involving 5386 patients. Based on the currently limited evidence, LPS surgery showed similar oncological outcomes to open surgery in terms of lymph nodes retrieved, positive circumferential resection, incomplete total mesorectal excision, local recurrence, distant metastasis, and unsuccessful resection. LPS surgery was associated with better recovery than open surgery in terms of earlier first bowel movement, earlier start of fluid intake, and shorter hospital stay. However, there was no significant difference in perioperative mortality, re-operation, chest infection, anastomotic leakage, urinary injury, or incision hernia between the LPS and open surgery groups. Importantly, LPS surgery was associated with less intraoperative bleeding, wound infection, and bowel obstruction.

Conclusion: Though the overall quality of LPS seems higher than that of open surgery, there is still insufficient evidence to recommend its routine application. However, its similar oncological outcomes, better recovery, and fewer complications suggests that LPS TME may represent a good option for experienced centers or surgeons.

Keywords: Rectal cancer; Total mesorectal excision; Laparoscopic surgery; Open surgery; Meta-analysis

Introduction

Colorectal cancer has emerged as one of the most common causes of cancer-related deaths worldwide. Although its incidence and mortality have been declining, colorectal cancer still remains the third most commonly diagnosed cancer in the United States [1]. Radical surgical involving total mesorectal excision (TME) has become the primary treatment choice for rectal cancer [2], especially for curable, locally advanced tumors (stage II or III). Laparoscopic (LPS) TME offers several theoretical advantages over open TME for rectal cancer, including less pain, faster recovery, lower morbidity rate, and better quality of life (QoL), whilst achieving equal oncological outcomes and long-term overall survival (OS). However, the procedure of LPS surgery for rectal cancer is complex, potentially involving an extensive learning curve. The safety and efficacy of LPS surgery, and whether or not it should be recommended in patients with rectal cancer, thus remain unclear. We conducted an updated meta-analysis of randomized controlled trials (RCTs) to evaluate the safety and efficacy of LPS *versus* open surgery for patients with resectable rectal cancer.

Materials and Methods

Literature search

PubMed, Embase, the Cochrane Database of Systematic Reviews, the Cochrane Controlled Trials Register, Web of Science, and the China National Knowledge Infrastructure (CNKI) databases were searched systematically to identify relevant articles published between January 1990 and February 2017. We used the following medical subject terms to conduct the literature search: "rectal cancer", "laparoscopic or laparoscopic-assisted surgery (LAS)", "open or conventional surgery", and "randomized controlled trials (RCT)". We also identified potentially relevant studies from the bibliographies of all retrieved papers.

Inclusion criteria

The inclusion criteria were as follows: all studies comparing LPS and open surgery for rectal cancer; RCT; resectable or non-metastasized cancer; and studies analyzing at least one of the following endpoints: lymph nodes (LNs) retrieved, circumferential resection (CRM) positive, TME incomplete, local recurrence, distant metastasis, unsuccessful resection, perioperative mortality, re-operation, chest infection, anastomotic leakage, urinary injury, incision hernia, intraoperative bleeding, wound infection, bowel obstruction, first bowel movement, start of fluid intake, hospital stay, and OS rates.

Exclusion criteria

The exclusion criteria were as follows: guideline articles, comments, or reviews; non-randomized studies; studies on other rectal lesions such as benign lesions and inflammatory bowel disease; articles without a specific group of patients with rectal cancer; and low-quality studies without sufficient data covering the required characteristics. In the event of multiple studies conducted by the same authors or the same

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institution, only the most recent and informative publication was selected.

Data extraction and study quality assessment

The relevant data were retrieved independently from the included articles by two authors (MY Shen and KY Yang). Information including the characteristics of the study, participants in each group, subject terms, and endpoints were identified from the titles and abstracts, and the whole articles were acquired if necessary. The authors compared the results and evaluated the quality of the studies. Any disagreement was settled by the third investigator (Y Zhou). The basic characteristics of the included RCTs and the clinical outcomes following LPS and open surgery are shown in Tables 1 and 2. The Cochrane Risk of Bias was evaluated in Table 3.

Statistical analysis

Meta-analyses were conducted using RevMan 5.3 software (Cochrane Collaboration). Dichotomous variables were analyzed by risk ratio (RR) with 95% confidence intervals (95% CI). Continuous variables were analyzed by mean differences (MD). Heterogeneity was assessed by $\chi 2$ tests. A fixed-effects model was chosen for the meta-analysis if the results were statistically homogeneous (P>0.1 and I2 ≤ 50%), and a random-effects model if the results were statistically heterogeneous (P<0.1 or I2>50%).

Results

A total of 16 RCTs were identified involving 5386 patients (3120 in the LPS surgery group and 2266 in the open surgery group) [2 -17]. The clinical outcomes in the two groups are listed in Tables 1 and 2. We have studied the following clinical outcomes, including oncological outcomes (LNs retrieved, CRM positive, TME incomplete, local recurrence, distant metastasis, unsuccessful resection, and OS rates), safety outcomes (perioperative mortality, re-operation, chest infection, anastomotic leakage, urinary injury, incision hernia, Intraoperative bleeding, wound infection, and bowel obstruction), and recovery outcomes (first bowel movement, start of fluid intake, and hospital stay). Several forest plots for the outcomes were shown in Figures 1-6. Publication bias for the outcomes was determined by funnel plots (Figure 7), and no publication bias was detected.

Study, year	Participants	Intervention	Comparison	Outcomes	Study settings
Stevenson, 2015[2]	Rectal adenocarcinoma; < 15 cm of the anal verge ≥ 18 years; T4 tumors or an involved CRM excluded.	LAS, n=238	Open surgery, n=235	b, c, e, f, j, k, o	RCT
Andersson, 2014[3]	Rectal cancer; <15 cm from the anal verge; tumors invading adjacent tissues or organs, T4 tumors, T3 rectal tumor with 2 mm of the endopelvic fascia excluded	LPS, n=260	Open surgery n=125	j	RCT
Arteaga, 2006[4]	Rectal cancer; <15 cm from the anal verge; patients with cT3-4 receive preoperative radiotherapy (45 Gy in 4 weeks).	LPS, n=20	Open surgery, n=20	a, b, f, g, h, j, k, l, m, n, o, p, q, r	RCT
Braga, 2006[5]	Rectal adenocarcinoma, ≥ 18 years; patients with cT3 received neoadjuvant chemotherapy with 5-FU plus oxalyplatin.	LPS, n=83	Open surgery, n=85	a, b, d, e, g, h, i, j, k, l, m, n, o, q, r	RCT
Bonjer, 2015[6]	Rectal adenocarcinoma; <15 cm from the anal verge without distant metastasis; T4 tumors, T3 rectal tumor with 2 mm of the endopelvic fascia excluded.	LPS, n=699	Open surgery, n=345	b, d, e, f	RCT
Fleshman, 2015[7]	Rectal adenocarcinoma; ≤ 12 cm from the anal verge with clinical stage II, IIIA, IIIB; ≥ 18 years, a body mass index ≤ 34.	LAS n=240	Open surgery, n=222	a, b, c, g, h, j, m, r	Prospective, RCT
Jeong, 2014[8]	Mid-rectal or low-rectal cancer patients receive preoperative chemo-radiotherapy; cT3N0-2M0; 18-80 years.	LPS, n=170	Open surgery, n=170	b, c, d, e	Prospective, RCT
Kang, 2010[9]	cT3N0-2 mid or low rectal cancer; no distant metastasis; receive preoperative chemoradio-therapy.	LPS, n=170	Open surgery, n=170	g, h, j, k, o	Prospective, RCT
Liang, 2011[10]	Rectal cancer without liver or lung metastases.	LPS, n=169	Open surgery, n=174	g, i, j, n, o, p, q	RCT
Lujan, 2009[11]	mid and low rectal adenocarcinoma; T4 excluded; patients received neoadjuvant therapy with oral capecitabine and 50–54 Gy external beam radiotherapy.	LPS, n=101	Open surgery, n=103	a, b, d, e, g, h, i, j, k, m, n, o, q, r	Prospective, RCT
Ng, 2008[12]	Rectal cancer; cancer <6 cm.	LAS, n=51	Open surgery, n=48	a, b, d, e, g, h, i, k, n, o	Prospective, RCT
Ng, 2009[13]	Cancer of the rectosigmoid junction and upper rectum.	LAS, n=76	Open surgery, n=77	a, b, g, h, i, j, k, l, n, o	RCT
Ng, 2014[14]	mid and low rectal cancer.	LAS, n=40	Open surgery n=40	a, b, c, d, e, g, h, i, j, k, l, n, o	Prospective, RCT
Pas, 2013[15]	Rectal cancer <15 cm from the anal verge; no distant metastasis; ≥ 18 years.	LPS, n=699	Open surgery, n=345	f, g, i, j, k, n, o	RCT
Stevenson, 2015[2]	Rectal adenocarcinoma; <15 cm of the anal verge, ≥ 18 years; T4 tumors or an involved CRM excluded.	LAS, n=238	Open surgery, n=235	b, c, e, f, j, k, o	RCT
Veenhof, 2011[16]	non-metastasized rectal cancer.	LPS, n=22	Open surgery, n=18	g, i, j, n, o	Prospective, RCT
Zhou, 2004[17]	Rectal adenocarcinoma; with the lowest margin under peritoneal reflection and 1.5 cm above dentate line.	LPS, n=82	Open surgery, n=89	b, d, g, j, k, o, p, q, r	Prospective, RCT

LPS: lapascopic surgery; LAS: lapascopic-associated surgery; RCT: Randomized Controlled Trial.
a: LNs retrieved; b: CRM positive; c: TME incomplete; d: Local recurrence; e: Distant metastasis; f: Un-successful resection; g: Perioperative mortality; h: Re-operation; i: Chest infection; j: Anastomotic leakage; k: Urinary injury; l: Incision hernia; m: Operation bleeding; n: Wound infection; o: Bowel obstruction; p: First bowel movement; q: Start fluid intake; r: Length of hospital stay.

Table 1: Basic characteristics of the RCTs included in this meta-analysis.

Outcome	No. of Patients	No. of Trials	LPS	Open	RR or MD (95% CI)	*P* Value	I^2, %	P Value for Heterogeneity
Oncological Outcomes								
LNs retrieved	1206	7	611	595	0.78 (-0.04, 1.60)	0.06	44	0.10
CRM positive	3234	11	94/1800	58/1434	1.09 (0.80, 1.50)	0.58	0	0.77
TME incomplete	1355	4	39/688	27/667	1.39 (0.87, 2.22)	0.16	33	0.22
Local recurrence	2106	7	54/1226	39/880	0.99 (0.66, 1.49)	0.97	0	0.53
Distant metastasis	2408	7	204/1382	151/1026	0.90 (0.74, 1.09)	0.26	0	0.78
Unsuccessful resection	2601	4	85/1656	51/945	1.25 (0.90, 1.74)	0.18	20	0.29
Safety Outcomes								
Perioperative mortality	3144	12	16/1753	17/1391	0.69 (0.35, 1.36)	0.29	0	1.00
Re-operation	1546	8	46/781	57/765	0.80 (0.55, 1.16)	0.24	0	0.51
Chest infection	2131	8	30/1241	27/890	0.77 (0.46, 1.29)	0.32	0	0.72
Anastomotic leakage	3903	13	112/2200	82/1703	0.95 (0.72, 1.27)	0.74	0	0.81
Urinary injury	2772	10	65/1560	42/1212	1.44 (1.00, 2.09)	0.05	0	0.51
Incision hernia	441	4	11/219	13/222	0.87 (0.41, 1.83)	0.70	0	0.41
Operation bleeding	874	4	444	430	-117.13 (-164.46- -69.79)	<0.001*	52	0.10
Wound infection	2171	9	69/1261	81/910	0.68 (0.50, 0.94)	0.02*	0	0.67
Bowel obstruction	3155	12	87/1751	107/1404	0.69 (0.52, 0.91)	0.008*	11	0.34
Recovery Outcomes								
First bowel movement	554	3	271	283	-0.94 (-1.66, -0.22)	0.01*	92	<0.001
Start fluid intake	926	5	455	471	-1.00 (-1.64, -0.36)	0.002*	89	<0.001
Length of hospital stay	1045	5	526	515	-3.26 (-6.10, -0.41)	0.02*	95	<0.001

LPS: lapascopic surgery; No.: number; RR: risk ratios; MD: mean difference; CI: confidence intervals; LNs: lymph nodes; CRM: circumferential resection; TME: total mesorectal excision.

Table 2: Clinical outcomes comparing LPS and open surgery.

Study, year	Random sequence generation	Allocation concealment	Selective reporting	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Other bias
Andersson, 2014[3]	Low risk,	Low risk	Unclear risk	Low risk	Unclear risk	Unclear risk	Low risk
Arteaga, 2006[4]	Low risk	Unclear risk	Low risk	Unclear risk	Unclear risk	Unclear risk	Low risk
Braga, 2006[5]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Bonjer, 2015[6]	Low risk	Unclear risk	Low risk	Low risk	Low risk	Low risk	Low risk
Fleshman, 2015[7]	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk
Jeong, 2014[8]	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk	Low risk
Kang, 2010[9]	Low risk	Unclear risk	Low risk	Low risk	Low risk	Low risk	Low risk
Liang, 2011[10]	Unclear risk	Low risk	High risk	Low risk	Low risk	Low risk	Unclear risk
Lujan, 2009[11]	Low risk	Low risk	Unclear risk	Low risk	Low risk	Low risk	Unclear risk
Ng, 2008[12]	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk
Ng, 2009[13]	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk	High risk
Ng, 2014[14]	Low risk	Low risk	Low risk	High risk	High risk	Low risk	Low risk
Pas, 2013[15]	Low risk	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk
Stevenson, 2015[2]	Low risk	Low risk	Low risk	Unclear risk	Low risk	Low risk	Low risk
Veenhof, 2011[16]	Low risk	Low risk	Unclear risk	Low risk	Low risk	Low risk	Low risk
Zhou, 2004[17]	Unclear risk	High risk	High risk	High risk	Unclear risk	Hign risk	Unclear risk

RCTs: randomized controlled trails

Table 3: Quality assessment of the randomized controlled trails included based on the Cochrane Risk of Bias Tool.

Oncological Outcomes

LNs retrieved

Seven RCTs compared LN retrieval between LPS and open surgery, and a fixed-effects model (test for heterogeneity: P=0.10; I2=44%) detected no significant difference between the groups in terms of LNs retrieved (MD 0.78; 95% CI, -0.04–1.60, P=0.06).

CRM positive

A fixed-effects model (test for heterogeneity: P=0.77; I^2=0%) found no significant difference in CRM positivity between the LPS (94/1800) and open surgery (58/1434) groups in 11 RCTs (RR 1.09; 95% CI, 0.80–1.50, P=0.58).

TME incomplete

Four RCTs reported the results in relation to incomplete TME, and a fixed-effects model (test for heterogeneity: P=0.22; I^2=33%) found no significant difference between the LPS (39/688) and open surgery (27/667) groups (RR 1.39; 95% CI, 0.87–2.22, P=0.16).

Local recurrence

Local recurrence was compared between the two groups in seven

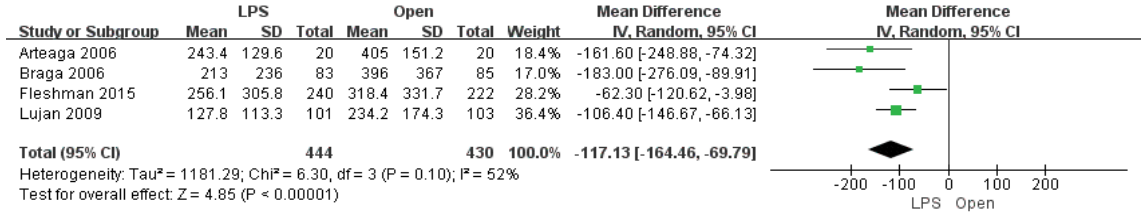

Figure 1: Forest plot of intraoperative bleeding in LPS and open surgery groups.

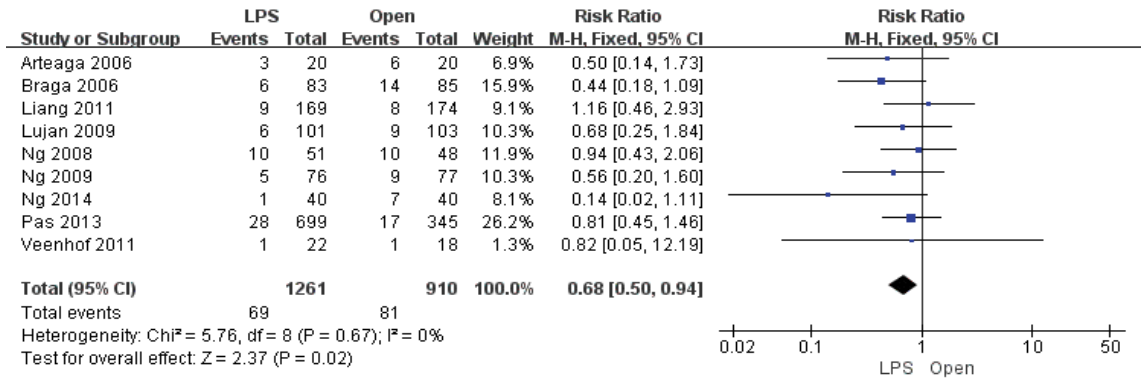

Figure 2: Forest plot of wound infection in LPS and open surgery groups.

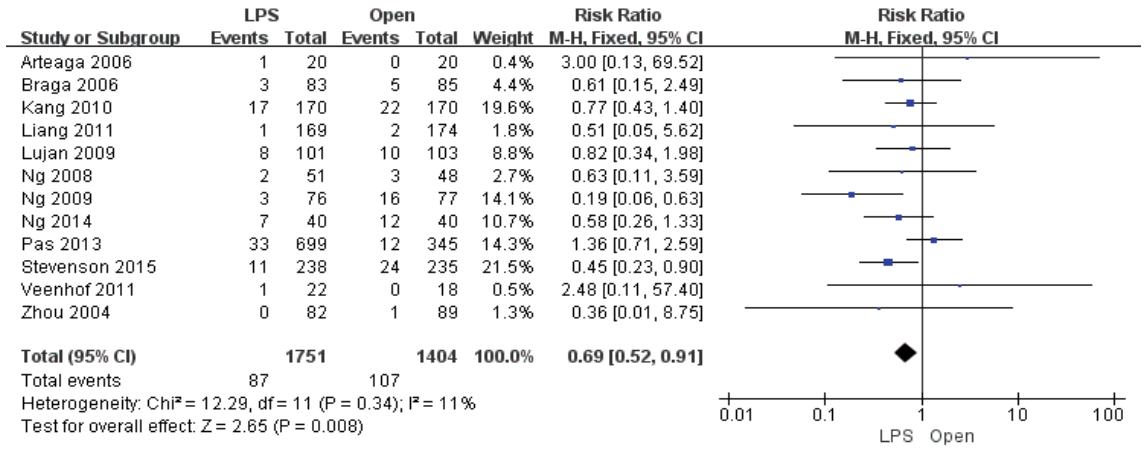

Figure 3: Forest plot of bowel obstruction in LPS and open surgery groups.

RCTs, and a fixed-effects model (test for heterogeneity: P=0.53; I^2=0%) showed no significant difference between the LPS (54/1226) and open surgery (39/880) groups (RR 0.99; 95% CI, 0.66–1.49, P=0.97).

Distant metastasis

Seven RCTs compared distant metastasis, and a fixed-effects model (test for heterogeneity: P=0.78; I^2=0%) found no significant difference between the LPS (204/1382) and open surgery (151/1026) groups (RR 0.90; 95% CI, 0.74–1.09, P=0.26).

Unsuccessful resection

A fixed-effects model (test for heterogeneity: P=0.29; I^2=20%) found no significant difference in the incidence of unsuccessful resection between the LPS (85/1656) and open surgery (51/945) groups in four RCTs (RR 1.25; 95% CI, 0.90–1.74, P=0.18).

OS

Five studies focused on OS. Bonjer et al., [6] reported 3-year OS rates in the LPS and open surgery groups of 86.7% and 83.6%, while Simon et al. [14] reported 5-year OS rates of 85.9% and 82%, and Jeong et al. [8] found 3-year OS rates of 90.4% and 91.7%, respectively. Lujan et al. [11] and Simon et al. [12] reported 5-year OS rates in the LPS and open surgery groups of 75.3% and 72.1%, and 75.2% and 76.5%, respectively. No significant difference could be found in these studies.

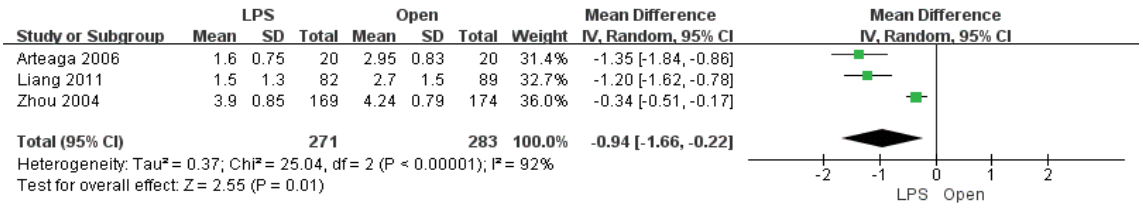

Figure 4: Forest plot of first bowel movement in LPS and open surgery groups.

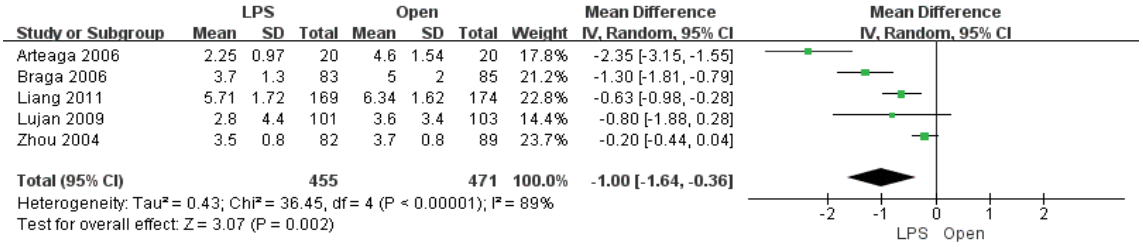

Figure 5: Forest plot of start of fluid intake in LPS and open surgery groups.

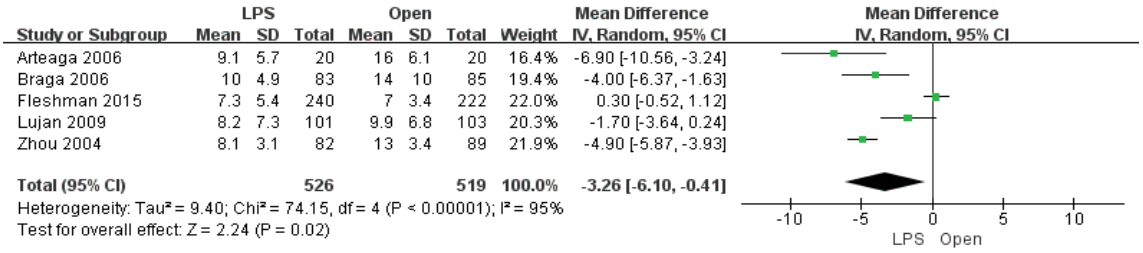

Figure 6: Forest plot of length of hospital stay in LPS and open surgery groups.

Safety Outcomes

Perioperative mortality

Twelve RCTs compared LPS and open surgery in terms of perioperative mortality (test for heterogeneity: P=1.00; I^2=0%), and no significant difference between the LPS (16/1753) and open surgery (17/1391) groups was observed in a fixed effects model (RR 0.69; 95% CI, 0.35–1.36, P=0.29).

Re-operation rate

Re-operation rates for LPS and open surgery were compared in eight RCTs, and a fixed-effects model (test for heterogeneity: P=0.51; I^2=0%) showed no significant difference between the LPS (46/781) and open surgery (57/765) groups (RR 0.80; 95% CI, 0.55–1.16, P=0.24).

Chest infection

The incidence of chest infections was analyzed in eight RCTs and a fixed-effects model (test for heterogeneity: P=0.71; I^2=0%) found no significant difference between the LPS (30/1241) and open surgery (27/890) groups (RR 0.77; 95% CI, 0.46–1.29, P=0.32).

Anastomotic leakage

Thirteen RCTs reported on the occurrence of anastomotic leakage, and a fixed-effects model (test for heterogeneity: P=0.81; I^2=0%) found no significant difference between LPS (112/2200) and open surgery (82/1703) (RR 0.95; 95% CI, 0.72–1.27, P=0.74).

Urinary injury

Ten RCTs focused on urinary injury (test for heterogeneity: P=0.51; I^2=0%), and there was no significant difference between the LPS (65/1560) and open surgery (42/1212) groups in a fixed-effects model (RR 1.44; 95% CI, 1.00–2.09, P=0.05).

Incision hernia

Four RCTs reported on the results of incision hernia for LPS *versus* open surgery, and a fixed-effects model (test for heterogeneity: P=0.41; I^2=0%) found no significant difference between the LPS (11/219) and open surgery (13/222) groups (RR 0.87; 95% CI, 0.41–1.83, P=0.70).

Intraoperative bleeding

Four RCTs focused on the occurrence of intraoperative bleeding (test for heterogeneity: P<0.10; I^2=52%), and LPS surgery was associated with significantly less intraoperative bleeding than open surgery according to a random-effects model (MD -117.13; 95% CI, -164.46–-69.79, P<0.001) (Figure 1).

Wound infection

Nine RCTs compared LPS and open surgery in terms of wound

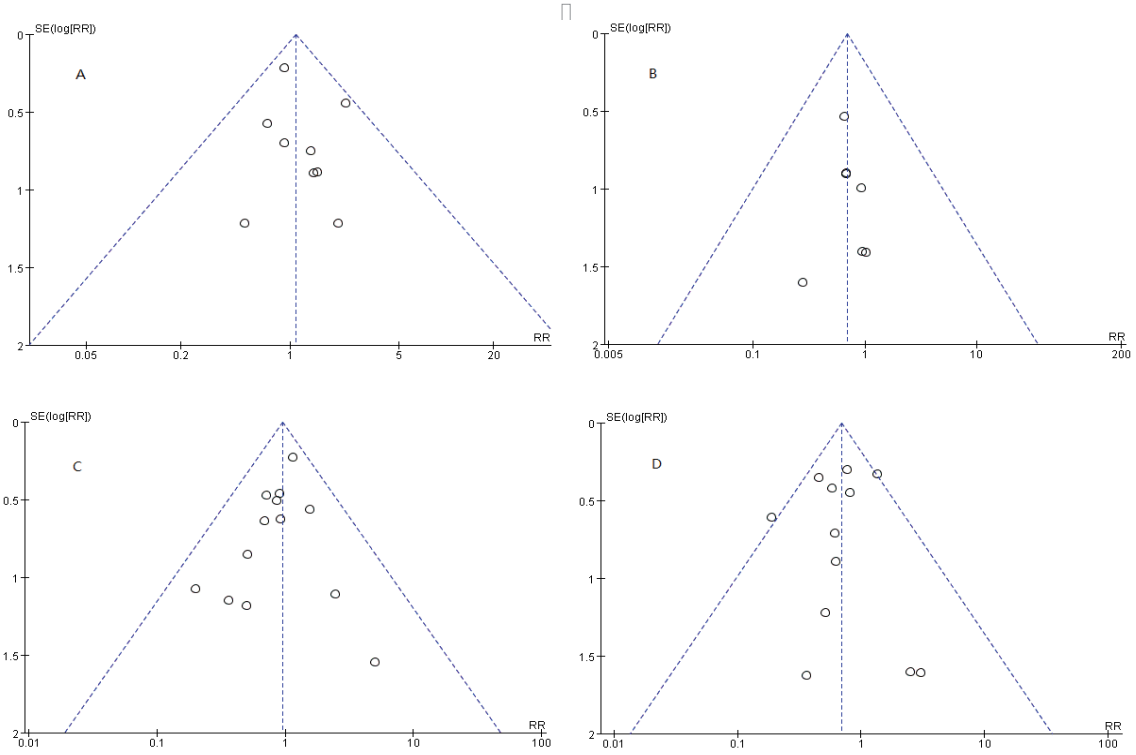

Figure 7: Funnel plot: (A) CRM positive; (B) perioperative mortality; (C) anastomotic leakage; (D) bowel obstruction.

infection, and a fixed-effects model (test for heterogeneity: P=0.67; I^2=0%) found that LPS surgery was associated with significantly less wound infection (69/1261) than open surgery (81/910) (RR 0.68; 95% CI, 0.50–0.94, P=0.02) (Figure 2).

Bowel obstruction

Twelve RCTs were analyzed in a fixed-effects model (test for heterogeneity: P=0.34; I^2=11%), which showed a significantly lower incidence of bowel obstruction with LPS surgery (87/1751) compared with open surgery (107/1404) (RR 0.69; 95% CI, 0.52–0.91, P=0.008) (Figure 3).

Recovery Outcomes

First bowel movement

Nine RCTs focused on the time of the first bowel movement, and a random-effects model (test for heterogeneity: P<0.01; I^2=92%) indicated that the first bowel movement was significantly earlier following LPS compared with open surgery (MD -0.94; 95% CI, -1.66 – -0.22, P<0.001) (Figure 4).

Start fluid intake

Analysis of seven RCTs using a random-effects model (test for heterogeneity: P<0.01; I^2=89%) showed that fluid intake started significantly earlier following LPS compared with open surgery (MD -1.00; 95% CI, -1.64 – -0.36, P<0.001) (Figure 5).

Length of hospital stay

Five RCTs reported on the length of hospital stay, and a random-effects model (test for heterogeneity: P<0.001; I^2=95%) showed that LPS surgery was associated with a significantly shorter length of hospital stay compared with open surgery (MD -3.26; 95% CI, -6.01 – -0.41, P=0.02) (Figure 6).

Discussion

Several high-quality RCTs of LPS *versus* open surgery for rectal cancer were not included in previous meta-analyses [2,6,7]. However, these RCTs have reported conflicting results. According to the COLOR II trial, Bonjer et al. [6] found that LPS surgery was associated with similar locoregional recurrence rates and similar disease-free and OS compared with open surgery, on the basis of which they suggested that LPS was as safe and effective as open surgery in patients with rectal cancers without invasion of adjacent tissues.

In contrast, a multicenter randomized, non-inferiority phase 3 trial (AlaCaRT) that evaluated the safety and efficacy of LPS *versus* open surgery for rectal cancer [2] failed to provide sufficient evidence for the routine use of LPS surgery. Likewise, the results of a multicenter balanced randomized trial conducted in the United States and Canada (ACOSOG Z6051) [7] did not support the use of LPS resection. In light of these considerations, we conducted an updated meta-analysis of RCTs to assess the safety and efficacy of LPS *versus* open TME for patients with resectable rectal cancer.

Oncological outcomes are important in patients with rectal cancer. Our current results suggested that LPS surgery could achieve similar oncological outcomes to open surgery for rectal cancer in terms of LNs retrieved, CRM positivity, incomplete TME, local recurrence, distant metastasis, and unsuccessful resection. Although OS and disease-free survival are also important, few RCTs have evaluated these outcomes

[6,8,11,12,14]. Importantly, analysis of the RCTs included in our study indicated that LPS surgery had similar oncological outcomes to open surgery in terms of OS and disease-free survival [6,8,11,12,14]. Moreover, previous meta-analyses also demonstrated that LPS surgery offered equivalent oncological outcomes to open surgery [18-23]. Further studies are needed to validate these results.

Safety is of utmost importance to surgeons. Our analysis found no significant difference in perioperative mortality between LPS and open surgery. The need for re-operation is associated with more pain, increased cost, and more complications, and we found no significant difference in re-operation rates between LPS and open surgery, and also no significant difference in the incidence of chest infections. Anastomotic leakage is a serious postoperative complication with potentially serious impacts on patient QoL. We found no significant difference in anastomotic leakage rates between the two groups, as well as no differences in terms of urinary injury and incision hernia. Importantly, however, the incidences of wound infection and bowel obstruction were significantly lower in the LPS group. LPS sphincter-preserving resection was associated with better preservation of QoL compared with open surgery in Chinese patients with rectal cancer [24]. However, the sample size in that study was small, and further studies are needed to compare the effects of LPS and open surgery on QoL in rectal cancer patients.

Recovery outcomes are important issues to consider. In this meta-analysis, patients who underwent LPS surgery had faster recovery times compared with open surgery, including earlier first bowel movement, earlier start of fluid intake, and shorter hospital stay, indicating faster recovery following LPS compared with open surgery. Unfortunately, no economic-outcome data are currently available, and no meta-analysis could be conducted. However, LPS surgery is likely to be more costly than open surgery [5], which would increase the economic burden for patients, especially those from less-developed regions. We recommend that further studies should be conducted to investigate this issue.

Our results suggest that LPS surgery may be associated with advantages in terms of faster recovery and fewer complications than open surgery. However, laparoscopic TME for rectal cancer is a complex and technically difficult procedure [25-28], and the learning curve is affected by numerous factors, such as primary tumor stage (T stage), male sex, and standardization for accurate performance of the same technique for expanded indications [26]. Fortunately, surgeons can learn to carry out LPS surgery effectively under the supervision of experienced surgeons [27], though at least 30 procedures are required before a surgeon is considered to be competent at performing LPS colorectal surgery [28].

Analysis of the currently limited evidence suggests that, although the overall quality of LPS seems higher than that of open surgery, there is still insufficient evidence to recommend its routine application. Further studies are needed before LPS TME should be recommended as the routine or gold standard treatment for rectal cancer. However, its similar oncological outcomes, better recovery, and fewer complications compared with open surgery suggest that LPS TME may be a good choice for rectal cancer in the case of experienced centres or surgeons.

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Conflict of Interest

All authors declare that they have no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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