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REVIEW

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The perioperative results of robotic and laparoscopic surgery for rectal cancer in obese patients: a systematic review and meta-analysis

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Abstract

Background The incidence of rectal cancer (RC) among obese patients is gradually increasing. Obesity can elevate the risk of RC surgery in numerous aspects. This paper aims to compare the perioperative results of robotic and laparoscopic surgery for RC in obese patients

Methods We conducted a standardized search of relevant articles using PubMed, Cochrane Library and Web of Science Core Collection in December 2024. All original research articles relevant to our topic were incorporated into the literature screening process, including randomized controlled trials, prospective cohort studies, and retrospective cohort studies. Study selection was subsequently performed according to predefined inclusion and exclusion criteria.

Results This study selected five studies, involving 499 patients. Among these patients, 191 underwent robotic surgery, while the remaining 308 underwent laparoscopic surgery. The results showed that for obese patients with RC, robotic rectal cancer surgery (RRCS) is more effective in reducing hospital stay (WMD, -1.67; $p=0.00001$), the rate of overall postoperative complications (OR, 0.41, $p=0.02$), and the readmission rate (OR, 0.37; $p=0.03$) compared to laparoscopic rectal cancer surgery (LRCS), albeit with longer operative times (WMD, 41.38; $p=0.006$). No statistically significant differences were observed between the two surgical methods in terms of estimated blood loss, conversion rates, lymph node yield, positive CRM rates, diverting stoma rates, anastomotic leakage rates, urinary retention rates, and reoperation rates.

Conclusions For obese patients, RRCS may offer certain potential advantages over LRCS, including a shorter hospital stay, lower overall postoperative complication rates, and lower readmission rates. However, it also involves a longer operative time. These findings suggest that RRCS has the potential to be a safer and more beneficial alternative for obese patients with RC.

Keywords Rectal cancer, Obesity, Robotic, Surgery

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Introduction

Rectal cancer (RC) is a common malignant tumor of the digestive tract [1]. Currently, surgical treatment still holds an important position within the realm of RC therapy, and laparoscopic rectal cancer surgery (LRCS) has garnered wide acceptance, attributed to its benefits over open surgery, which include minimal invasion and faster recovery [2].

Obesity is an increasingly severe global health problem and serves as a risk factor for the development of RC [3, 4]. In addition, the incidence of RC among obese patients has been rising annually [5]. For obese patients, the surgical field of view and operating space are limited, rendering anatomical landmarks obscure and blood vessel separation difficult. This, in turn, increases the difficulty and risk associated with rectal cancer surgery, particularly for laparoscopic rectal cancer surgery [6].

Since the advent of robotic rectal cancer surgery (RRCS), its advantages have attracted the attention of colorectal surgeons. The integration of stereoscopic vision, higher resolution and enhanced stability in robotic surgery can mitigate surgical risks [7]. It is noteworthy that fragile adipose tissue is prone to bleeding, and the robotic surgical system lacks a tactile feedback mechanism, which may impact intraoperative bleeding in obese patients. A prior study reported that obese and non-obese patients undergoing RRCS had similar perioperative outcomes [8]. Therefore, robotic surgery holds promise in addressing some of the limitations encountered in LRCS for obese patients.

Although RRCS may overcome certain difficulties posed by obesity, it is still unclear whether RRCS provides greater safety and efficacy in obese patients than LRCS. This paper aims to compare the perioperative results of robotic and laparoscopic surgery for RC in obese patients.

Methods

Literature search strategy

This study was performed in accordance with the PRISMA and MOOSE guidelines [9, 10]. The research protocol was compiled and registered in PROSPERO (CRD42025640294). Two authors (LH and XL) independently searched for relevant literature across three widely utilized databases: PubMed, Cochrane Library and Web of Science Core Collection. We only searched English literature published up to November 30, 2024. The full search strategy is provided in Table S1.

Screening criteria

In this paper, we meticulously adhered to the PICOS method as a guiding principle for formulating the comprehensive inclusion criteria for study selection. Population: obese patients with RC; Intervention: RRCS; Comparison: LRCS; Outcomes: the perioperative results. Study design: the original comparative study, including randomized controlled trials, prospective cohort studies, and retrospective cohort studies.

Exclusion criteria include: (1) Non-original studies and meeting abstracts; (2) Studies where the population included non-rectal cancer patients; (3) Duplicated studies published by the same research team; (4) Studies that lack valuable data.

Two authors (XL and SXP) independently conducted studies screening based on the inclusion and exclusion criteria. Any disagreements were resolved through discussion or by other authors.

Study selection and data collection

The study selection and data collection were conducted by two authors (SXP and LXS). The following data were extracted: (1) Patients' number, male proportion, age, and body mass index (BMI); (2) The primary perioperative results, such as operative time, hospital stay, estimated blood loss, conversion to open; (3) The secondary perioperative results, such as lymph node yield, positive circumferential resection margin (CRM), distal resection margin (DRM), diverting stoma, ureteric injury, overall postoperative complications, anastomotic leak, urinary retention, ileus, reoperation, readmission.

Quality assessment

We utilized the Newcastle-Ottawa scale (NOS) as a framework to evaluate the degree of bias in non-randomized studies [11]. The "leave-one-out" method is a sensitivity analysis technique that systematically excludes each study one at a time and recalculates the pooled effect size. By observing changes in the overall effect size and statistical significance after excluding individual studies, this method helps identify studies that cause excessive heterogeneity. We employed this technique to test the stability of our findings and conduct heterogeneity assessments [12].

Data analysis

We utilized the Review Manager (V5.3) to conduct data statistics. For continuous variable, the results were presented as mean and standard deviation. If it was represented as median and interquartile range in the original article, we would perform the data transformation according to the method proposed by Luo [13]. We employed I^2 value to assess the level of heterogeneity, with a threshold of $>50\%$ considered significant, at which point the random-effects model was used for calculation.

Results

Search results

After a series of careful selection, five articles were finally selected [14–18]. The PRISMA flowchart outlining of articles screening is presented in Fig. 1. The RRCS group consists of 191 patients, while LRCS group consists of 308 patients. In the study selection process, we found that two studies performed by the same research team had overlapping patient populations [14, 19]. Finally, we selected to include the study with higher quality and a larger patient cohort.

Table 1 summarizes the basic characteristics and surgical results. Four key demographic characteristics (male proportion, age, BMI, and the rate of neoadjuvant therapy) were extracted from the included studies for comparative analysis. The analysis results revealed a similarity in the male proportion ($p = 0.41$), age ($p = 0.47$), BMI ($p = 0.96$), and the rate of neoadjuvant therapy ($p = 0.09$) across the two groups (Table 2).

Assessment of quality

Table S2 summarizes the NOS scores for the included studies. All studies reached a score of 7–8 points, indicating high quality and low risk of bias.

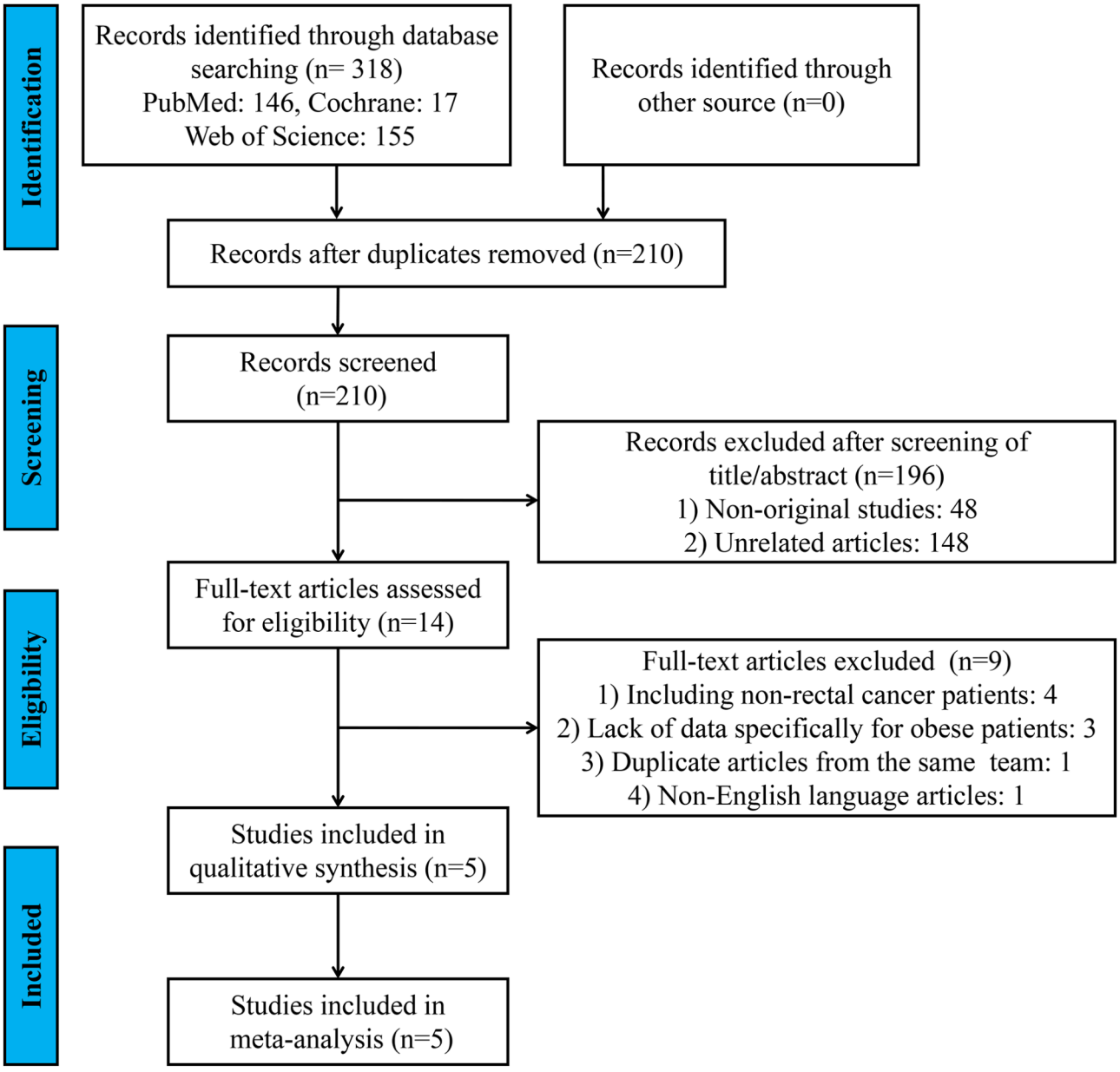

Fig. 1 PRISMA diagram of the articles selection

Table 1 Basic characteristics and operative outcomes of the included studies

Studies	Zhao 2024[14]		Esen 2018[15]		Panteleimonitis 2018[16]		Gorgun 2016[17]		Shiomi 2016[18]	
	RRCS	LRCS	RRCS	LRCS	RRCS	LRCS	RRCS	LRCS	RRCS	LRCS
Country	China		Turkey		UK		USA		Japan	
Study type	RCS		RCS		PSM		RCS		RCS	
Number of patients[a]	32	178	15	12	63	61	29	27	52	30
Male (n)	18	92	NA	NA	40	41	22	16	45	24
Age (year)[b]	62.7 (9.2)	61.9 (10.2)	NA	NA	65.8	67.25	58.8 (10.7)	60.3 (9.8)	64.66 (8.86)	67.14 (8.33)
Body mass index (kg/m^2)[b]	≧28	≧28	NA	NA	32.60 (4.32)	32 (3.04)	34.9 (7.2)	35.2 (5.0)	26.15 (4.07)	26.94 (3.36)
Neoadjuvant therapy (n)	6	21	9	11	24	14	19	14	1	0
Operative time (min)[b]	226.4 (37.5)	188.3 (34.3)	381 (102)	216 (90)	261.41 (72.84)	220.30 (45.56)	329.0 (102.2)	294.6 (81.1)	250.84 (75.72)	259.97 (66.41)
Hospital stay (days)[b]	9.6 (2.3)	10.7 (2.7)	7 (2)	9 (4)	6.35 (2.28)	9.41 (6.07)	6.4 (4.2)	8.4 (4.4)	8.80 (5.09)	10.78 (4.66)
EBL (ml)[b]	45.2 (26.3)	59.5 (34.3)	NA	NA	15.73 (7.59)	17.06 (30.37)	434.0 (612.4)	339.4 (271.9)	20.51 (30.55)	84.06 (119.84)
Conversion to open (n)	1	5	NA	NA	0	2	1	5	0	0
Lymph node yield[b]	15.1 (3.1)	14.9 (3.3)	30 (19)	23 (10)	17.79 (7.78)	17.24 (8.73)	25.5 (14.0)	21.8 (9.6)	28.80 (9.96)	25.73 (9.56)
Positive CRM (n)	1	10	1	0	NA	NA	2	2	0	0
DRM (cm)	NA	NA	NA	NA	NA	NA	3.9 (2.1)	3.2(2.0)	NA	NA
Diverting stoma (n)	9	38	NA	NA	NA	NA	15	19	NA	NA
Overall postoperative complications (n)	4	37	3	4	NA	NA	NA	NA	5	9
Anastomotic leak (n)	1	11	NA	NA	1	0	NA	NA	2	1
Urinary retention (n)	2	10	NA	NA	NA	NA	7	5	0	4
Ureteric injury (n)	0	4	NA	NA	NA	NA	NA	NA	NA	NA
Ileus (n)	NA	NA	NA	NA	NA	NA	4	8	NA	NA
Reoperation (n)	NA	NA	NA	NA	0	2	2	2	NA	NA
Readmission (n)	NA	NA	NA	NA	4	12	4	6	NA	NA

RRCS, robotic rectal cancer surgery; LRCS, laparoscopic rectal cancer surgery; RCS, retrospective cohort study; PSM, propensity score matched; EBL, estimated blood loss; CRM: circumferential resection margin; DRM: distal resection margin; NA, not available; [a] Number of patients included in the analysis; [b] Values are given as mean SD (standard deviation)

Table 2 The demographics of the included studies

Variable	Number of studies with available data	Weighted mean difference /Odds ratio	95% CI	*p* value
Male (n)	4	1.21	(0.77, 1.88)	0.41
Age (years)	3	−0.85	(−3.19, 1.48)	0.47
BMI (kg/m^2)	3	0.02	(−0.95, 1.00)	0.96
Neoadjuvant therapy (n)	5	1.54	(0.94, 2.54)	0.09

CI, confidence interval; BMI, body mass index

Primary outcome measures

Five articles reported operative time and hospital stay, and the pooled results indicated that compared to LRCS, RRCS required a longer surgical duration (WMD, 41.38, $p = 0.006$), while the hospital stay was shorter (WMD, -1.67, $p = 0.00001$) (Fig. 2A and B). Four articles reported blood loss and rate of conversion, and there were no significant difference in estimated blood loss (WMD, -13.97, $p = 0.12$) and conversion rates (OR, 0.32, $p = 0.11$) across the two groups, (Fig. 2C and D).

Secondary outcome measures

The analysis results revealed that there were no significant difference in lymph node yield, the rate of positive CRM and the incidence of diverting stoma across the two groups [WMD, 0.56, $p = 0.29$; OR, 0.79, $p = 0.72$; and OR, 0.85, $p = 0.78$] (Fig. 3A, B and C). The analysis results revealed that the rate of overall postoperative complications was lower in RRCS than LRCS (OR, 0.41, $p = 0.02$) (Fig. 3D). A combined analysis revealed that the rate of anastomotic leak and urinary retention was similar across the two groups [OR, 0.90, $p = 0.87$; and OR, 0.72, $p = 0.66$]

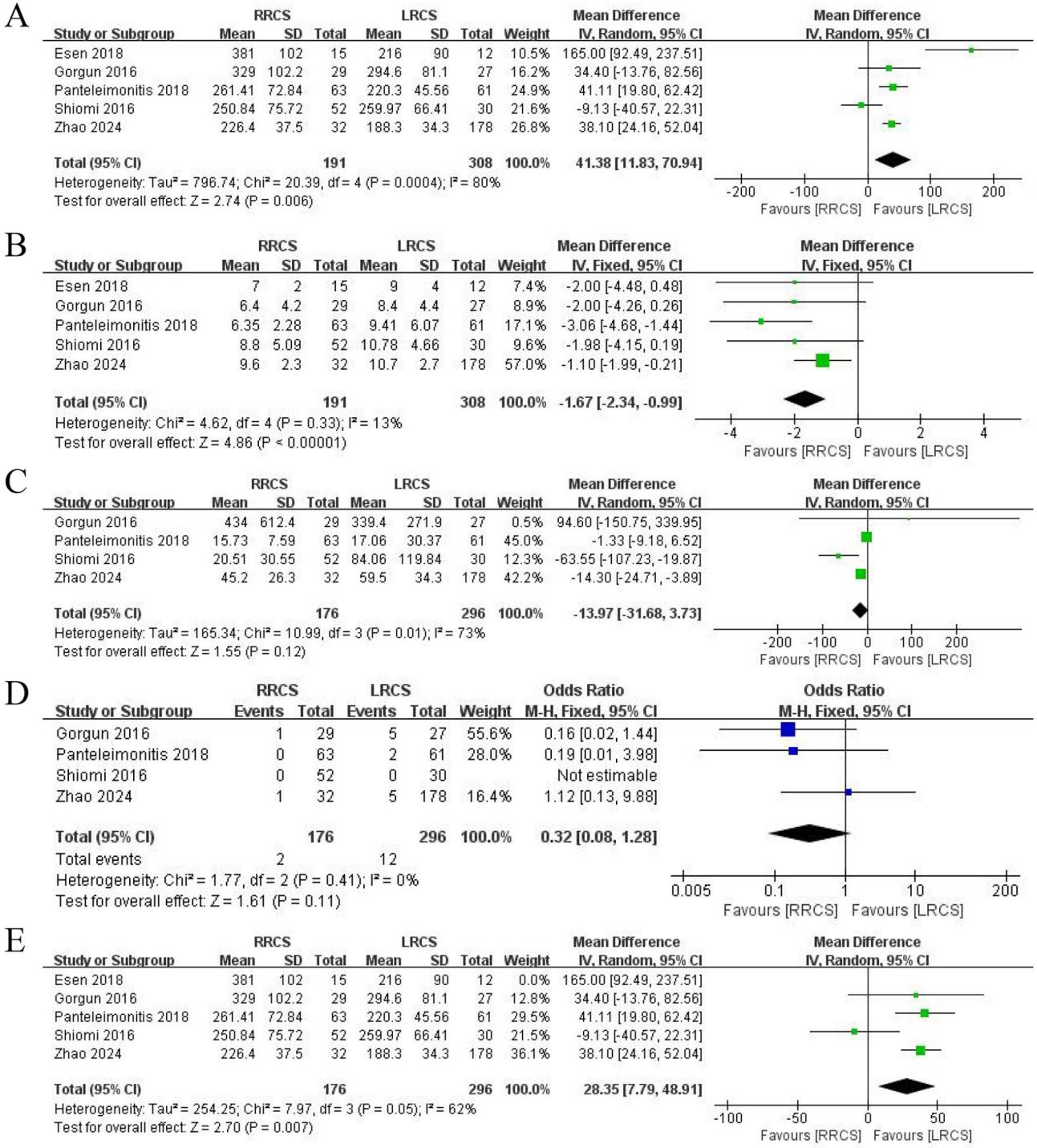

Fig. 2 (**A**) Forest plots of operative time; (**B**) Forest plots of hospital stay; (**C**) Forest plots of estimated blood loss; (**D**) Forest plots of conversion rates; (**E**) Forest plots of operative time after leave-one-out. RRCS, robotic rectal cancer surgery; LRCS, laparoscopic rectal cancer surgery

(Fig. 4A and B). The analysis results revealed that the readmission rate was less in RRCS compared with LRCS (OR, 0.37, $p = 0.03$), while there was no significant difference in the reoperation rate between the two groups (OR, 0.51, $p = 0.40$) (Fig. 4C and D).

Sensibility analysis

Based on the analysis results, the operative time ($I^2 = 80\%$, $p = 0.006$), and estimated blood loss ($I^2 = 73\%$, $p = 0.12$) showed significant heterogeneity. To study the factors that producing heterogeneity, we employed the "leave-one-out" method to perform sensitivity analyses on the

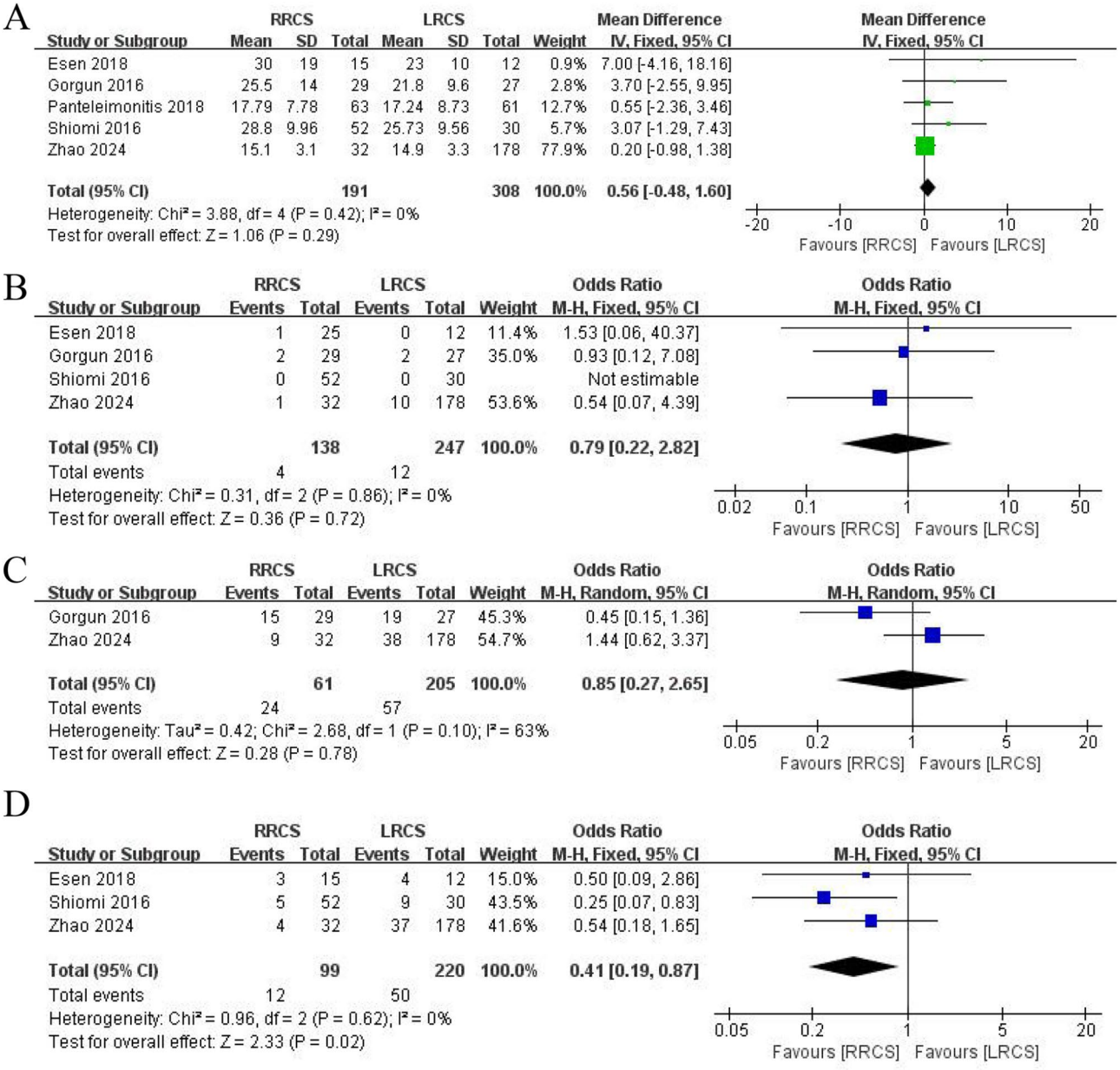

Fig. 3 (**A**) Forest plots of lymph node yield; (**B**) Forest plots of the rate of positive CRM; (**C**) Forest plots of diverting stoma; (**D**) Forest plots of the rate of overall postoperative complications. CRM, circumferential resection margin; RRCS, robotic rectal cancer surgery; LRCS, laparoscopic rectal cancer surgery

above parameters. For operative time, the analysis results indicated that the I^2 value decreased to 62% after removing the study by Esen et al. [15], and the result is still significant (WMD, 28.35, $p = 0.007$) (Fig. 2E). The source of high heterogeneity may be due to the result of Esen's study revealed that the operative time in the RRCS group was significantly prolonged compared to the LRCS group, even exceeding two hours, whereas other studies indicate that the difference in operative time was within one hour. For estimated blood loss, the analysis results showed that after excluding the study by Shiomi et al. [18], the I^2 value decreased to 55%. However, there was still no significant difference in the estimated blood loss between the two groups.

Discussion

Currently, comparative studies on the results of RRCS versus LRCS in obese patients are still scarce, and high-quality meta-analyses in this area are lacking. Chen et al. performed a comparative assessment of the short-term outcomes between robotic and laparoscopic surgery for colorectal disease in obese individuals [20]. Their conclusions showed that robotic colorectal surgery resulted in shorter hospital stay and less estimated blood loss, while

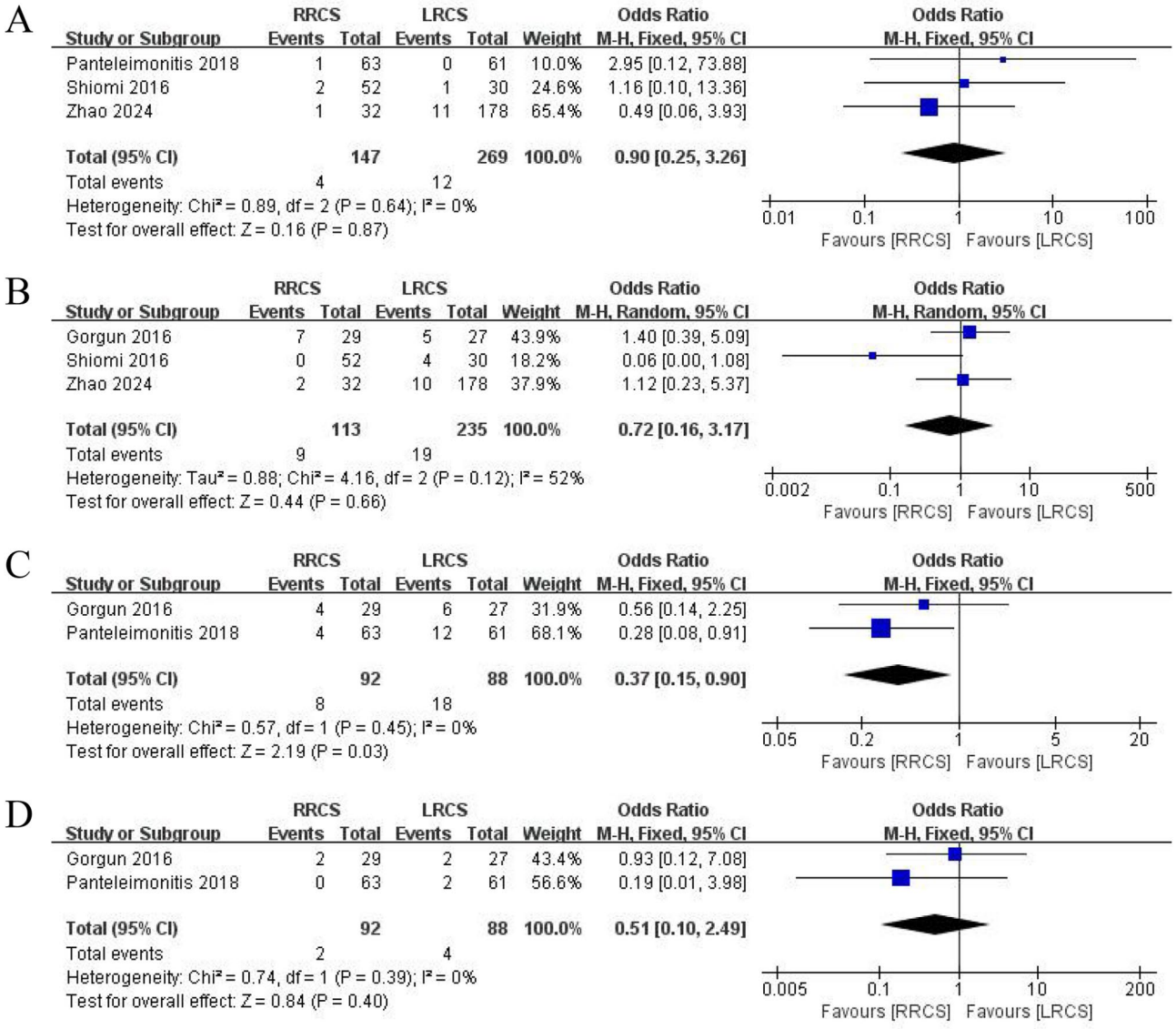

Fig. 4 (**A**) Forest plots of anastomotic leak; (**B**) Forest plots of urinary retention; (**C**) Forest plots of readmission; (**D**) Forest plots of reoperation. RRCS, robotic rectal cancer surgery; LRCS, laparoscopic rectal cancer surgery

conversion rates remained comparable. It is noteworthy that the population they included comprised both patients with colorectal cancer and those with benign colorectal diseases, which may render their conclusions not fully applicable to RC patients.

Our study revealed that RRCS requires a shorter hospital stay compared to LRCS in obese patients, and the results of Gorgun's study [17] also echo this discovery. In addition, a single-center randomized controlled trial conducted by Feng et al. compared robotic and laparoscopic abdominoperineal resection for low RC, and the study results similarly indicated that the length of hospital stay after RRCS was shorter compared to LRCS [21]. The shorter hospital stay after robotic surgery may stem from the earlier recovery of bowel function and decreased occurrence of complications [22].

Obesity emerges as an important factor contributing to increased blood loss among patients undergoing LRCS [23]. Intraoperative bleeding is mainly related to excessive tissue traction and accidental vascular injury [24]. For obese patients, our study found no significant difference in estimated blood loss between RRCS and LRCS. A recent study has shown that for overweight patients, the estimated blood loss during robotic surgery is significantly reduced compared to that during laparoscopic surgery [25].

The transition to open surgery signifies a serious surgical outcome that may result in heightened patient mortality, and its incidence serves as a crucial indicator for

assessing the proficiency of minimally invasive surgical techniques [26]. In rectal cancer surgery, obesity is a risk factor for conversion to open surgery [27]. Our study revealed that for obese patients, the conversion rate was similar between RRCS and LRCS. A recent RESET trial found no differences in conversion rates among robotic total mesorectal excision (TME), laparoscopic TME, and transanal TME [28]. This finding is consistent with the results of our study. However, a meta-analysis conducted by Phan et al., suggested that RRCS has a lower conversion rate compared to LRCS [29].

This study also revealed that for obese patients, RRCS has a lower readmission rate compared to LRCS, but with a longer operative time. The above findings were the same as those of retrospective research conducted by Ielpo [30]. The common reasons for readmission include wound problems, dehydration, ileus, and intra-abdominal abscess [31]. The longer operative time associated with RRCS is related to the time-consuming installation and replacement of robotic arms, as well as the surgeon's lack of experience [32].

The CRM positivity rate is considered an important indicator for evaluating surgical outcomes, as it is closely related to surgical quality and affects local tumor recurrence. Our study revealed no significant difference in CRM positivity rate between the RRCS and LRCS. A ROLARR trial conducted by Jayne et al., found no statistically significant difference in the CRM positivity rate between robotic and laparoscopic surgery for RC [27]. This finding is consistent with the results of our research. Conversely, a multicenter randomized controlled trial conducted by Chinese scholars has shown that RRCS may reduce the CRM positive rate compared to LRCS [33].

The impact of gender on surgical outcomes in RC is also worth discussing, as the relatively narrower pelvis in male patients with RC can result in limited surgical space, thereby increasing the difficulty and risk of the surgery [34]. This can lead to suboptimal quality of TME specimens, an elevated CRM positivity rate, and an increased incidence of local recurrence. Aliyev et al. found that compared to laparoscopic TME, robotic sphincter-preserving TME provides better mesorectal specimens and excellent local tumor control for male patients with mid-low RC [35]. Furthermore, a recent study has shown that RRCS has advantages in preserving male sexual function, especially in overweight patients [25].

Several deficiencies should be pointed out. First, the selected articles were all non-randomized controlled trials, lacking randomized controlled trials for comparison. Second, the geographical and demographic limitations of the included studies may restrict the applicability of our research findings to populations in other regions. Third, this study did not analyze the impact of tumor location on perioperative outcomes due to the absence of corresponding subgroup analyses in the included studies. Lastly, the inconsistency in the definitions of obesity across different studies could adversely affect the results, we hope that future studies will adopt standardized definitions and management protocols for obesity to ensure the comparability and reproducibility of their findings.

Conclusion

For obese patients, RRCS may offer certain potential advantages over LRCS, including a shorter hospital stay, lower overall postoperative complication rates, and lower readmission rates. However, it also involves a longer operative time. These findings suggest that RRCS has the potential to be a safer and more beneficial alternative for obese patients with RC.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12957-025-03781-7.

Supplementary Material 1

Supplementary Material 2

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Author contributions
LH: literature search, paper writing, and data analysis; XL: literature search, study screening, and data analysis; SXP: study screening, study selection, and data collection; LXS: research design, study selection, and data collection.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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References

1. Siegel RL, Miller KD, Wagle NS, et al. Cancer statistics, 2023. Ca Cancer J Clin. 2023;73(1):17.

2. Schnitzbauer V, Gerken M, Benz S, et al. Laparoscopic and open surgery in rectal cancer patients in Germany: short and long-term results of a large 10-year population-based cohort. Surg Endosc. 2020;34(3):1132.
3. Bardou M, Rouland A, Martel M, et al. Review article: obesity and colorectal cancer. Aliment Pharmacol Ther. 2022;56(3):407.
4. Kivimaki M, Strandberg T, Pentti J, et al. Body-mass index and risk of obesity-related complex multimorbidity: an observational multicohort study. Lancet Diabetes Endocrinol. 2022;10(4):253.
5. Mandic M, Safizadeh F, Niedermaier T, et al. Association of overweight, obesity, and recent weight loss with colorectal cancer risk. Jama Netw Open. 2023;6(4):e239556.
6. Chen G, Lu Y, Zhu J, et al. A space expander of laparoscopic rectal cancer surgery for overweight or obese patients. Surg Innov. 2023;30(5):664.
7. Obatake M, Hotchi M, Ishimura N, et al. Propensity score-matched analysis of the short-term outcomes of robotic versus laparoscopic surgery for rectal cancer. Asian J Endosc Surg. 2023;16(3):455.
8. Bayraktar O, Aytac E, Ozben V, et al. Does robot overcome obesity-related limitations of minimally invasive rectal surgery for cancer?? Surg Laparosc Endosc Percutan Tech. 2018;28(1):e8.
9. Shamseer L, Moher D, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ. 2015;350:g7647.
10. Brooke BS, Schwartz TA. Pawlik TM MOOSE reporting guidelines for meta-analyses of observational studies. Jama Surg. 2021;156(8):787.
11. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol. 2010;25(9):603.
12. Lau J, Ioannidis JP, Terrin N, et al. The case of the misleading funnel plot. BMJ. 2006;333(7568):597.
13. Luo D, Wan X, Liu J, et al. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. Stat Methods Med Res. 2018;27(6):1785.
14. Zhao S, Li R, Zhou J, et al. Comparative analysis of robotic and laparoscopic surgery for mid and low rectal cancer in patients with varied body mass indexes: evaluating of short-term outcomes. J Robot Surg. 2024;18(1):67.
15. Esen E, Aytac E, Agcaoglu O, et al. Totally robotic versus totally laparoscopic surgery for rectal cancer. Surg Laparosc Endosc Percutan Tech. 2018;28(4):245.
16. Panteleimonitis S, Pickering O, Abbas H, et al. Robotic rectal cancer surgery in obese patients may lead to better short-term outcomes when compared to laparoscopy: a comparative propensity scored match study. Int J Colorectal Dis. 2018;33(8):1079.
17. Gorgun E, Ozben V, Costedio M, et al. Robotic versus conventional laparoscopic rectal cancer surgery in obese patients. Colorectal Dis. 2016;18(11):1063.
18. Shiomi A, Kinugasa Y, Yamaguchi T, et al. Robot-assisted versus laparoscopic surgery for lower rectal cancer: the impact of visceral obesity on surgical outcomes. Int J Colorectal Dis. 2016;31(10):1701.
19. Zhao S, Li R, Zhou J, et al. Comparison of robotic versus laparoscopic surgery for visceral obesity in mid-low rectal cancer: a propensity-matched analysis. J Robot Surg. 2024;18(1):178.
20. Chen ZL, Du QL, Zhu YB, et al. A systematic review and meta-analysis of short-term outcomes comparing the efficacy of robotic versus laparoscopic colorectal surgery in obese patients. J Robot Surg. 2024;18(1):167.
21. Feng Q, Tang W, Zhang Z, et al. Robotic versus laparoscopic abdominoperineal resections for low rectal cancer: a single-center randomized controlled trial. J Surg Oncol. 2022;126(8):1481.
22. Park EJ, Baik SH. Robotic surgery for colon and rectal cancer. Curr Oncol Rep. 2016;18(1):5.
23. He Y, Wang J, Bian H, et al. BMI as a predictor for perioperative outcome of laparoscopic colorectal surgery: a pooled analysis of comparative studies. Dis Colon Rectum. 2017;60(4):433.
24. Ahmed J, Cao H, Panteleimonitis S, et al. Robotic vs laparoscopic rectal surgery in high-risk patients. Colorectal Dis. 2017;19(12):1092.
25. Liu Y, Ju H, Yao Y, et al. Analysis of the impact on sexual function in early-onset overweight male patients with rectal cancer following robotic surgery. J Robot Surg. 2024;18(1):357.
26. Crippa J, Grass F, Achilli P, et al. Risk factors for conversion in laparoscopic and robotic rectal cancer surgery. Br J Surg. 2020;107(5):560.
27. Jayne D, Pigazzi A, Marshall H, et al. Effect of robotic-assisted vs conventional laparoscopic surgery on risk of conversion to open laparotomy among patients undergoing resection for rectal cancer: the ROLARR randomized clinical trial. JAMA. 2017;318(16):1569.
28. Rouanet P, Guerrieri M, Lemercier P et al. A prospective European trial comparing laparotomy, laparoscopy, robotic-assisted, and transanal total mesorectal excision procedures in high-risk patients with rectal cancer: the RESET trial. Ann Surg. 2024.
29. Phan K, Kahlaee HR, Kim SH, et al. Laparoscopic vs. robotic rectal cancer surgery and the effect on conversion rates: a meta-analysis of randomized controlled trials and propensity-score-matched studies. Tech Coloproctol. 2019;23(3):221.
30. Ielpo B, Duran H, Diaz E, et al. Robotic versus laparoscopic surgery for rectal cancer: a comparative study of clinical outcomes and costs. Int J Colorectal Dis. 2017;32(10):1423.
31. Hazen S, van Geffen E, Sluckin TC, et al. Long-term restoration of bowel continuity after rectal cancer resection and the influence of surgical technique: a nationwide cross-sectional study. Colorectal Dis. 2024;26(6):1153.
32. Bedirli A, Salman B, Yuksel O. Robotic versus laparoscopic resection for mid and low rectal cancers. Jsls. 2016;20(1).
33. Feng Q, Yuan W, Li T, et al. Robotic versus laparoscopic surgery for middle and low rectal cancer (REAL): short-term outcomes of a multicentre randomised controlled trial. Lancet Gastroenterol Hepatol. 2022;7(11):991.
34. Aliyev V, Goksel S, Bakir B, et al. Sphincter-saving robotic total mesorectal excision provides better mesorectal specimen and good oncological local control compared with laparoscopic total mesorectal excision in male patients with mid-low rectal cancer. Surg Technol Int. 2021;38:160.
35. Aliyev V, Piozzi GN, Huseynov E, et al. Robotic male and laparoscopic female sphincter-preserving total mesorectal excision of mid-low rectal cancer share similar specimen quality, complication rates and long-term oncological outcomes. J Robot Surg. 2023;17(4):1637.

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