Systematic Review

Comparison of Laparoscopic and Robotic Lateral Lymph Node Dissection for Rectal Cancer: A Systematic Review and Meta-analysis of Short- and Long-term Outcomes

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Fabio Rondelli[1,2], Alessio Lucarini[3], Giovanni Maria Garbarino[4], Graziano Ceccarelli[2], Valentina Tassi[5], Gioia Brachini[6], Edoardo Maria Muttillo[3], Leonardo Di Cicco[3], Francesco Saverio Li Causi[3], Alice Ceccacci[3], Paolo Mercantini[3], Gianluca Costa[7,8]

[1]Department of Surgical and Biomedical Sciences, School of Medicine, University of Perugia, 06100 Perugia, Italy
[2]Department of General Surgery, San Giovanni Battista Hospital, USL Umbria 2, 06034 Foligno, Perugia, Italy
[3]Surgical and Medical Department of Translational Medicine, Sant'Andrea Hospital, Sapienza University of Rome, 00189 Rome, Italy
[4]Upper Gastrointestinal Surgery Unit, IRCCS Humanitas Research Hospital, 20089 Rozzano, Milan, Italy
[5]Thoracic Surgery Unit, Santa Maria Hospital, 05100 Terni, Italy
[6]Emergency Department, Policlinico Umberto I, Sapienza University, 00161 Rome, Italy
[7]Surgery Center, Colorectal Surgery Research Unit, Fondazione Policlinico Universitario Campus Bio-Medico, University Campus Bio-Medico of Rome, 00128 Rome, Italy
[8]General Surgery, Department of Life Sciences, Health, and Health Professions, Link Campus University, 00165 Rome, Italy

AIM: The importance of lateral lymph node dissection (LLND) for advanced low rectal cancer is still questioned, but selected patients might benefit from this procedure. The purpose of this study was to compare robotic LLND (R-LLND) versus laparoscopic LLND (L-LLND) to identify the safety, feasibility, and advantages of R-LLND.
METHODS: PubMed, Scopus, and Cochrane databases were searched for studies assessing the benefit of R-LLND over L-LLND. Pooled odds ratios (OR) and weighted mean difference (WMD) were obtained using models with random effects. The risk of bias was evaluated with the Newcastle-Ottawa scale.
RESULTS: Six studies were included in our analysis for a total of 652 patients (316 robotic and 336 laparoscopic). The R-LLND group had a longer operative time (WMD 60.46, $p = 0.02$) and less blood loss (WMD –22.33, $p = 0.01$). Differences were found in the postoperative length of stays (7 days $\pm$ 1.2 and 14 $\pm$ 5.2 versus 7 days $\pm$ 0.3 and 16 $\pm$ 18.5, WMD –1.30, $p = 0.03$) and in the mean time to regular diet (3 days $\pm$ 0.5 and 5 $\pm$ 2.3 versus 3 days $\pm$ 1.2 and 6 $\pm$ 3.8, WMD –0.60 $p = 0.01$); a slightly higher number of harvested lateral lymph nodes was present in the L-LLND group (WMD 1.23, $p = 0.02$).
CONCLUSIONS: Our work demonstrates a slight benefit from the robotic approach when performing LLND in terms of intra- and peri-operative outcomes, despite not reaching statistical significance a trend in favor of robotic surgery is evident in almost all the analyzed topic.

Keywords: lateral lymph nodes; rectal cancer; colorectal surgery; robotic; lymphadenectomy

Introduction

With the widespread implementation of neoadjuvant chemoradiotherapy (nCRT) and Total Neoadjuvant Therapy (TNT) before Total Mesorectal Excision (TME) in the treatment of locally advanced rectal cancer (LARC), the rate of local recurrence has drastically decreased over the years [1–4]. In distal rectal cancer, the involvement of iliac and obturatory lymph nodes (usually referred to as lateral lymph nodes) is considered a regional disease. However, the role of lateral lymph node metastasis (LLNM) has been questioned as a probable cause of early locoregional recurrence [5,6]. In a recent study, lateral lymph node dissection (LLND) of magnetic resonance imaging (MRI)-positive lymph nodes has been correlated to a reduction of 5-year locoregional recurrence, from 19.5% to 5.7% [7].

As for gastric cancer [8], a trend of "east versus west" is present in the current guidelines [9]. Due to high operative morbidity in Western countries, LLND never gained consent [10,11]. The introduction of preoperative chemoradiation and widespread TNT, associated with TME, lead to a subsequent reduction of local recurrence, decreasing the interest of LLND. On the other hand, in eastern countries, TME and lateral lymph node dissection are proposed to treat LLNM and improve disease-free survival (DFS) [12]. A recent collaborative study showed that combining LLND +

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Correspondence to: Alessio Lucarini, Surgical and Medical Department of Translational Medicine, Sant'Andrea Hospital, Sapienza University of Rome, 00189 Rome, Italy (e-mail: alessio.lucarini@uniroma1.it).

TME decreases local recurrence in patients with suspected lymph node metastasis even after nCRT [13]. Therefore, LLND has regained interest in the treatment of suspected LLNM both in Western and Eastern countries.

Over the years, a laparoscopic approach to LLND (L-LLND) has been proposed for its advantage over open surgery in terms of length of stay, blood loss, and sexual and urinary dysfunction [13–15]. Yet, it is a demanding procedure requiring advanced skills and the necessity to operate in a narrow space full of vital structures, often dealing with oedematous, fibrous, and/or distorted planes.

Laparoscopic low anterior resection (LAR) still has some technical constraints, such as limited dexterity with unstable instruments, unnatural hand-eye coordination, and the necessity of an expert camera assistant, all factors that could hamper a fine and stable dissection of the TME plane [16]. Since its introduction back in the late 2000s, robotic surgery has rapidly gained popularity in the surgical management of rectal cancer. Over the years, many retrospective studies have demonstrated that robotic surgery might provide technical advantages over standard laparoscopy (increased movement freedom thanks to the EndoWrist® technology, enhanced dexterity, and 3D vision), which are all ideal for complex procedures in narrow spaces. These results are confirmed (with some reserves) by several recent randomized controlled trials [17–19].

Several recent retrospective papers have been rolling out on the role of robotic (R-LLND) versus laparoscopic LLND, with debated results [20–25]. This metanalysis aims to assess whether there is a benefit of R-LLND over L-LLND in terms of short and long-term outcomes.

Materials and Methods

Literature Search

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines for conducting and reporting systematic reviews were followed **(Supplementary Material)** [26]. A systematic literature search was performed independently by 2 of the authors (AL and GMG) through PubMed, Scopus, and Cochrane databases. The search was limited to human studies and those reported in the English language. The period included in our search was from 1 January 2020 to 1 January 2024. The search strategy was based on different combinations of words for each database. For the PubMed database, the following combination was used: ("Rectal Neoplasms" [Mesh] AND robot* [tiab] AND lapar* [tiab] AND latera* [tiab]). The same keywords were inserted into the search manager fields of the other databases. Extensive cross-checking of the reference lists of all retrieved articles that fulfilled the inclusion criteria further broadened the search.

Study Selection

The same two authors independently screened the titles and abstracts of the studies that were identified in the database search through the online data extraction tool Covidence® (https://www.covidence.org/). Duplicate studies were automatically excluded. The following criteria were set for inclusion: all kinds of studies (randomized controlled trials, retrospective, prospective, etc.), including a comparative analysis of patients undergoing laparoscopic or robotic LLND for rectal cancer, results published in the English language between 1 January 2020 and 1 January 2024. The following exclusion criteria were set: case reports and case series, non-comparative studies, and patients undergoing LLND not for rectal cancer.

Population, Intervention, Comparison, Outcomes (PICO) criteria [27] were as follows: (1) Population: patients included in comparative studies undergoing a TME with L- or R-LLND for rectal cancer; (2) Intervention: robotic approach; (3) Control: laparoscopic approach; (4) Outcome: intra- and postoperative outcomes.

Data Extraction

One of the authors (AL) extracted the data as follows: first author, year of publication, type of study, and country of origin. Two authors (AL and GMG) then proceeded with data extraction on Covidence® retrieving data as follows: study design, period of study, number of participants, age, gender, American Society of Anesthesiologist (ASA) score, body mass index (BMI), operative time, blood loss, transfusion, laparotomic conversions, number of uni- and bi-lateral lymph node retrieved, total number of retrieved lymph nodes, length of stay, time to oral feeding, rate of AL graded according to the International Study Group of Rectal [28], stoma rate, wound infection, postoperative hemorrhage, mortality, distant, local and overall disease recurrence. All relevant tables and figures were reviewed for data extraction. Whenever discrepancies between the two reviewers were found, a third author (GiC) was consulted.

Risk of Bias

Methodological quality and risk of bias for each study were assessed using the Newcastle-Ottawa quality assessment scale for case-control study by two authors (AL and GMG) [29]. Whenever discrepancies between the two reviewers were found, a third author (GiC) was consulted.

Statistical Analysis

Continuous variables were analyzed by the weighted mean difference (WMD) and 95% confidence interval (CI). Categorical variables were evaluated using the odds ratios (OR) and 95% CI. When variables were reported in the papers as median and range or interquartile range, they were converted to mean and standard deviation (SD) according to Hozo *et al*. [30]. Pooled relative risk (RR) was obtained using models with random effects. The degrees of heterogeneity between the studies were assessed by the I^2 value. We considered an I^2 value of 40% or lower as trivial or not important heterogeneity and an I^2 value of 75% or higher

Table 1. Characteristics of the included studies.

Study	Country and year	Period of study	Type of study	No. of patients	R-LLND/ L-LLND	Newcastle-Ottawa scale
Ishizaki *et al.* [21]	Japan 2023	Jan 2013–Jan 2022	Monocentric, retrospective	60	27/33	8/8
Morohashi *et al.* [23]	Japan 2021	Nov 2014–Aug 2020	Monocentric, retrospective	95	40/55	8/8
Zhang *et al.* [25]	China 2023	Jan 2015–Apr 2021	Multicentric, retrospective	205	95/110	8/8
Kim *et al.* [22]	South Korea 2018	May 2006–Dec 2014	Monocentric, prospective	85	50/35	8/8
Song *et al.* [24]	South Korea 2021	Mar 2006–Jun 2016	Monocentric, retrospective	99	70/29	8/8
Bae *et al.* [20]	South Korea 2023	Jan 2015–Dec 2021	Multicentric, retrospective	108	34/74	8/8

LLND, lateral lymph node dissection; R-LLND, robotic LLND; L-LLND, laparoscopic LLND.

Table 2. Newcastle-Ottawa scale assessment of the included studies.

Study	S-D1	S-D2	S-D3	S-D4	C-D5	O-D6	O-D7	O-D8
Ishizaki *et al.* [21]	*	*	*	*	*	*	*	*
Morohashi *et al.* [23]	*	*	*	*	*	*	*	*
Zhang *et al.* [25]	*	*	*	*	*	*	*	*
Kim *et al.* [22]	*	*	*	*	*	*	*	*
Song *et al.* [24]	*	*	*	*	*	*	*	*
Bae *et al.* [20]	*	*	*	*	*	*	*	*

S, Selection; C, Comparability; O, Outcomes.

as considerable heterogeneity. A conventional level of $p < 0.05$ was accepted as statistically significant. A funnel plot will be omitted if fewer than ten studies will be included due to statistical inconsistency. Statistical analysis was carried out using Jamovi v 2.5 (The Jamovi project, Sydney, Australia).

Results

The literature search yielded 52 papers on PubMed and 165 on SCOPUS, for a total of 217 papers. After duplicate removal, a total of 111 papers were screened. After title and abstract screening, 36 papers were deemed not relevant to the purpose of the study. A total of 75 papers underwent a full-text screening; 69 were excluded for the following reasons: 28 studies did not match the inclusion criteria, 23 studies did not match the study design purposes, and 18 were only abstracts, posters, reviews, and letters to the editor.

Finally, a total of 6 studies reporting the outcomes of 652 patients were included in this review [20–25]. PRISMA flowchart is reported in Fig. 1. The articles were published between May 2018 and May 2023, data are reported in Table 1 (Ref. [20–25]).

The studies retrieved were conducted in Japan, China, and South Korea [20–25].

The Newcastle-Ottawa quality assessment scale is reported in Tables 1,2 (Ref. [20–25]).

Preoperative Data

A total of 652 patients underwent an LLND, 316 robotic and 336 laparoscopic. The mean age ranged between 57 years $\pm$ 12.4 and 63 $\pm$ 9.5 in the robotic group versus 58.3 years $\pm$ 11.6 and 63 $\pm$ 11.7 in the laparoscopic group. The mean BMI ranged between 21.1 kg/m^2 $\pm$ 3.7 and 23.4 $\pm$ 2.7 in the robotic group versus 22.3 kg/m^2 $\pm$ 3.3 and 23.8 $\pm$ 3.6 in the laparoscopic group. A total of 201 males (63.6%) and 115 females (36.4%) were present in the robotic group versus 232 males (69%) and 104 females (31%) in the laparoscopic group. A neoadjuvant treatment was performed in 228 (72.2%) and 222 (66.1%) patients in the robotic and laparoscopic groups, respectively. Patients were classified American Society of Anesthesiologist (ASA) $\geq$3 in 24 (8.7%) and 25 (8.9%) cases in the robotic and laparoscopic groups, respectively.

All results are reported in Table 3 (Ref. [20–25]).

Intraoperative Data

The mean operative time ranged between 255 minutes $\pm$ 43.3 and 507 $\pm$ 123.2 minutes for the robotic group versus 220 $\pm$ 65 and 345 $\pm$ 94.8 for the laparoscopic group (WMD 60.46, 95% CI 10.12–110.80, p = 0.02).

The mean intraoperative blood loss ranged between 50 mL $\pm$ 12.5 and 113 $\pm$ 171.2 in the robotic group versus 70 $\pm$ 12.5 and 153 $\pm$ 208.7 in the laparoscopic group (WMD –22.33, 95% CI –39.57 – –5.09, p = 0.01). A total of 7 (4.3%) versus 2 (1.7%) red blood cell transfusions were needed in the robotic and laparoscopic groups, respectively (OR 0.59, 95% CI –0.71 – 1.89, p = 0.37). Zero conversions were reported in the robotic group, while only 2 (0.9%) were reported in the laparoscopic group (OR –0.51, 95% CI –2.12 – 1.11, p = 0.53). A total of 179 unilateral LLND (61.9%) and 110 bilateral LLND (38.1%) versus 189 unilateral LLND (62.4%) and 114 bilateral LLND (37.6%) were performed in the robotic and laparoscopic groups, respectively.

All results are reported in Table 4 (Ref. [20–25]) and Fig. 2.

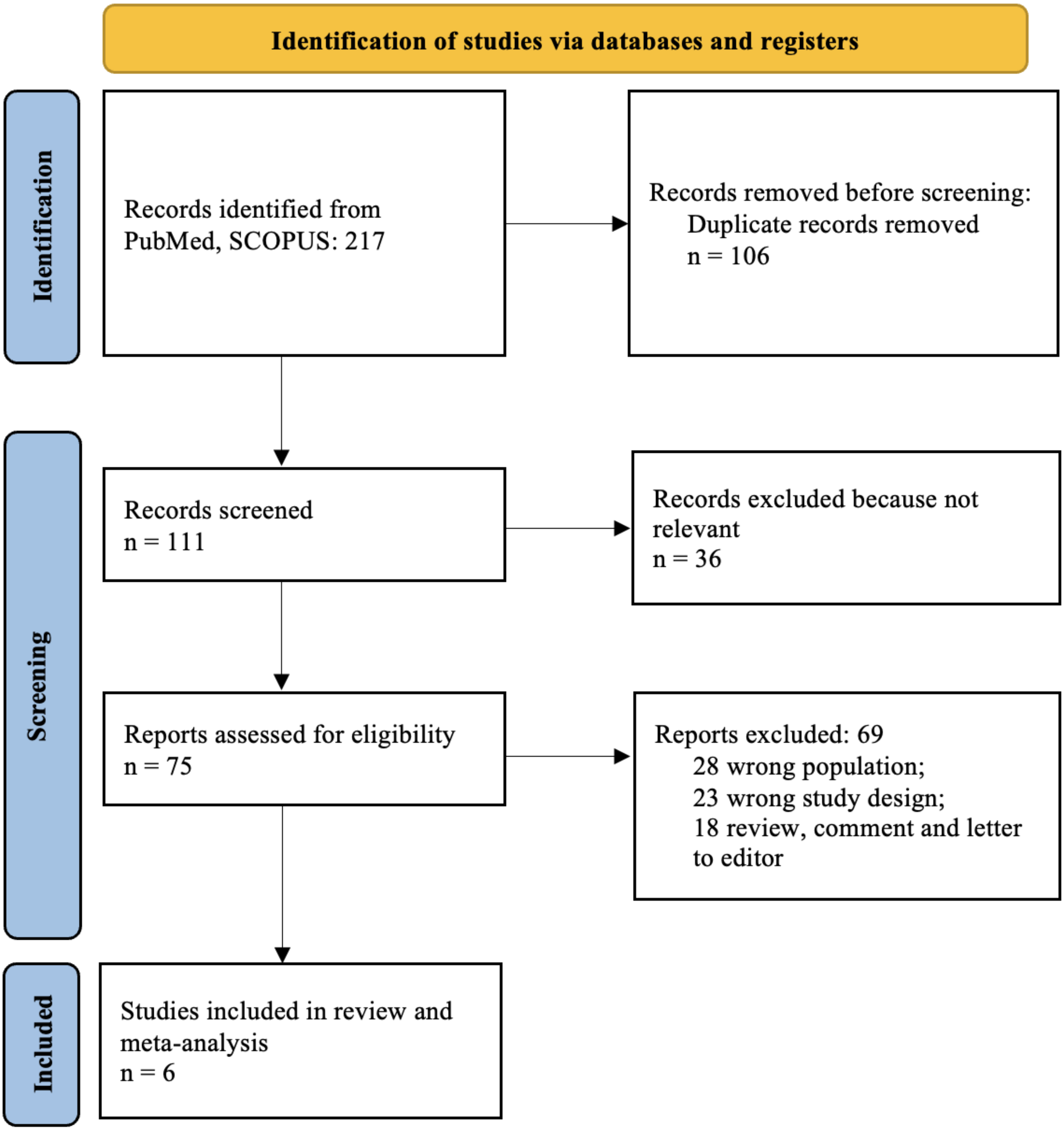

Fig. 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flowchart.

Postoperative Data

The mean length of stay (LOS) ranged between 7 days ± 1.2 and 14 ± 5.2 versus 7 days ± 0.3 and 16 ± 18.5 in the robotic and laparoscopic group, respectively (WMD –1.30, 95% CI –2.45 – –0.15, p = 0.03). The mean time to regular diet ranged between 3 days ± 0.5 and 5 ± 2.3 versus 3 days ± 1.2 and 6 ± 3.8 in the robotic and laparoscopic group, respectively (WMD –0.60, 95% CI –1.07 – –0.12, p = 0.01). Anastomotic leakage occurred in 16 (5.1%) and 27 (8%) in the robotic and laparoscopic groups, respectively (OR –0.31, 95% CI –1.06 – 0.44, p = 0.41). Post-operative bleeding occurred in 4 (1.3%) and 6 (1.8%) in the robotic and laparoscopic groups, respectively (OR –0.18, 95% CI –1.40 – 1.05, p = 0.78). Wound infection occurred in 10 (3%) and 14 (4.2%) in the robotic and laparoscopic groups, respectively (OR –0.09, 95% CI –0.93 – 0.75, p = 0.83). All results are reported in Table 5 (Ref. [20–25]) and Fig. 3.

Oncological Outcomes

The mean number of lateral lymph nodes dissected in the robotic group ranged between 6 ± 1.7 and 19 ± 13.2, while

Table 3. Characteristic of the included patients.

Study	Age (years)	Sex (M-F)	ASA score (>3)	BMI (kg/m^2)	NA-CHT/RT
Ishizaki *et al.* [21]	61 ± 9.5	20-7	0	21.1 ± 3.7	27/33
(R-LLND/L-LLND)	59 ± 14.2	22-11	1	22.8 ± 3.8	
Morohashi *et al.* [23]	63 ± 9.5	31-9	NA	22.8 ± 3.8	32/43
(R-LLND/L-LLND)	63 ± 11.7	41-14		22.3 ± 3.3	
Zhang *et al.* [25]	60.4 ± 12.5	54-41	13	22.4 ± 3.5	37/44
(R-LLND/L-LLND)	58.3 ± 11.6	74-36	21	23.8 ± 3.6	
Kim *et al.* [22]	57 ± 12.4	29-21	4	23.4 ± 2.7	41/24
(R-LLND/L-LLND)	60.1 ± 12.3	21-14	2	23 ± 2.9	
Song *et al.* [24]	57.5 ± 12.5	46-24	4	22.7 ± 1.1	61/24
(R-LLND/L-LLND)	60 ± 11.5	24-5	1	22.8 ± 1.1	
Bae *et al.* [20]	60 ± 3.2	21-13	2	NA	30/54
(R-LLND/L-LLND)	63 ± 2.8	50-24	1		

NA, Not Available; BMI, body mass index; NA-CHT/RT, neoadjuvant chemo hormone therapy/radiation therapy; ASA, American Society of Anesthesiologist; M, male; F, female.

Table 4. Intraoperative data.

Study	Operative time (min)	Blood loss (mL)	PRBC (unit)	Conversion	Unilateral LLND	Bilateral LLND
Ishizaki *et al.* [21]	NA	113 ± 171.2	0/0	0/1	NA	NA
(R-LLND/L-LLND)		153 ± 208.7				
Morohashi *et al.* [23]	507 ± 123.2	60 ± 220	1/0	0/1	7/0	33/55
(R-LLND/L-LLND)	345 ± 94.8	80 ± 187.5				
Zhang *et al.* [25]	255 ± 43.3	80 ± 63.3	NA	NA	48/67	47/43
(R-LLND/L-LLND)	220 ± 65	110 ± 81.7				
Kim *et al.* [22]	260.3 ± 75.9	81.9 ± 75.7	4/2	0/0	40/29	10/6
(R-LLND/L-LLND)	254 ± 92.2	135.4 ± 77.4				
Song *et al.* [24]	260 ± 25	50 ± 12.5	2/0	0/0	54/25	16/4
(R-LLND/L-LLND)	230 ± 27.5	70 ± 12.5				
Bae *et al.* [20]	353 ± 40.5	100 ± 37.5	NA	0/0	30/68	4/6
(R-LLND/L-LLND)	275 ± 19.5	100 ± 11.7				

PRBC, Packed Red Blood Cells.

in the laparoscopic group, the range was between 5 ± 0.8 and 15 ± 13.2 (WMD 1.23, 95% CI 0.2 – 2.25, p = 0.02). The mean number of total lymph nodes dissected (TME + LLND) in the robotic group ranged between 16.3 ± 8.3 and 38 ± 17.7, while in the laparoscopic group, the range was between 18.1 ± 9.7 and 34 ± 21.7 (WMD –1.44, 95% CI –4.22 – 1.35, p = 0.3).

The long-term outcomes were reported only in two studies [22,24]. The reported overall recurrence was 37 (30.8%) versus 25 (39.1%) in the robotic and laparoscopic groups, respectively. The reported local recurrence was 11 (9.2%) versus 6 (9.4%) in the robotic and laparoscopic groups, respectively. The reported distant recurrence was 30 (25%) versus 20 (31.3%) in the robotic and laparoscopic groups, respectively. The mean follow-up ranged between 22.1 (5–50) and 44.6 months versus 28.3 (6–60) and 39.8 months in the robotic and laparoscopic groups, respectively.

All results are reported in Table 6 (Ref. [20–25]) and Fig. 4.

Discussion

In this systematic review and meta-analysis, we investigate the potential benefit of a robotic approach over laparoscopy when performing an LLND during TME for rectal cancer. Our meta-analysis suggests that the robotic approach might bring some benefits in terms of blood loss, conversion to laparotomy, length of stay, time to regular diet, and lateral and total lymph nodes harvested. Thus, the robotic platform might play a major role in overcoming the difficulties and the burden of this complex surgical procedure.

In the current literature, no randomized controlled trials are present on this topic. Therefore, the quality of evidence is very low, and no pooled analyses are available to the best of our knowledge.

In our meta-analysis, we included only six studies [20–25] four monocentric and two multicentric, five retrospective studies, and one prospective. The quality of evidence was graded 8 out of 8 according to the Newcastle-Ottawa scale, but all the included studies are retrospective, and therefore, major concerns must be raised before drawing any definitive conclusion. Despite this limit, all papers included in

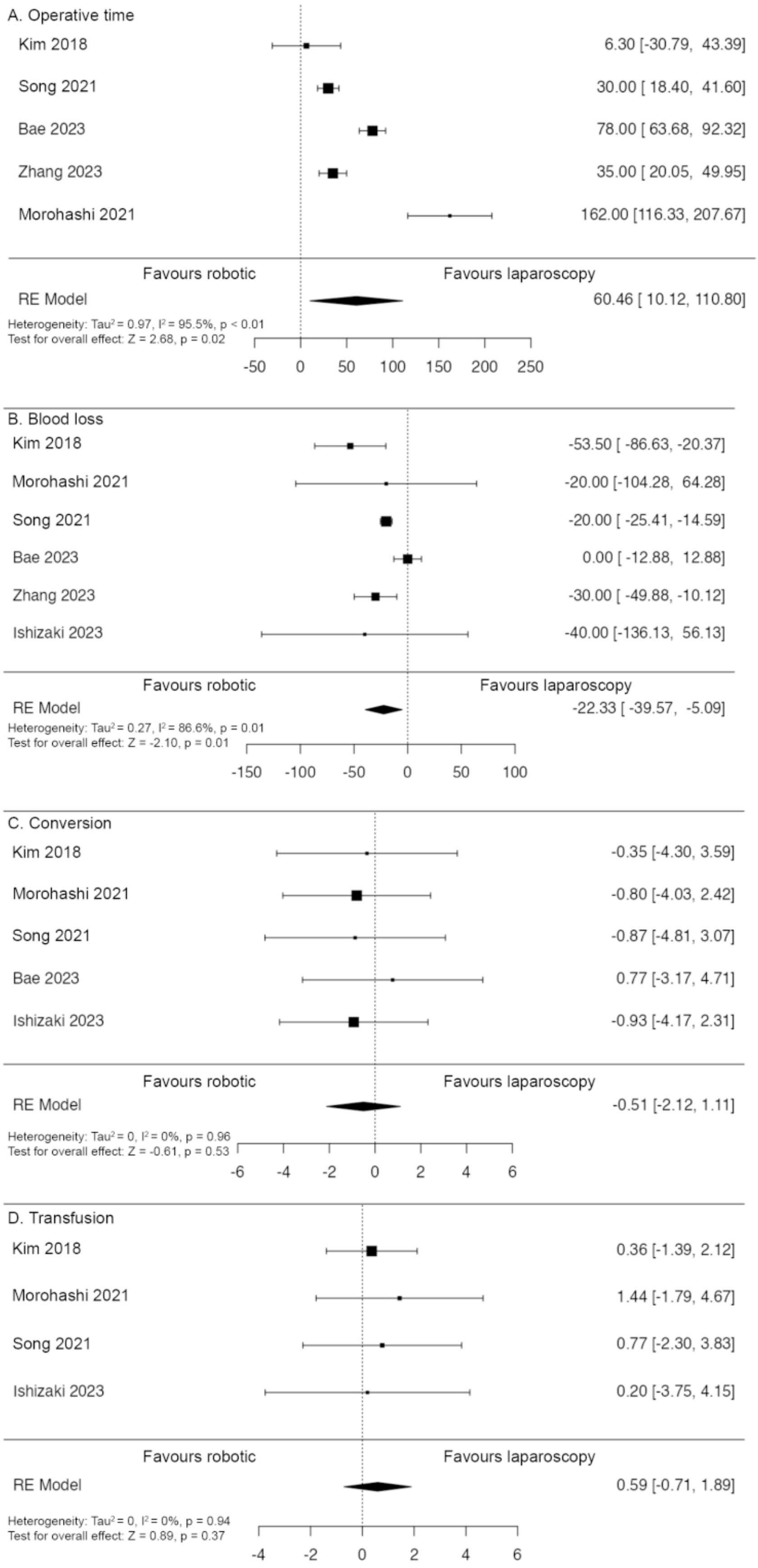

Fig. 2. Forest plot of intraoperative data. (A) Operative time. (B) Blood loss. (C) Conversion. (D) Transfusion. RE, Random Effect.

Table 5. Postoperative data.

Study	Length of stay (days)	Time to regular diet (days)	Anastomotic leakage	Postoperative bleeding	Wound infection
Ishizaki *et al.* [21] (R-LLND/L-LLND)	14 ± 3.7 15 ± 8.5	3 ± 1 3 ± 1.2	1/5	0/0	2/3
Morohashi *et al.* [23] (R-LLND/L-LLND)	14 ± 5.2 16 ± 18.5	3 ± 1 3 ± 3.2	1/7	0/0	2/3
Zhang *et al.* [25] (R-LLND/L-LLND)	9 ± 3.7 11 ± 8.8	5 ± 2.3 6 ± 3.8	1/3	2/1	2/2
Kim *et al.* [22] (R-LLND/L-LLND)	10.2 ± 8.1 14.3 ± 21.7	3.6 ± 2.2 4.4 ± 1.6	4/3	1/1	1/1
Song *et al.* [24] (R-LLND/L-LLND)	7 ± 1.2 9 ± 1	3 ± 0.5 4 ± 0.25	4/1	1/1	1/0
Bae *et al.* [20] (R-LLND/L-LLND)	7 ± 1.5 7 ± 0.3	NA	5/8	0/3	2/5

Table 6. Oncological outcomes.

Study	Lateral lymph node dissected	Total lymph node dissected	Overall recurrence	Local recurrence	Distant recurrence
Ishizaki *et al.* [21] (R-LLND/L-LLND)	19 ± 13.2 15 ± 13.2	38 ± 17.7 34 ± 21.7	NA	NA	NA
Morohashi *et al.* [23] (R-LLND/L-LLND)	15 ± 7.8 13 ± 10.7	25 ± 14 26 ± 14.7	NA	NA	NA
Zhang *et al.* [25] (R-LLND/L-LLND)	8 ± 4 6 ± 3	24 ± 9.2 23 ± 10.3	NA	NA	NA
Kim *et al.* [22] (R-LLND/L-LLND)	6.6 ± 5.1 6.4 ± 3.1	16.3 ± 8.3 18.1 ± 9.7	15/11	3/4	13/7
Song *et al.* [24] (R-LLND/L-LLND)	6 ± 1.7 6 ± 1	18.5 ± 4.2 23 ± 3.2	22/14	8/2	17/13
Bae *et al.* [20] (R-LLND/L-LLND)	7 ± 1.5 5 ± 0.8	NA	NA	NA	NA

our work concluded that the robotic approach is safe and feasible when compared to laparoscopy, with some potential benefits in terms of peri-operative and pathological outcomes. Our results corroborate the conclusion of these works, and even though these papers did not reach statistical significance for many items taken into account, when data were pooled and analyzed, a slight vantage from the robotic approach is present, thus demonstrating a probable real benefit in daily practice. As already known, a longer operative time is found in the robotic group (WMD 60.46, $p = 0.02$), but it comes with a reduced intraoperative blood loss (WMD –22.33, $p = 0.01$) and reduced postoperative stay (WMD –1.30, $p = 0.03$) with an early return to regular diet (WMD –0.60, $p = 0.01$). A critical consideration in robotic LLND is the balance between operative efficiency and resource utilization. Although robotic surgery requires a longer operative time, its association with reduced postoperative morbidity and faster recovery may translate into overall better hospital resource allocation [31,32]. This is particularly relevant in high-volume centers with well-established robotic programs. However, these benefits may not extend to institutions with limited robotic expertise, where the learning curve for LLND remains steep [33]. It is well recognized that LLND is a highly demanding procedure, and outcomes are likely to be superior in centers with high surgical volume and specialized experience [31–34]. Anastomotic leakage did not differ between the two groups, but no data are reported on leakage prevention (such as stoma, indocyanine green, splenic flexure mobilization, etc.) [35]. Despite an unknown role in long-term outcomes, a major number of harvested lymph nodes in the LLND were documented (WMD 1.23, $p = 0.02$) but with an inverse trend on total harvested lymph nodes (TME + LLND) favoring robotic surgery (WMD –1.44, $p = 0.3$). To be noted, all the included study reported a mean number of harvested lymph nodes higher than what is required from the American Joint Committee on Cancer 8th edition on rectal cancer diagnosis and staging [36]. Only 2 studies reported a statistical difference in terms of harvested lateral lymph nodes in favor of laparoscopic surgery [20,25]. When it comes to total harvested lymph nodes, only one study reported a statistically significant difference, favoring robotic surgery [24]. The greater number of harvested lymph nodes in laparoscopic LLND (L-LLND) compared to robotic LLND

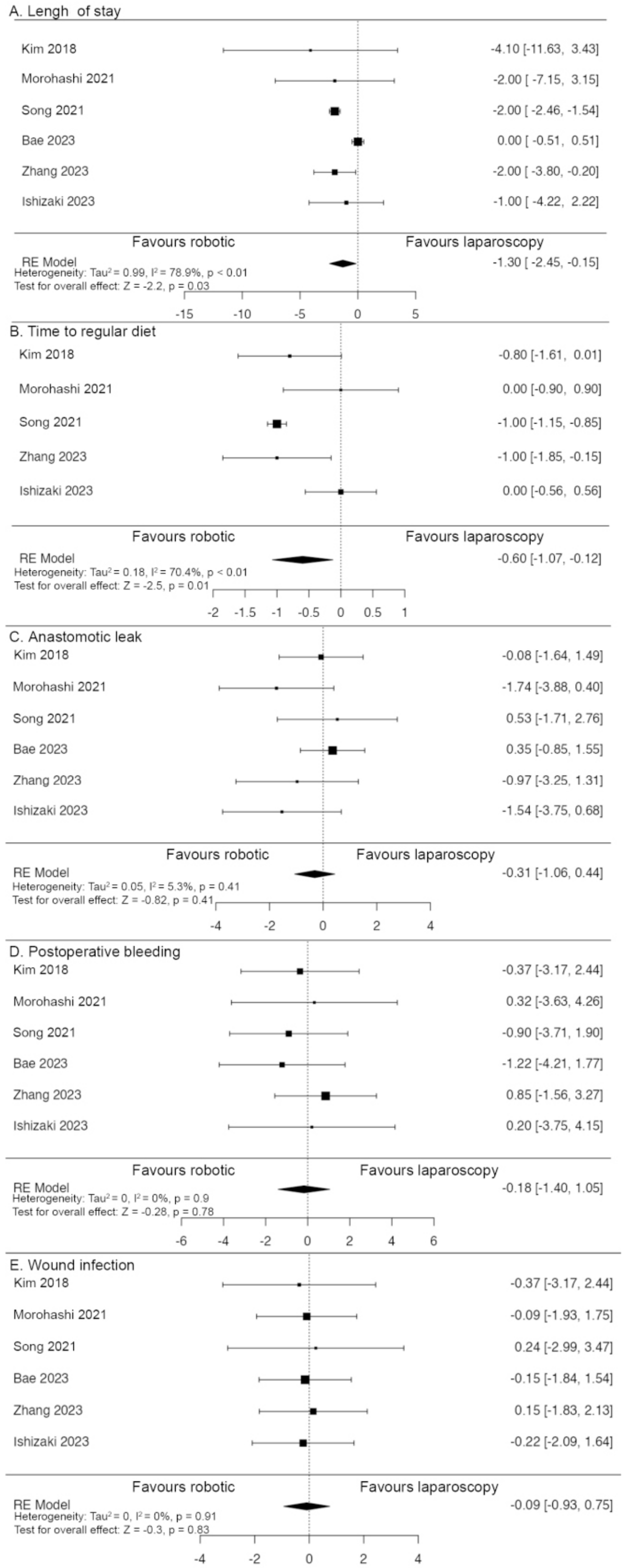

Fig. 3. Forest plot of postoperative data. (A) Length of stay. (B) Time to regular diet. (C) Anastomotic leak. (D) Postoperative bleeding. (E) Wound infection.

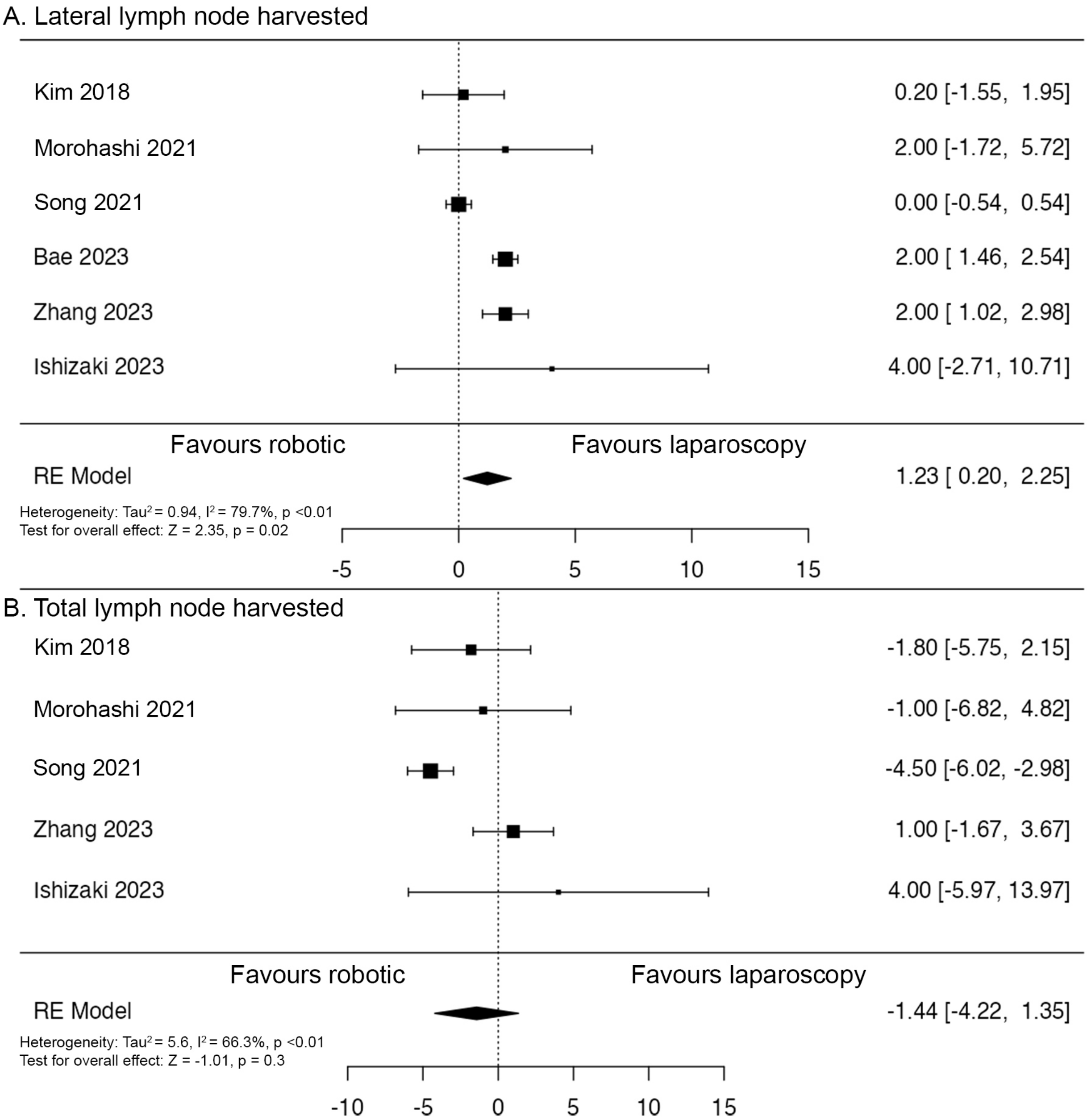

Fig. 4. Forest plot of oncological outcomes. (A) Lateral lymph node harvested. (B) Total lymph node harvested.

(R-LLND) may be attributed to a higher level of expertise in the laparoscopic approach rather than the “new” robotic technique. Additionally, the lack of haptic feedback in the robotic platform could influence the precision of dissection in narrow spaces such as the 263 lymph node station. All these papers did not report the occurrence of ypT0 with positive lymph nodes, which remains an orphan status [37]. An interesting topic would be the role of the surgical platform in neurovascular iatrogenic injuries, which is pivotal in the treatment of rectal cancer to not compromise the quality of life [38–40] but the heterogeneity of the reported results does not allow for this analysis. In this surgical procedure, the current rate of observed urinary retention rate is between 8 and 16% [41,42].

Our results confirm that the robotic platform allows better and finer movements in a narrow space such as the lateral pelvic compartment, allowing better lymph node retrieval and a safer dissection, resulting in a slight reduction of perioperative morbidity. It must be highlighted how, in this space, dissecting vital and delicate structures, the absence of tactile feedback from the robotic platform could play a role in the decision-making between the two approaches. To note, as in almost any robotic versus laparoscopic comparison in abdominal surgery, no dramatic advantage of the robotic technique can be noted, but a slight benefit is evident [17,19,43].

Even if the focus of this paper is only to compare the two surgical approaches, the oncological role of the LLND itself remains uncertain due to the scarcity of evidence and the limited diffusion of the technique. One of the most significant limitations in the current literature is the absence of Randomized Controlled Trials addressing this topic. To date, no high-quality prospective studies have directly compared robotic and laparoscopic LLND, leaving us reliant on retrospective analyses. Our meta-analysis included only six studies, of which four were monocentric and two multicentric. Five of these were retrospective cohort studies, with only one being prospective. While all study scored 8 out of 8 on the Newcastle-Ottawa scale for quality assessment, their retrospective nature (except one prospective study, by Kim *et al*. [22]) introduces inherent biases, making it difficult to draw definitive conclusions. Moreover, all the studies are from East Asia, where this practice is more common than in the occidental world; therefore, the application of these results in a Western population might be questioned, especially since most papers did not specify selection criteria to allocate patients to one technique or the other, making it particularly challenging to generalize the results. The only data that can be noticed is that, even in pooled analysis, patients were homogeneous between the two groups, even in terms of oncological staging and neoadjuvant treatment. The heterogeneity analysis revealed substantial variability among studies in several key parameters: operative time (I^2 = 95.5%), blood loss (I^2 = 86.6%), postoperative length of stay (I^2 = 78.9%), time to resumption of a regular diet (I^2 = 70.4%), and the number of lateral lymph nodes harvested (I^2 = 79.7%).

This variability may stem from intraoperative factors, particularly differences in robotic and laparoscopic learning curves across studies—an aspect not explicitly addressed in the retrieved papers but likely varying. For postoperative outcomes, such as length of hospital stay and time to regular diet, discrepancies may be attributed to variations in standardized care pathways across different medical centers.

Moving forward, well-designed prospective trials with long-term follow-up are necessary to establish the true oncological and functional benefits of robotic over laparoscopic LLND. Additionally, more comprehensive reporting on neurovascular outcomes and anastomotic integrity is needed to fully assess the impact of the robotic approach on patient quality of life. Until such data become available, the choice between robotic and laparoscopic LLND should be individualized, taking into account the surgeon's expertise, patient factors, and institutional capabilities.

Conclusions

In conclusion, our work demonstrates a slight benefit from the robotic approach when performing LLND in terms of intra- and peri-operative outcomes. Several limitations are present, and therefore, results must be interpreted with caution.

Availability of Data and Materials

The data analyzed are available from the corresponding author upon reasonable request.

Author Contributions

Conceptualization: FR, GiC, GB; methodology: AL, GMG, EMM; software: AL, FSLC; validation: GrC, PM; formal analysis: AL, VT; execution: VT; acquisition of data: AL, LDC, AC, GMG; data curation: AL, GMG, GiC; writing—original draft preparation: AL, GB, EMM; writing—review and editing: FR, GiC, GrC, PM; supervision: FR, GiC, GrC, PM. Data analysis: FSLC. All authors have been involved in revising it critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

Not applicable.

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Conflict of Interest

Gianluca Costa is serving as one of the Editorial Board members of this journal. We declare that Gianluca Costa had no involvement in the peer review of this article and has no access to information regarding its peer review. Other authors declare no conflict of interest.

Supplementary Material

Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.62713/aic.3917.

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