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SCIENTIFIC REVIEW

Laparoscopic Versus Open Complete Mesocolon Excision in Right Colon Cancer: A Systematic Review and Meta-Analysis

Mohamed Ali Chaouch[1] · Mohamed Wejih Dougaz[1] · Ibtissem Bouasker[1] · Hichem Jerraya[1] · Wafa Ghariani[1] · Mehdi Khalfallah[1] · Ramzi Nouira[1] · Chadli Dziri[1]

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Abstract

Background Laparoscopic complete mesocolon excision (LCME) for right colonic cancer improves oncological outcomes. This systematic review and meta-analysis aimed to compare intraoperative, postoperative, and oncological outcomes after LCME and open total mesocolon excision (OCME) for right-sided colonic cancers.
Methods Literature searches of electronic databases and manual searches up to January 31, 2019, were performed. Random-effects meta-analysis model was used. Review Manager Version 5.3 was used for pooled estimates.
Results After screening 1334 articles, 10 articles with a total of 2778 patients were eligible for inclusion. Compared to OCME, LCME improves results in terms of overall morbidity (OR = 1.48, 95% CI 1.21 to 1.80, $p = 0.0001$), blood loss (MD = 56.56, 95% CI 19.05 to 94.06, $p = 0.003$), hospital stay (MD = 2.18 day, 95% CI 0.54 to 3.83, $p = 0.009$), and local (OR = 2.12, 95% CI 1.09 to 4.12, $p = 0.03$) and distant recurrence (OR = 1.63, 95% CI 1.23–2.16, $p = 0.0008$). There was no significant difference regarding mortality, anastomosis leakage, number of harvested lymph nodes, and 3-year disease-free survival. Open approach was significantly better than laparoscopy in terms of operative time (MD = − 34.76 min, 95% CI − 46.01 to − 23.50, $p < 0.00001$) and chyle leakage (OR = 0.41, 95% CI 0.18 to 0.96, $p = 0.04$).
Conclusions This meta-analysis suggests that LCME in right colon cancer surgery is superior to OCME in terms of overall morbidity, blood loss, hospital stay, and local and distant recurrence with a moderate grade of recommendation due to the retrospective nature of the included studies.

Abbreviations

LCME	Laparoscopic complete mesocolon excision
OCME	Open complete mesocolon excision
CME	Complete mesocolon excision
RCTs	Randomized clinical trials
CCTs	Controlled clinical trials

✉ Mohamed Ali Chaouch
Docmedalichaouch@gmail.com

[1] Department B of Surgery, Charles Nicolle Hospital, Tunis, Tunisia

Introduction

Extended lymphadenectomy with complete mesocolon excision (CME) in colon cancer provides better oncological outcomes [1–3]. Extended surgical dissection following embryological planes with central vascular ligation, firstly described by Hohenberger et al. [4], provided one intact mesocolon package. The CME is currently applied worldwide and especially in Asian countries [5]. CME procedure with D3 lymph nodes excision is the standard intervention for stage II and stage III colon cancer [6–9]. The laparoscopic approach is recognized as safe and feasible [9, 10]. Laparoscopic complete mesocolon excision (LCME) with central vascular ligation has technical advantages comparing to open approach due to better postoperative recovery [11, 12]. A systematic review with a meta-analysis [11] compared laparoscopic to open complete mesocolon excision with central vascular ligation for right and left colon cancers. They concluded that the laparoscopic approach offers the same quality of the resected specimen, a better postoperative recovery, and at least non-inferior long-term oncological outcomes than open approach [11]. However, the right and left colon cancers should be evaluated separately. They differ in genetic, clinical, oncological, and survival features [13–16]. There were many studies comparing LCME to open complete mesocolon excision (OCME) for right colon cancer [17–26]. These studies [17–26] analyzed small numbers of patients, and few studies compared long-term follow-up. This meta-analysis aimed to assess the safety and the efficacy of LCME for right-sided colon cancer compared to OCME.

Methods

Criteria of eligibility

Retained studies: We considered randomized clinical trials (RCTs) and controlled clinical trials (CCTs), comparing LCME to OCME, with no language restrictions.

Participants: Patients with right colon or transverse colon cancer undergoing right total mesocolon excision were considered for inclusion. Studies including participants with colon cancer are only eligible if the results of right-sided colon carcinoma were presented separately.

Interventions: These include laparoscopic, laparoscopic-assisted, or open total right mesocolon excision as right or transverse colon resection. The CME or D3 lymphadenectomy was defined as dissection of the Toldt's fascia space and a high (apical or central) ligation of the feeding vessels at their origin with the removal of draining lymph nodes along the superior mesenteric vein. Mobilization of the colon was performed according to the surgeon's preference (medial-to-lateral or lateral-to-medial approach). The anastomosis could be performed either intraperitoneally or extraperitoneally. The surgeons decided the type of surgery, and no preference criterion was employed for the method to be used for all non-randomized studies.

Outcomes measures: The outcomes evaluated in this systematic review and meta-analysis were operative time (skin to skin operative duration), blood loss, harvested lymph nodes number, mortality (rates of 30-day postoperative patient's death), overall morbidity (rates of 30-day postoperative surgical and medical complications), chyle leakage, anastomotic leakage, hospital stay, local recurrence, distant recurrence, 3-year disease-free survival, and 5-year disease-free survival.

Search methods for identification of studies

Electronics searches: An electronic search was performed to identify all published randomized controlled trials (RCTs) and controlled clinical trials (CCTs), with no language restrictions. We used a combination of terms related to "D3 lymphadenectomy" and "complete mesocolon excision" using a laparoscopic or open approach to the right or transverse cancer. We used a different combination of keywords. They were essentially: "complete mesocolon excision," "D3 lymphadenectomy," "extended lymphadenectomy techniques," "high-level vessel ligation," "cancer," "right colon," "ascending colon," "transverse colon," "surgery," "mini-invasive," "laparoscopy," "open," "colectomy," and "resection." These keywords were introduced in the following databases from their inception until January 31, 2019: Cochrane Library's Controlled Trials Registry and database of systematic review, United States National Library of Medicine, National Institutes of Health PubMed/MEDLINE, Excerpta Medica Database, Google Scholar, Web of Science Core collection, and SciELO.

We followed in this systematic review and meta-analysis the 2010 Preferred Reporting Items for Systematic review and Meta-analysis (PRISMA) guidelines [27].

Data collection and analysis

Study Selection: Two authors (MAC and MWD) independently reviewed all abstracts. They retrieved full text of all studies that met the inclusion criteria. Disagreements were resolved by discussion and consensus or after consulting a third member of the review team.

Assessment of studies quality: Two authors (MAC and MWD) evaluated the retrieved non-randomized trial according to the methodological index of non-randomized studies (MINORS) [28]. We scored all of the 12 methodological items for non-randomized comparative studies as follows: 0—not reported,1—reported but inadequate, or 2—reported and adequate. The global ideal score for comparative studies was 24. We have excluded one study after methodological indexing because the MINORS score was equal to 8 [29]. Two authors (MAC and MWD) assessed the quality of included studies.

Data Extraction: The following variables were extracted from the retained studies: country of origin, method of patients selection for OCME or LCME, study period, study design, age, sex, BMI, TNM stage, pathological type, adjuvant chemotherapy, follow-up, operative time, blood loss, chyle leakage, anastomotic leakage, mortality, morbidity, hospital stay, harvested lymph nodes number, local recurrence, distant recurrence, 3-year disease-free survival, and 5-year disease-free survival. In the case of propensity score-matched studies, we used only the data of patients retained after propensity score analysis.

A measure of effect size: We used the RevMan 5.3.5 statistical package from the Cochrane collaboration for meta-analysis [30]. We selected the mean difference (MD) as an effective measure for continuous data. For dichotomous variables, odds ratios (OR) with 95% confidence intervals (95% CI) were calculated. Random-effects model was used.

Assessment of heterogeneity: We used the Cochrane Chi-square test (Q test) to assess heterogeneity and the I^2 statistic to estimate the degree of heterogeneity [31]. I^2 between 0 and 40% was considered as a low level, between 30 and 60% as moderate level, between 50 and 90% as substantial level, and between 75 and 100% as high level of heterogeneity [32].

Results

Literature search results

We retrieved 21 relevant articles (Fig. 1). Of these, 10 studies published between 2010 and 2018 met eligibility criteria [17–25, 33]. Ten studies were excluded with reasons: two studies [26, 34] did not comply with CME or D3 lymphadenectomy technique, two studies [35, 36] concerned CME in transverse colon, five studies [6, 37–40] included CME for transverse and/or left colon cancer without subgroup analysis for right-sided colon cancer, and one study [29] excluded after quality assessment. No RCT found. Ten CCTs were identified [17–26]. They involved a total of 2778 patients who underwent LCME (n = 1407) or OCME (n = 1371). The quality assessment of the included studies is summarized in Table 1.

Fig. 1 PRISMA flowchart showing the screening process of retained articles

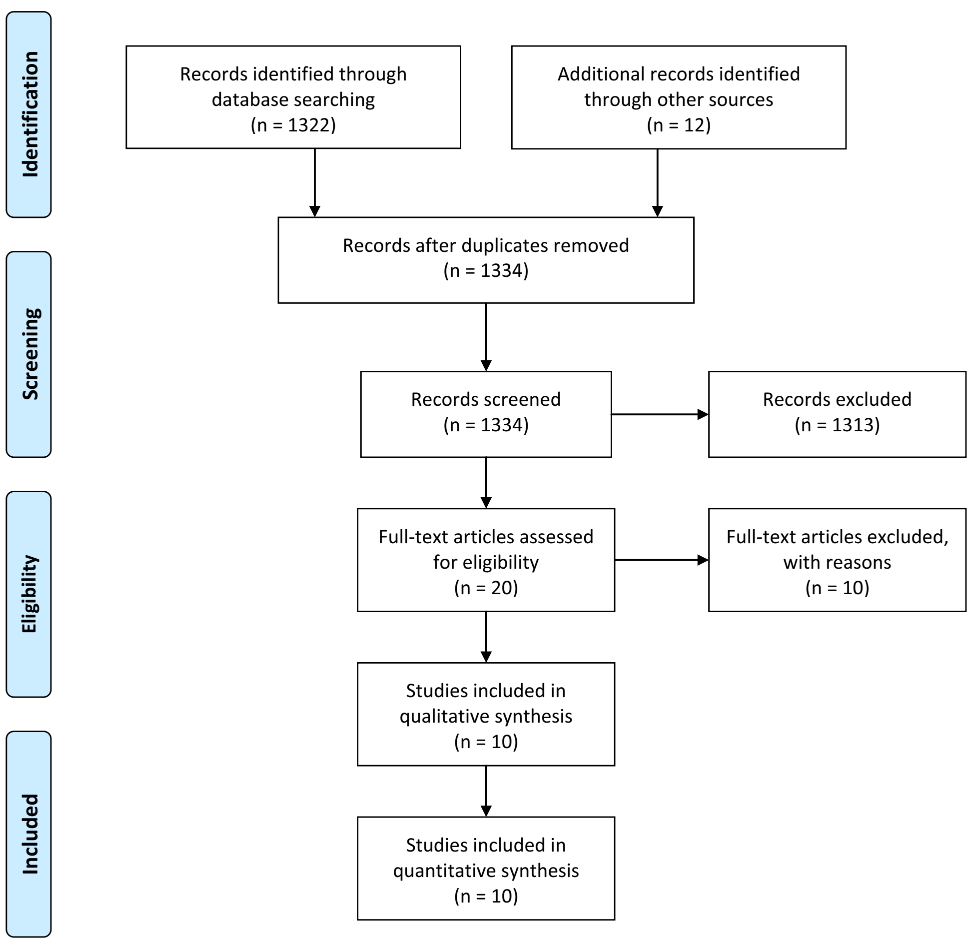

Table 1 Studies' details and quality assessment

First author	Country of origin	Year of publication	Study period	Study type and design	Number of patients (LCME/OCME)	LCME right/ transverse colon	OCME right/ transverse colon	Laparoscopic approach for LCME	Quality assessment
Kim [33]	South Korea	2016	2008–2013	Retrospective, single center	215 (116/99)	116/0	99/0	LAS	21/24
Huang [23]	China	2015	2012–2013	Retrospective, single center	102 (53/49)	53/0	49/0	LAS	18/24
Bae [18]	South Korea	2014	2006–2008	Retrospective, single center	170 (85/85)	73/12	76/9	LAS	20/24
Han [19]	China	2014	2003–2010	Retrospective, single center	324 (177/147)	177/0	147/0	LAS	20/24
Zhao [17]	China	2014	2000–2009	Retrospective, multicenter	220 (119/101)	89/30	65/36	LAS	18/24
Shin [24]	South Korea	2017	2000–2013	Prospective, single center	1366 (683/683)	683/0	683/0	LAS	22/24
Sheng [20]	China	2017	2012–2014	Retrospective, single center	150 (78/72)	78/0	72/0	HALS	19/24
Chen [22]	China	2017	2011–2012	Retrospective, multicenter	82 (27/55)	27/0	55/0	LAS	19/24
Li [21]	China	2018	2012–2015	Retrospective, single center	88 (40/48)	40/0	48/0	LAS	20/24
Guan [25]	China	2010	2006–2010	Retrospective, single center	61 (29/32)	29/0	32/0	LAS	18/24

LCME laparoscopic complete mesocolon excision, *OCME* open complete mesocolon excision, *L/O* laparoscopy/open groups, *NR* not reported, *LAS* laparoscopic-assisted surgery, *HALS* hand-assisted laparoscopic surgery

Studies and patients' characteristics

Details of the included studies are reported in Table 1. As concern patient selection for OCME or LCME, it was a patient's own preferences in six studies [17, 19-21, 23, 25], a surgeon's discretion in only one study [24], and not mentioned in three studies [18, 22, 33]. Data extracted from the ten studies were: age, gender, body mass index (BMI), laparoscopic approach for LCME, tumor size, histology, adjuvant chemotherapy, and mean follow-up [17–25, 33]. All these studies were from China and South Korea. Nine studies were published in English [17–24, 33], and one other study in Chinese [25]. Patient's characteristics are reported in Table 2.

Outcomes

Operative time Eight studies [17, 19-25] reported the operative time with 1206 patients in LCME and 1187 patients in the OCME group (Fig. 2a). There was a statistically significant longer operative time in LCME group (MD = −34.76, 95% CI [− 46.01 to − 23.50], $p < 0.00001$). There was a high heterogeneity between the studies ($I^2 = 89\%$).

Blood loss This criterion was reported in six studies [18–20, 22, 23, 25] including 449 patients in the LCME group and 440 patients in the OCME group (Fig. 2b). We found a statistically significant lower blood loss in LCME group (MD = 56.56, 95% CI 19.05 to 94.06, $p = 0.003$). There was a high heterogeneity between the studies ($I^2 = 94\%$).

Harvested lymph nodes number: The number of harvested lymph nodes was presented in eight studies [17, 19–25], with 1206 patients in the LCME group and 1187 patients in the OCME group (Fig. 2c). We found no statistically significant mean difference between LCME and OCME (MD = − 0.72, 95% CI − 2.26 to 0.83, $p = 0.36$). There was a high heterogeneity between the studies ($I^2 = 86\%$).

Mortality Seven studies [17–19, 21, 23, 24, 33] mentioned the postoperative mortality (Fig. 3a). It was evaluated during the first 30 postoperative days. It counted 9 out of 2485 patients. Two within 1273 patients in the LCME group versus 7 within 1212 patients in the OCME group. There was no significant difference in mortality between the two groups (OR = 2.70, 95% CI 0.75 to 9.67, $p = 0.13$).

Overall morbidity: Overall morbidity was reported in all retained studies [17–26] (Fig. 3b), including 2778 patients. Postoperative morbidity was reported in 217 out of 1407 patients in the LCME group versus 288 out of 1371 patients in the OCME group. We observed lower

Table 2 Patients' demographics and baseline clinical data were similar between the two groups

Studies	Age LCME/OCME	Gender (Male %) LCME/OCME	BMI (mean, kg/m2) LCME/OCME	Tumor size (mean, cm) LCME/OCME	Follow-up (months) LCME/OCME	Adjuvant chemotherapy (%) LCME/OCME	ASA score (%) LCME/OCME		Stage (TNM) (%) LCME/OCME	
Kim [33]	69/67	46.6/55.6	23.5/22.8	4.8/6.2	60/60	58.6/78.7	I	10.3/26.3	I	20.7/10.1
							II	78.4/49.5	II	41.4/40.4
							III	11.3/24.2	III	37.9/49.5
Huang [23]	56/55	60/57	NR	NR	NA	NR	I	NR	I	13.3/8.1
							II	NR	II	49/57.8
							III	NR	III	37.7/34.7
Bae [18]	64/65	53/55	22.8/22.7	4.5/5	58/61	81.8/75.3	I	71.8/69.4	I	8.2/9.4
							II	27.1/27.1	II	48.2/47.1
							III	1.2/2.4	III	43.5/43.5
Han [19]	67/65	46/54	NR	NR	54/54	II: 17.7, III: 82.8 / II: 16.2, III: 74.6	I	NR	I	13/13.6
							II	NR	II	54.2/46.3
							III	NR	III	32.8/40
Zhao [17]	61.3/64.5	55/56	22.3/22.6	4.8/4.7	30/27	NR	I	NR	I	5/6.9
							II	NR	II	52.9/53.5
							III	NR	III	42.0/39.6
Shin [24]	61/61	56.8/54.5	23.9/23.2	5/5.1	41/55.1	49.8/50.2	I, II	97.4, 2.6	I	19.9/16.8
							III, IV	96.8, 3.2	II	41/44.7
									III	39.2/38.5
Sheng [20]	61.1/62.4	55.1/55.5	21.7/21.7	NR	19.8/20	85.8/83.3	I	29/28	I	9/11
							II	35/32	II	35/30
							III	14/12	III	34/31
Chen [22]	73.5/75.1	66.7/61.8	23.7/25.1	NR	NA	55.5/58.1	I	14.8/14.6	I	11.1/12.7
							II	37/34.6	II	40.7/41.8
							III	48.2/50.2	III	48.1/45.5
Li [21]	59.5/60.8	55/47.9	NR	NR	NA	NR	I	NR	I	10/8.3
							II	NR	II	67.5/70.8
							III	NR	III	22.5/20.9

Table 2 continued

Studies	Age LCME/ OCME	Gender (Male %) LCME/ OCME	BMI (mean, kg/m2) LCME/ OCME	Tumor size (mean, cm) LCME/OCME	Follow-up (months) LCME/OCME	Adjuvant chemotherapy (%) LCME/OCME	ASA score (%) LCME/ OCME		Stage (TNM) (%) LCME/ OCME	
Guan [25]	60/61	62/62.5	NR	NR	NR	NR	I	NR	I	6.9/ 12.5
							II	NR	II	34.5/ 21.9
							III	NR	III	58.6/ 65.6

WD Well differentiated, *MD* moderately differentiated, *PD* poorly differentiated, *M* mucinous, *NA* not applicable, *NR* not reported; *LCME* laparoscopic complete mesocolon excision, *OCME* open complete mesocolon excision, *BMI* body mass index, *ASA* American Society of Anesthesiologists, *TNM* tumor, nodes and metastases

postoperative morbidity in LCME (OR = 1.48, 95% CI 1.21 to 1.80, $p = 0.0001$).

Chyle leakage: Five studies reported the chyle leakage rate [18–20, 22, 41] (Fig. 3c). This condition was reported in 30 patients: 22 out of 483 patients in the LCME group versus eight out of 458 patients in the OCME group. Chyle leakage was significantly less in OCME group (OR = 0.41, 95% CI 0.18 to 0.96, $p = 0.04$).

Anastomosis leakage: It was reported in eight studies [17–22, 24, 33] (Fig. 3d). These studies included 1325 in the LCME group and 1290 in the OCME group. Anastomosis leakage was reported in 18 out of 1325 patients in the LCME group versus 22 out of 1290 patients in the OCME group. There was no difference between the two groups (OR = 1.37, 95% CI: 0.73 to 2.60, $p = 0.33$).

Hospital stay: Eight studies reported the hospital stay [17–21, 23–25], with 1206 patients in the LCME group and 1187 patients in the OCME group (Fig. 3e). We found a statistically significant lower hospital stay in the laparoscopic group (MD = 2.18, 95% CI 0.54 to 3.83, $p = 0.009$). There was a higher heterogeneity between the studies ($I^2 = 98\%$).

Local recurrence: Seven studies including 2409 patients [18–20, 22–24, 26] reported the local recurrence rate (Fig. 4a). A local recurrence was reported in 70 patients: 20 out of 1219 patients in the LCME group versus 50 out of 1190 patients in the OCME group. There was a lower rate of local recurrence in the LCME group (OR = 2.12, 95% CI 1.09 to 4.12, $p = 0.03$).

Distant recurrence: Distant recurrence rate was reported in six studies [18–20, 22–24]. They included 1194 patients in the two groups (Fig. 4b). Distant recurrence was reported in 224 patients: 90 out of 1103 patients in the LCME group versus 134 out of 1091 patients in the OCME group. There was a lower rate of distant metastases in LCME group (OR = 1.63, 95% CI 1.23 to 2.16, $p = 0.0008$).

Three-year disease-free survival Three studies [17, 22, 26] including 517 patients reported the 3-year disease-free survival. There were 262 patients in the LCME group versus 197 patients in the OCME group (Fig. 4c). There was no statistically significant difference between the two procedures regarding 3-year disease-free survival (OR = 0.66, 95% CI 0.43 to 1.03, $p = 0.07$).

Five-year disease-free survival One study [18] had reported 5-year disease-free survival. It included 85 patients in the LCME group and 85 patients in the OCME group. The 5-year disease-free survival rates were 83.3% and 78.8%, respectively. This difference was not statistically significant ($p = 0.578$).

Discussion

This meta-analysis, included 2778 patients, comparing LCME to OCME proves that LCME improves results in terms of overall morbidity, blood loss, hospital stay, and local and distant recurrence. There is no significant difference regarding mortality, anastomosis leakage, number of harvested lymph nodes, and 3-year disease-free survival. The open approach was significantly better than laparoscopy in terms of operative time and chyle leakage.

Several minimally invasive techniques in colorectal surgery were recognized as safe and feasible [42]. They included total laparoscopic surgery, single port, laparoscopic-assisted surgery (LAS), hand-assisted laparoscopic surgery (HALS), and robotic surgery. In this systematic review, LAS was used in nine studies and HALS in only one study. Currently, CME presents the standard surgical treatment [43]. CME in right colectomy is based on

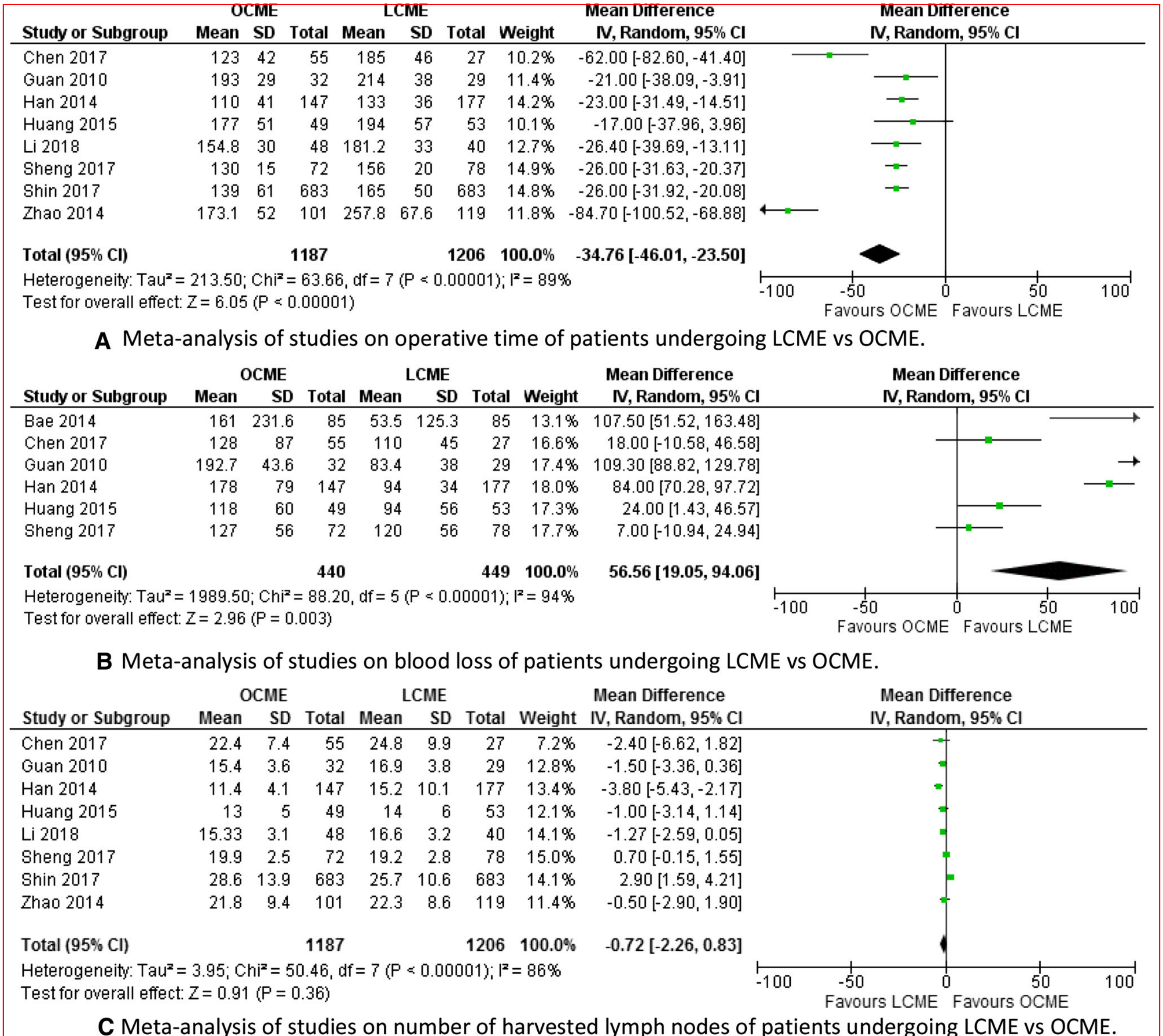

Fig. 2 Forrest plot comparing intraoperative outcomes of LCME versus OCME: **a** operative time, **b** blood loss, **c** number of harvested nodes

embryological concept. It consists of a sharp separation of the visceral and parietal fascia. It is superior to classic colon surgery in terms of oncological outcomes [3, 4, 12]. Open or laparoscopic approach could be used [3, 11, 12]. The CME technique has a variety of different definitions. Hohenberger et al. [4] had well described the OCME and central ligation. In the case of cecum or ascending colonic cancer, the ileocolic vessels, right colic vessels, and right branches of the middle colonic vessels were divided centrally. In the case of transverse colon cancer, a central ligation of the middle colic vessels will be performed considering the variations that may be found. According to the additional pattern of lymphatic spread, central tie of gastroepiploic vessels may be needed. Others authors had made slight modifications: the timing of duodenal Kocher maneuver [44, 45] and removal of sub-pyloric lymph nodes, over the pancreatic head and along the left gastroepiploic arcade lymph nodes removal [8, 45]. It remains difficult to ascertain that the full procedure as described by Hohenberger et al. [4] has been performed in all the retained studies. As concern LCME, it was detailed by several authors [46–48]. In the included studies in this meta-analysis, the modified CME (mCME) with central vascular ligation reported by Shin et al. [24] is a mix of principles described by Hohenberger et al. [4], Bokey et al. [44], and the recommendations made by the Japanese

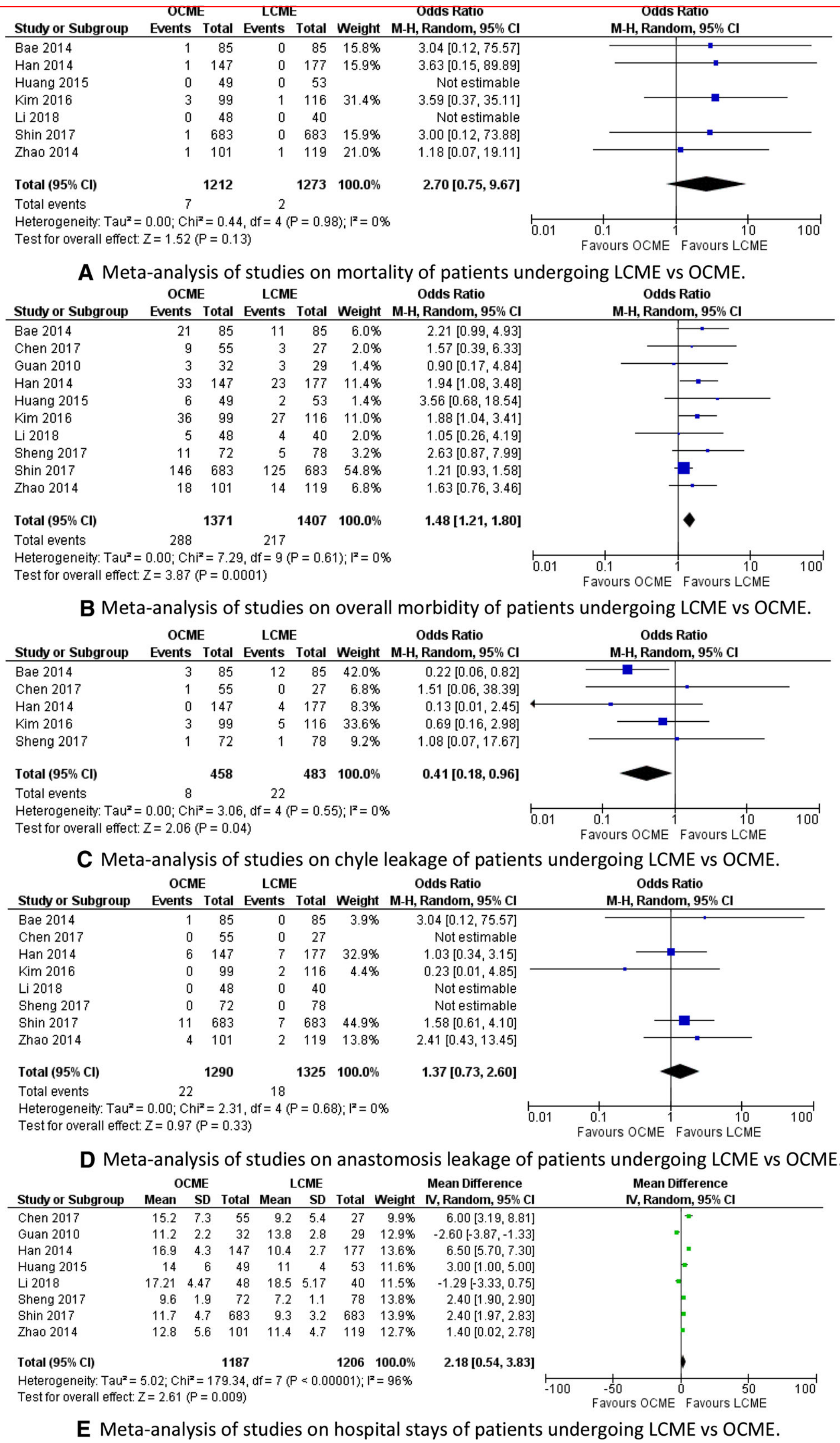

Fig. 3 Forrest plot comparing postoperative outcomes of LCME versus OCME: **a** mortality, **b** overall morbidity, **c** chyle leakage, **d** anastomosis leakage, **e** hospital stay

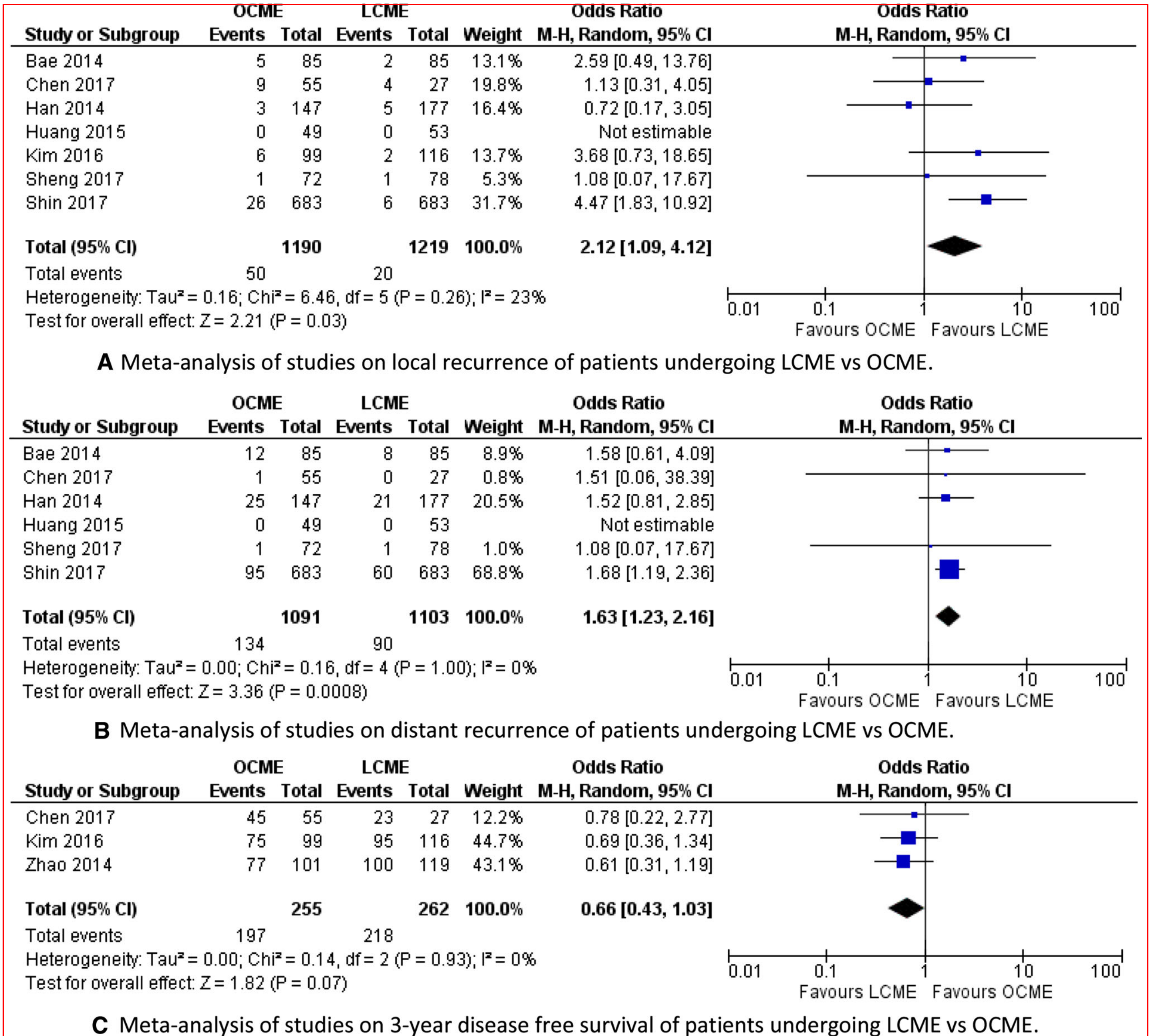

Fig. 4 Forrest plot comparing oncological outcomes of LCME versus OCME: **a** local recurrence, **b** distant recurrence, **c** 3-year disease-free survival

guidelines [49]. This mCME is performed without the Kocher maneuver and generalized ligation of middle colonic vessels and gastroepiploic vessels. However, all these technical changes seem to not affect the radical excision principles and the cornerstones were suturing point, ensuring a central vascular ligation and order of dissection [4, 50–53]. There is a growing literature comparing LCME and OCME [5, 11, 17–23, 37], especially in Asian countries. Patients included in these studies were from Eastern populations with a low median BMI. This condition could affect the feasibility of these studies in Western societies because CME in case of patients with a high BMI level requires more training and longer learning curve. Zou et al. [54] suggested that the lateral-to-medial approach may be a safe alternative to the conventional medial-to-lateral approach, especially for inexperienced surgeons in obese patients with thick mesentery. The main advantages of this approach were easy to access to the retroperitoneal space by the protection of the ureter, vessels, and a potentially shortened learning curve. Several papers have looked at the influence of obesity on the outcome of colectomy, but few have specifically concerned LCME [55]. In addition, a systematic review and meta-analysis of Fung et al. [56] found that colorectal laparoscopic surgery in obese was correlated to a higher morbidity rate and conversion compared to non-obese patients. For that, HALS should have special attention. It could help to promote surgical education and to disseminate LCME worldwide. HALS associates the features of LAS and open surgery. It facilitates laparoscopic surgery, reduces operative time, shortens the learning curve, improves safety, and allow accurate digital dissection of operative specimens [20, 57].

Our meta-analysis showed that was no difference in terms of postoperative mortality with lower postoperative morbidity. LCME offers the same quality of the resected specimen as OCME. There is no significant difference in the "number of harvested lymph nodes" and "anastomosis leakage." These findings suggest that specimens from LCME and OCME are comparable in terms of oncological clearance and vascular adequacy. Only two studies, Sheng et al. [20] and Shin et al. [24], reported a lower number of harvested lymph nodes in LCME group. This difference is statistically significant only in the study of Shin et al.[24]. Concerning the anastomosis leakage, there are only two studies [19, 26] that report a higher rate of anastomosis leakage in LCME group with no statistical difference.

Regarding intraoperative blood loss, all the retained studies [17–25, 33] showed a significantly lower blood loss in LCME group. The high heterogeneity level among the studies can be explained by operator-dependent quantification.

All included studies [17–25, 33] concluded that the operative time was significantly longer in the LCME group. This conclusion is consistent with laparoscopic colorectal surgery [58]. However, these results can be partly due to the type of anastomosis. In addition, the duration of the LCME learning curve was not mentioned.

Postoperative recovery was significantly better after LCME in terms of hospital stay. Only two studies out of eight studies, Guan et al. [25] and Li et al.[21], reported a longer hospital stay in LCME group (13.8 vs. 11.2 days) and (18.5 vs. 17.2 days), respectively. This difference was not statistically significant. There was a high level of heterogeneity among the studies according to this outcome. This could be due to the absence of discharge criteria, postoperative nutritional details, and doubt in enhanced recovery protocols. This may alter the postoperative recovery evaluation.

Recurrence and long-term survival play an important role in choosing the best operative approach for right-sided colon cancer. Oncological outcomes were significantly better after LCME in terms of local and distant recurrence and similar in terms of 3-year disease-free survival. However, it must be indicated that this difference is based on the results of only three studies [17, 22, 26]. Thus, it should be verified by RCT with a large patient number. It remains difficult to compare directly the oncological outcomes using a retrospective cohort analysis.

Our study presented several limitations that must be considered. We have tried to standardize, but outcome measures were not well-defined. A limited number of studies with comparable outcomes were considered. It is not possible to match all patient groups for tumor grade, stage, and adjuvant chemotherapy, due to the fact that all of these factors can affect oncological outcomes. There are no RCTs comparing LCME to OCME for right-sided colon cancer. This systematic review and meta-analysis included only CCTs, increasing the risk of selection bias. It included two observational studies with propensity matching and eight retrospective comparative studies. Cameron et al. [59] also emphasized that "including low-quality, non-randomized comparative cohort studies could perpetuate the biases that are unknown, unmeasured, or uncontrolled." We cannot eliminate unknown confounders that might have skewed the results of mixing observational propensity-matched with retrospective unmatched comparative studies in our analysis,therefore, no causality can be inferred. Additionally, the retained studies were rigorously assessed and scored using the methodological index of non-randomized studies (MINORS) methods for bias assessment [28].

In conclusion, in the absence of RCTs, this comprehensive meta-analysis of the available evidence suggests that LCME in right colon cancer surgery is superior to OCME in terms of overall morbidity, blood loss, hospital stay, and local and distant recurrence. The overall level of evidence of our systematic review is 2a with a grade B of recommendation [60].

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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