Systematic Review and Meta-Analysis

Medicine®

OPEN

Comparison of clinical efficacy of robotic right colectomy and laparoscopic right colectomy for right colon tumor

A systematic review and meta-analysis

Quan Li Zhu, MD, Xin Xu, MD, Zhi Jian Pan, MD*

Abstract

Background: The purpose of this study was to compare the clinical efficacy of robotic right colectomy (RRC) and laparoscopic right colectomy (LRC) in the treatment of right colon tumor.

Methods: We systematically searched PubMed, Web of science, EMBASE ClinicalTrials.gov and Cochrane Central Register for studies (studies published between January 2011 and June 2020). The included studies compared the clinical efficacy of RRC and LRC in the treatment of right colon tumor, and analyzed the perioperative data.

Results: Our meta-analysis included 10 studies involving 1180 patients who underwent 2 surgical procedures, RRC and LRC. This study showed that compared with LRC, there was no significant difference in first flatus passage (weighted mean difference [WMD]: −0.37, 95% CI: −1.09–0.36, $P = .32$), hospital length of stay (WMD: −0.23, 95% CI: −0.73–0.28, $P = .32$), reoperation (OR: 1.66, 95% CI: 0.67–4.10, $P = .27$), complication (OR: 0.83, 95% CI: 0.60–1.14, $P = .25$), mortality (OR: 0.45, 95% CI: 0.02–11.22, $P = .63$), wound infection (OR: 0.65, 95% CI: 0.34–1.25, $P = .20$), and anastomotic leak (OR: 0.73, 95% CI: 0.33–1.63, $P = .44$). This study showed that compared with LRC, the lymph nodes retrieved (WMD: 1.47, 95% CI: −0.00–2.94, $P = .05$) of RRC were similar, with slight advantages, and resulted in longer operative time (WMD: 65.20, 95% CI: 53.40–77.01, $P < .00001$), less estimated blood loss (WMD: −13.43, 95% CI: −20.65–6.21, $P = .0003$), and less conversion to open surgery (OR: 0.30, 95% CI: 0.17–0.54, $P < .0001$).

Conclusions: RRC is equivalent to LRC with respect to first flatus passage, hospital length of stay, reoperation, complication, and results in less conversion to LRC.

Abbreviations: CI = confidence interval, LRC = laparoscopic right colectomy, OR = odd ratio, RRC = robotic right colectomy, WMD = weighted mean difference.

Keywords: laparoscopic right colectomy, robotic right colectomy

1. Introduction

Right colectomy is a major surgical procedure for the treatment of tumors in the right colon, and has achieved a good therapeutic effect. With the continuous development of minimally invasive surgery, people gradually improve the requirements of surgery. As a result, laparoscopic technology emerged. With the continuous exploration of researchers, laparoscopic right colectomy (LRC) has become the preferred surgical method, which is superior to traditional open surgery in terms of operation, postoperative, and prognosis. However, 2D imaging, limited dexterity, and a long learning curve are considered limitations of laparoscopic colorectal surgery.[1] Due to technical difficulties, most doctors only perform LRC and in extracorporeal anastomosis. Only a few colorectal surgeons can routinely complete LRC and in intracorporeal anastomosis.[2]

Since 2000, robotic surgery had become increasingly popular, especially in cardiac, gynaecological, and urological surgery.[3] The advantages inherent to the robot, such as better ergonomics, surgical dexterity, and improved stable 3D high-definition visualization, may make this possible. In 2002, robotic colectomies were reported first by Weber et al[4] This technology was developed to make up for the technical limitations of laparoscopic colectomy. It provided three-dimensional imaging, superior ergonomics compared with traditional laparoscopic instruments, the camera operation of surgeons, and the stable traction of surgical area. Moreover, robots had more advantages in anastomosis. Since then, different authors had demonstrated that robotic colorectal surgery was technically feasible and safe.[5] After that, more and more attention had been paid to the application of robot technology in colectomy.

Editor: Sergio Huerta.

The authors have no funding and conflicts of interest to disclose.

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Department of General Surgery, Hangzhou Normal University Affiliated Hospital, China.

** Correspondence: Zhi Jian Pan, Department of General Surgery, Hangzhou Normal University Affiliated Hospital, China (e-mail: pzj2518@126.com).*

How to cite this article: Zhu QL, Xu X, Pan ZJ. Comparison of clinical efficacy of robotic right colectomy and laparoscopic right colectomy for right colon tumor: a systematic review and meta-analysis. Medicine 2021;100:33(e27002).

Received: 8 February 2021 / Received in final form: 15 July 2021 / Accepted: 31 July 2021

http://dx.doi.org/10.1097/MD.0000000000027002

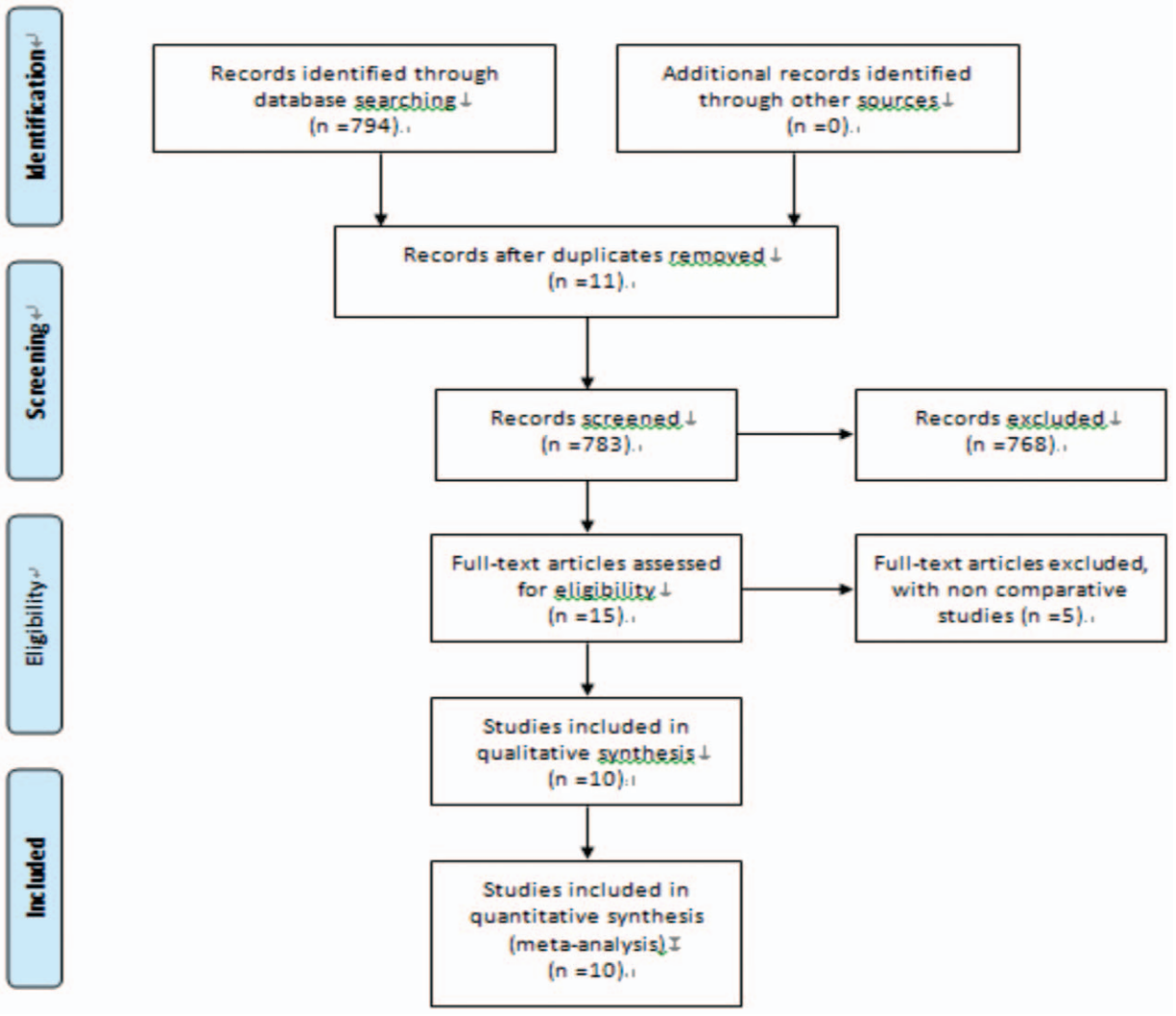

Figure 1. Flow chart of literature selection.

Most studies evaluating the benefits of robotic surgery compared it to open surgery rather than laparoscopic surgery. In recent years, studies had explored the effectiveness and safety of robotic right colectomy (RRC) and LRC. However, at present, there was still a lack of adequate evidence-based medical research to select RRC or LRC for right colon tumors. The use and the potential benefits of the robotic da Vinci Surgical System in right colectomy are far from being fully understood. The literature is mostly limited to analysis of series and case reports. Only Xu et al[6] conducted a meta-analysis of 7 studies in 2014, comparing RRC with LRC. There were no larger, multicenter studies reporting the clinical efficacy of RRC and LRC. The aim of this meta-analysis was to compare the clinical efficacy of RRC and LRC in the treatment of right colon tumors.

2. Methods

This study does not require approval from the ethics committee or institutional review board. This meta-analysis was performed in accordance with the preferred reporting items for systemic reviews and meta-analysis statement.[7] We searched PubMed, web of science, EMBASE, clinicaltrials.gov, and Cochrane Central Register for studies (articles published in English between 2011 and 2020). The retrieval words are: RRC and LRC. We also used the combined Boolean operators "AND" or "OR" title/abstract. Two investigators reviewed the results together in the case of discrepancies. The inclusion criteria were as follows: original documents; comparison of RRC and LRC; and there was a comparison of intraoperative and postoperative complications. The exclusion criteria were as follows: case report, review, articles without relevant information; and non comparative study. The identification process of relevant research is shown in Figure 1.

2.1. Statistical analysis

We used Review Manager Version 5.3 (The Cochrane Collaboration, Oxford, UK) to analyze the data. We used the GRADE approach to evaluate the quality of the evidence. We used Cochran Q to evaluate heterogeneity; when the value of Q was $<50\%$ or the P value was $>.01$, the heterogeneity was low. However, if the value of Q was $>50\%$ or the P value was $<.01$,

Table 1

Basic characteristics of the included studies and Newcastle–Ottawa Scale.

Study	Country	Year	Group	Patients	Age	BMI	Sex (M:F)	Study type	NOS
Emilio et al	Italy	2013	RRC	48	68±8	25±3.5	27/21	R	5
			LRC	48	74±11	28±4	16/32		
Florent et al	France	2019	RRC	42	67±8.6	26±4.7	21/21	R	6
			LRC	59	72±8.6	24±4.3	31/28		
Fulvio et al	Italy	2020	RRC	55	72 (65–79)	24.31 (22.11–27.56)	32/23	R	5
			LRC	68	72 (64–79.5)	24.81 (23.10–28.45)	40/28		
Henry et al	United States	2013	RRC	22	71.88±9.0	31.44±6.02	8/14	R	6
			LRC	25	72.6±11.1	27.88±6.1	10/15		
Jin et al	Korea	2011	RRC	6	NA	NA	NA	P	6
			LRC	6	NA	NA	NA		
Lujan et al	United States	2018	RRC	89	70.9±9.6	28.4±5.4	48/41	R	6
			LRC	135	72.6±11.4	27.1±5.2	61/74		
Maria et al	United States	2017	RRC	119	68 (58–77)	28 (24–32)	64/55	R	7
			LRC	163	64 (54–75)	29 (25–32)	83/80		
Mario et al	Italy	2015	RRC	18	74 (57–80)	26 (24–28)	9/9	R	6
			LRC	11	65 (59–75)	26 (23–28)	9/2		
Park et al	Korea	2012	RRC	35	62·8±10·5	24·4±2·5	14/21	P	7
			LRC	35	66·5±11·4	23·8±2·7	16/19		
Stefano et al	Italy	2014	RRC	102	68.8±11.6	25.6±3.8	56/46	R	5
			LRC	94	70.8±10.2	25.4±3.5	52/42		

BMI = body mass index, F = female, M = mMale, NA = not available, NOS = Newcastle–Ottawa Scale, P = prospective study, R = retrospective study, RRC = robotic right colectomy, LRC = laparoscopic right colectomy.

heterogeneity existed. When I^2 was >50%, the random effects model was used. For quantitative data, we used the weighted mean difference (WMD) or standard mean difference of continuous variables. We used odd ratio (OR) and 95% confidence interval (CI) for binary data.

3. Results

Our meta-analysis included 10 studies. Figure 1 summarizes the process of obtaining these studies. Seven hundred ninety four studies were obtained from the selected database, and 768 studies were excluded after screening the title and summary. After detailed treatment of the remaining studies, 5 other studies were excluded. Finally, 10 studies were included in our meta-analysis.[1,2,5,8–14] Table 1 summarized the baseline characteristics and assessments for 10 studies.

3.1. Quality assessment

We used the Newcastle–Ottawa Scale (NOS) to assess the risk of bias for inclusion in the study. The NOS scores were evaluated using a 9-point system. NOS score of 7 or more indicated high quality, and NOS score of 3 or less indicated low quality.[15] Two reviewers assessed the quality of the included studies. Table 1 showed the bias risk for the selected study.

3.2. Meta-analysis results

3.2.1. Operative time. Six studies reported data from operative time. According to the results of meta-analysis, the operative time of RRC was longer than that of LRC, which was statistically significant (n = 522, 255 cases in RRC group, 267 cases in LRC group). The random effect model was used (I^2 = 55%, WMD: 65.20, 95% CI: 53.40–77.01, $P < .00001$, Fig. 2).

3.2.2. Lymph nodes retrieved. Seven studies reported data from lymph nodes retrieved. According to the results of meta-analysis, the lymph nodes retrieved of RRC and LRC was not statistically significant (n = 746, 344 cases in RRC group, 402 cases in LRC group). The fixed effect model was used (I^2 = 0%, WMD: 1.47, 95% CI: −0.00–2.94, $P = .05$, Fig. 3).

3.2.3. Estimated blood loss. Five studies reported data of estimated blood loss. According to the results of meta-analysis, the estimated blood loss of RRC was less than that of LRC, which

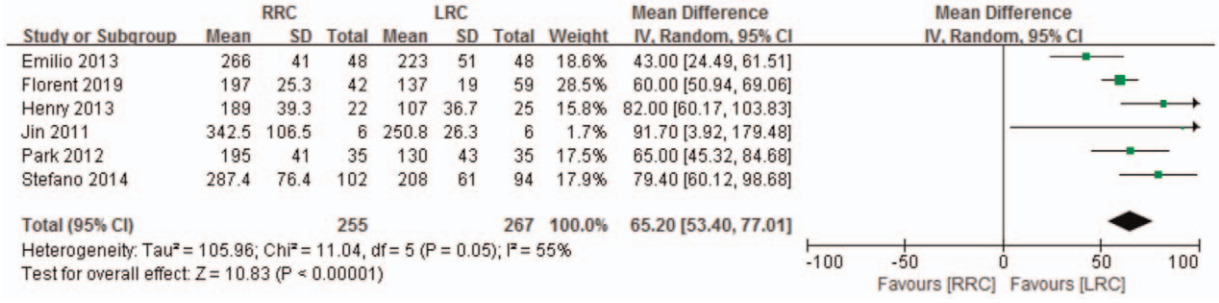

Figure 2. Operative time forest map. CI = confidence interval, RRC = robotic right colectomy, LRC = laparoscopic right colectomy, SD = standard deviation.

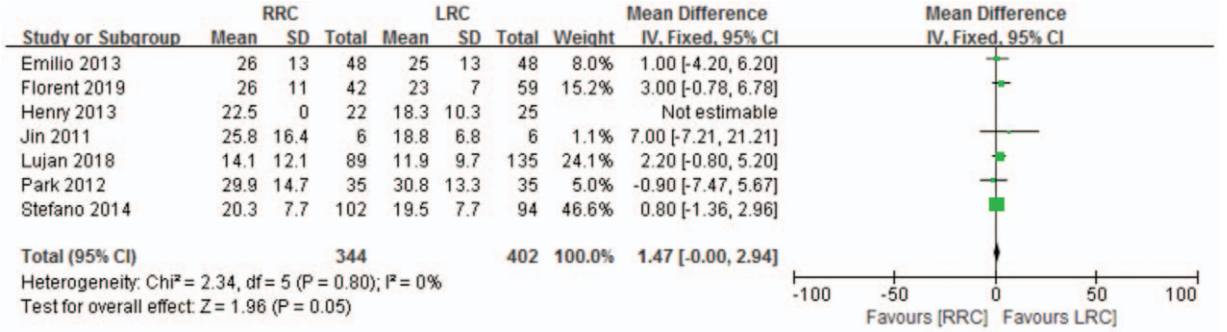

Figure 3. Lymph nodes retrieved forest map. CI = confidence interval, RRC = robotic right colectomy, LRC = laparoscopic right colectomy, SD = standard deviation.

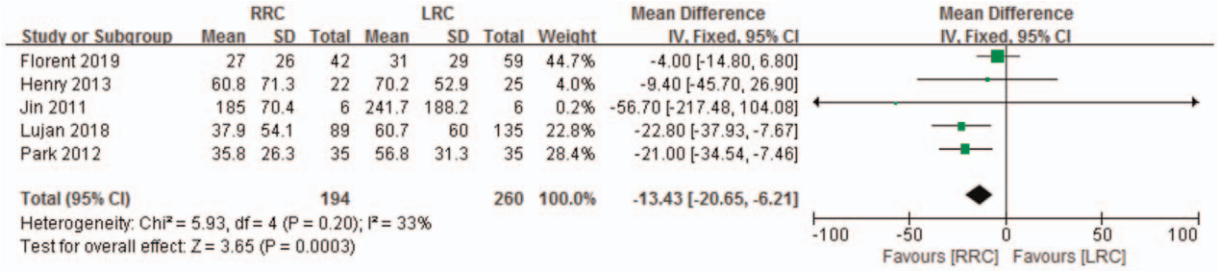

Figure 4. Estimated blood loss forest map. CI = confidence interval, RRC = robotic right colectomy, LRC = laparoscopic right colectomy, SD = standard deviation.

was statistically significant (n = 454, 194 in RRC group, 260 in LRC group). The fixed effect model was used ($I^2 = 33\%$, WMD: −13.43, 95% CI: −20.65–6.21, $P = .0003$, Fig. 4).

3.2.4. First flatus passage. Four studies reported data of first flatus passage. According to the results of meta-analysis, the first flatus passage of RRC and LRC was not statistically significant (n = 402, 178 in RRC group, 224 in LRC group). The random effect model was used ($I^2 = 83\%$, WMD: −0.37, 95% CI: −1.09–0.36, $P = .32$, Fig. 5).

3.2.5. Hospital length of stay. Four studies reported data of hospital length of stay. According to the results of meta-analysis, the hospital length of stay of RRC and LRC was not statistically significant (n = 442, 188 in RRC group, 254 in LRC group). The random effect model was used ($I^2 = 0\%$, WMD: −0.23, 95% CI: −0.73–0.28, $P = .32$, Fig. 6).

3.2.6. Conversion to open surgery. Nine studies reported data of conversion to open surgery. According to the results of meta-analysis, the conversion to open surgery of RRC was less than that of LRC, which was statistically significant (n = 1084, 488 in RRC group, 596 in LRC group). The fixed effect model was used ($I^2 = 43\%$, OR: 0.30, 95% CI: 0.17–0.54, $P < .0001$, Fig. 7).

3.2.7. Reoperation. Three studies reported data of reoperation. According to the results of meta-analysis, the reoperation of RRC and LRC was not statistically significant (n = 521, 233 in RRC group, 288 in LRC group). The fixed effect model was used ($I^2 = 0\%$, OR: 1.66, 95% CI: 0.67–4.10, $P = .27$, Fig. 8).

3.2.8. Complication. Five studies reported data of complication. According to the results of meta-analysis, the complication of RRC and LRC was not statistically significant (n = 854, 383 in

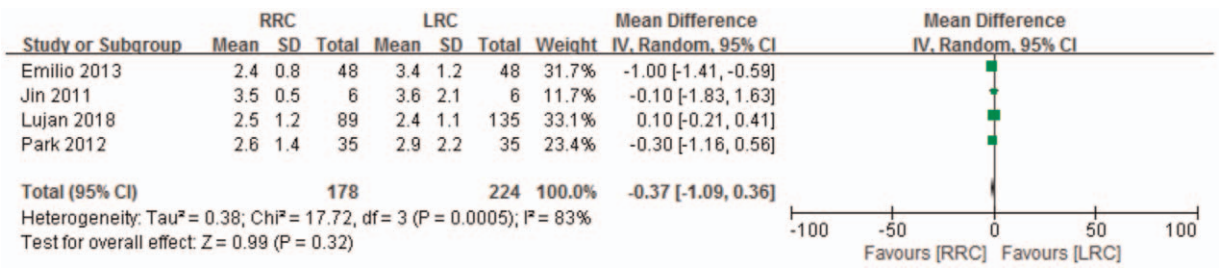

Figure 5. First flatus passage forest map. CI = confidence interval, RRC = robotic right colectomy, LRC = laparoscopic right colectomy, SD = standard deviation.

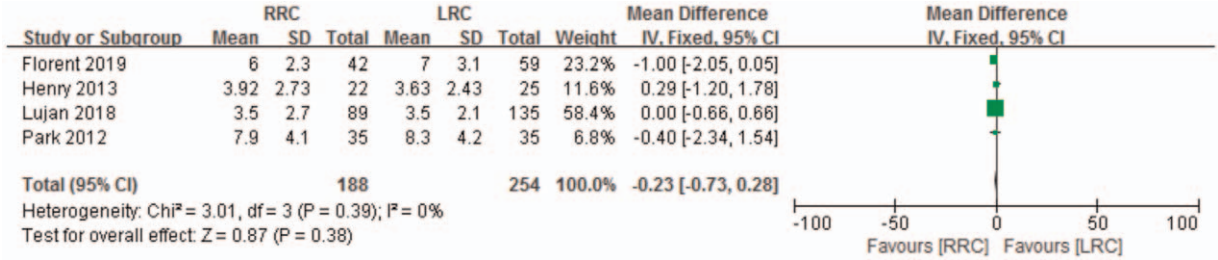

Figure 6. Hospital length of stay forest map. CI = confidence interval, RRC = robotic right colectomy, LRC = laparoscopic right colectomy, SD = standard deviation.

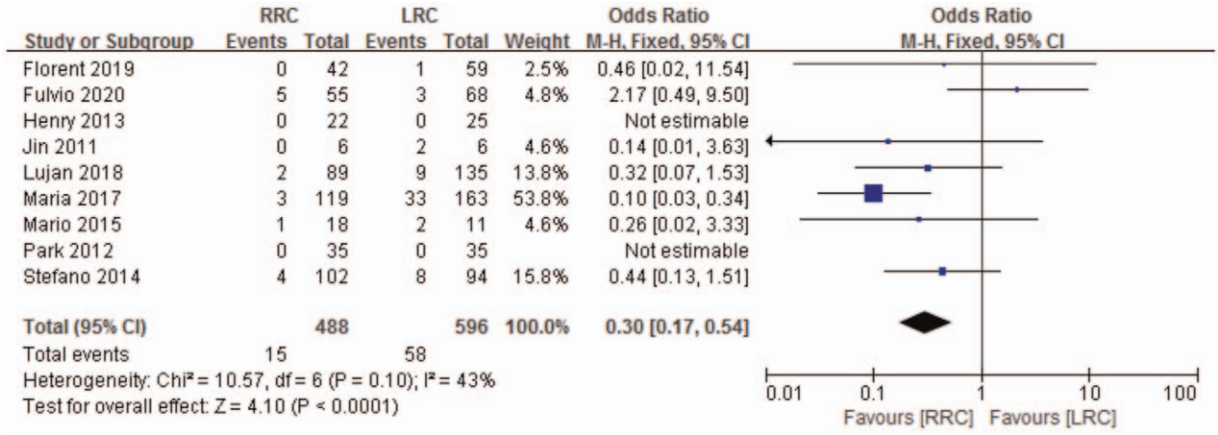

Figure 7. Conversion to open surgery forest map. CI = confidence interval, RRC = robotic right colectomy, LRC = laparoscopic right colectomy.

RRC group, 471 in LRC group). The fixed effect model was used ($I^2 = 0\%$, OR: 0.83, 95% CI: 0.60–1.14, $P = .25$, Fig. 9).

3.2.9. Mortality. Four studies reported data of mortality. According to the results of meta-analysis, the mortality of RRC and LRC was not statistically significant (n = 644, 304 in RRC group, 340 in LRC group). The fixed effect model was used (Heterogeneity: not applicable, OR: 0.45, 95% CI: 0.02–11.22, $P = .63$, Fig. 10).

3.2.10. Wound infection. Five studies reported data of mortality. According to the results of meta-analysis, the wound infection of RRC and LRC was not statistically significant (n = 709, 329 in RRC group, 380 in LRC group). The fixed effect model was used ($I^2 = 0\%$, OR: 0.65, 95% CI: 0.34–1.25, $P = .20$, Fig. 11).

3.2.11. Anastomotic leak. Six studies reported data of anastomotic leak. According to the results of meta-analysis, the anastomotic leak of RRC and LRC was not statistically significant (n = 810, 371 in RRC group, 439 in LRC group). The fixed effect model was used ($I^2 = 0\%$, OR: 0.73, 95% CI: 0.33–1.63, $P = .44$, Fig. 12).

4. Discussion

A total of 10 studies were included in this meta-analysis, with a total of 1180 cases. This was the largest study to compare the clinical efficacy of RRC and LRC in the treatment of right colon cancer so far. We compared the clinical efficacy of RRC and LRC from several aspects.

Our study reported that RRC operative time was longer than LRC, which was consistent with previous reports of small clinical sample studies. It is well known that robot docking and interchanges of robotic instruments increase operative time.[5] Similar to the laparoscopic technique, at the beginning of laparoscopic surgery, the operative time was prolonged due to the unskilful operation of the researchers. We know that the learning curve for laparoscopic colectomy was estimated to be between 55 and 70 cases.[16] According to international literature, the learning curve of RRH (technical skills necessary to significantly reduce operative time, conversion to open surgery rate, and to significantly improve the number of harvested lymph nodes) is complete after 45 procedures.[17] It is believed that the RRC technology can also be simplified and improved as the learning curve increases. In the future, the RRC may play an important role in medical devices for minimally invasive surgery, rather than just as a learning tool.

Our meta-analysis found that although the average lymph node retrieved of the 2 groups was similar statistically, the present literature reported that RRC's lymph node retrieved was slightly more than that of LRC, suggesting that RRC was similar to LRC in oncology and slightly better than LRC.

In terms of estimated blood loss, this meta-analysis found that RRC's estimated blood loss was less than LRC, which was

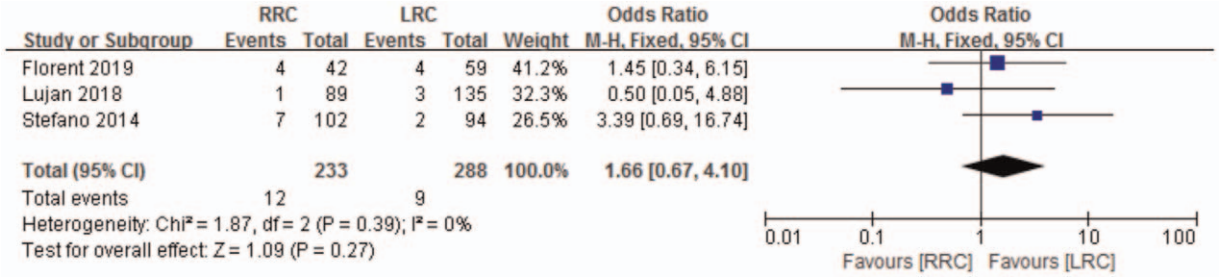

Figure 8. Reoperation forest map. CI = confidence interval, RRC = robotic right colectomy, LRC = laparoscopic right colectomy.

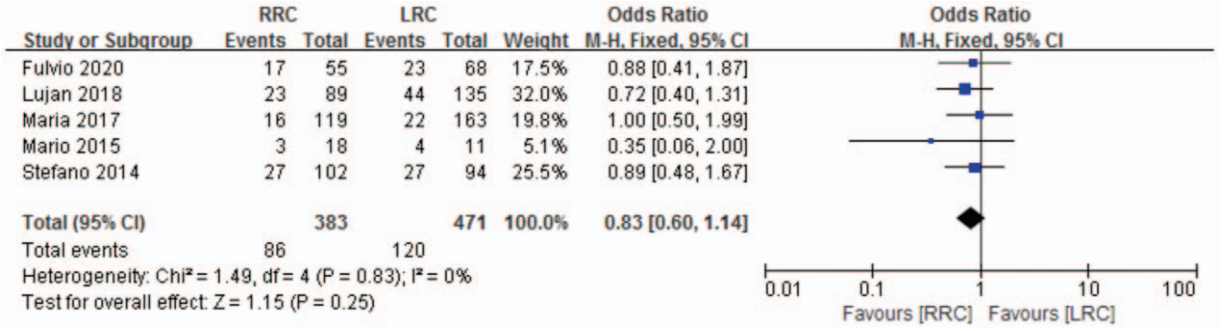

Figure 9. Complication forest map. CI = confidence interval, RRC = robotic right colectomy, LRC = laparoscopic right colectomy.

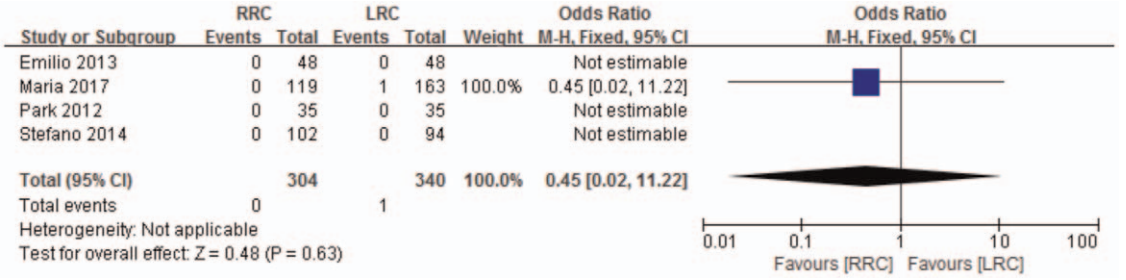

Figure 10. Mortality forest map. CI = confidence interval, RRC = robotic right colectomy, LRC = laparoscopic right colectomy.

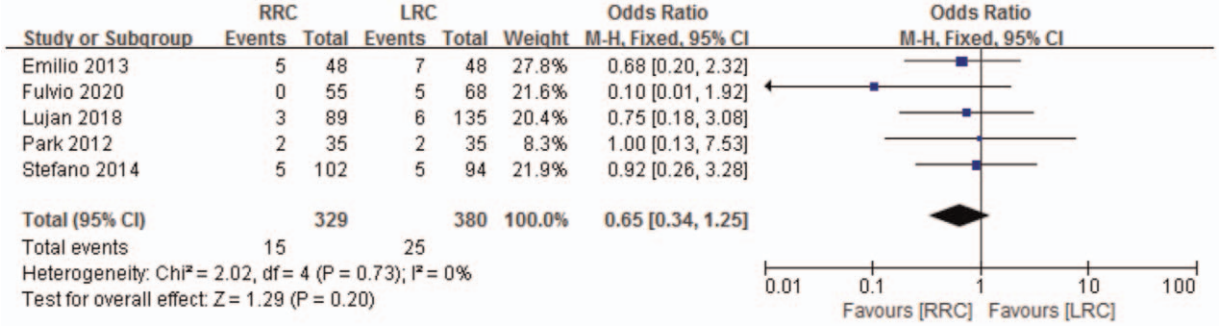

Figure 11. Wound infection forest map. CI = confidence interval, RRC = robotic right colectomy, LRC = laparoscopic right colectomy.

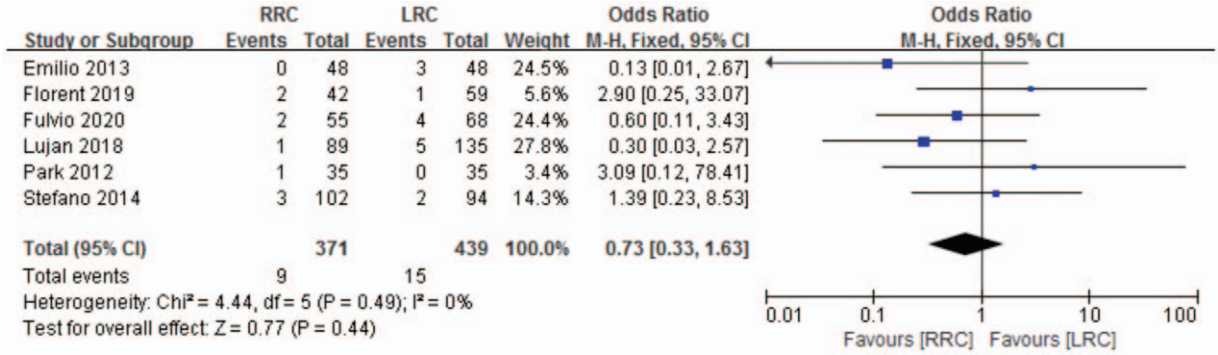

Figure 12. Anastomotic leak forest map. CI = confidence interval, RRC = robotic right colectomy, LRC = laparoscopic right colectomy.

consistent with the results of the 5 separate studies included in this study. It shows that RRC has more advantages in surgical bleeding and has certain benefits for the recovery of patients in the later stage.

Many authors believe that minimally invasive techniques were less immunosuppressive, were associated with less ileus, and resulted in quicker recovery.[18–21] Lujan et al[5] thought that there was probably less traction and tension applied to the colon and the mesentery during an intracorporeal anastomosis. Furthermore, the extent of the dissection and injury to tissues was likely less. Gerbaud et al[9] suggested that the RRC in intracorporeal anastomosis might lead to earlier intestinal ventilation and could avoid unnecessary transposition of the transverse colon and mesenteric traction, thus allowing the intestine to be extravasated and anastomosis performed, which would enable the intestinal function to be restored more quickly. However, in this meta-analysis, which combined 4 studies reporting RRC and LRC, there was no statistically significant difference in first flatus passage, which indicated that the clinical efficacy of RRC and LRC was the same and not better than LRC in the first flatus passage.

Hospital length of stay was an effective substitute for the analysis of postoperative recovery. This meta-analysis showed no significant difference between RRC and LRC in hospital length of stay, which was consistent with the results of the 4 separate studies included in this study. The results showed that RRC could achieve the same effect as LRC under the same discharge standard.

In this meta-analysis, the conversion to open surgery of RRC was less than that of LRC. Shin[1] had shown that 10% of laparoscopic colectomy patients need to be converted to open surgery to complete surgery. However, no patients in the robotic colectomy group were converted to open surgery, which was consistent with previous reports that the conversion rate of robotic approach was less than 5%. Mario et al[13] believed that robotic surgery overcome the limitations of laparoscopic surgery, reduced conversion rate and improved neurological function. Therefore, the RRC group had more advantages in the treatment of right colon tumor with less conversion to laparotomy.

In our research, we analyzed the research of complications from 2 aspects: general complications and several complications. On the total complication, there were 5 literatures describing the complication. After meta-analysis, there was no statistical difference between RRC and LRC, which indicated that the complications after RRC and LRC were similar. We also conducted a separate analysis on the complication from the perspectives of mortality, wound infection, and anastomotic leak. After meta-analysis, we found that there was no statistical difference between RRC and LRC in mortality, wounding infection and anastomotic leak, indicating that RRC and LRC were also similar in separate complications (in Figs. 9–12). The postoperative complications and mortality were consistent with those of laparoscopic surgery, indicating the safety and effectiveness of robotic surgery.

5. Conclusion

In our meta-analysis, first flatus passage, hospital length of stay, reoperation, and complications after RRC and LRC treatment of right colon tumor were similar. Compared with LRC, RRC's lymph nodes retrieved were slightly more, and longer operative time, as well as less estimated blood loss and conversion to open surgery. In conclusion, compared with LRC, RRC has less conversion to open surgery on the background of longer operative time.

This study is a meta-analysis, and most of the literature in this study is retrospective study. In addition, surgeons influence outcomes in the learning curve of robotic surgery. There is little research on economics at present. Therefore, high-quality, large-sample, prospective studies are needed to further confirm the conclusions of this study.

Author contributions

QLZ and ZJP designed the study, QLZ, ZJP, and XX searched the articles and analyzed the data. QLZ wrote the manuscript. All authors read and approved the final manuscript.
Conceptualization: Quan-li Zhu.
Data curation: Quan-li Zhu, Xin Xu, Zhi Jian Pan.
Formal analysis: Quan-li Zhu.
Funding acquisition: Quan-li Zhu.
Investigation: Quan-li Zhu, Zhi Jian Pan.
Methodology: Quan-li Zhu, Zhi Jian Pan.
Project administration: Quan-li Zhu, Zhi Jian Pan.
Resources: Quan-li Zhu, Xin Xu, Zhi Jian Pan.
Software: Quan-li Zhu.
Supervision: Quan-li Zhu.
Validation: Quan-li Zhu.
Visualization: Quan-li Zhu.
Writing – original draft: Quan-li Zhu.
Writing – review & editing: Quan-li Zhu.

References

[1] Shin JY. Comparison of short-term surgical outcomes between a robotic colectomy and a laparoscopic colectomy during early experience. J Korean Soc Coloproctol 2012;28:19–26.

[2] Trastulli S, Coratti A, Guarino S, Piagnerelli R, Annecchiarico M, Coratti F. Robotic right colectomy with intracorporeal anastomosis in comparison with the laparoscopic approach with extracorporeal and intracorporeal anastomosis: a retrospective multicentre study. Surg Endosc 2015;29:1512–21.

[3] Maeso S, Reza M, Mayol JA, et al. Efficacy of the Da Vinci surgical system in abdominal surgery compared with that of laparoscopy: a systematic review and meta-analysis. Ann Surg 2010;252:254–62.

[4] Weber P, Merola S, Wasielewski A, Ballantyne GH. Telerobotic-assisted laparoscopic right and sigmoid colectomies for benign disease. Dis Colon Rectum 2002;45:1689–96.

[5] Lujan HJ, Maciel VH, Romero R, Plasencia G. Laparoscopic versus robotic right colectomy: a single surgeon's experience. J Robot Surg 2013;7:95–102.

[6] Xu H, Li J, Sun Y, et al. Robotic versus laparoscopic right colectomy: a meta-analysis. World J Surg Oncol 2014;12:274.

[7] Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. PLoS Med 2021;18:e1003583.

[8] Morpurgo E, Contardo T, Molaro R, Zerbinati A, Orsini C, D'Annibale A. Robotic-assisted intracorporeal anastomosis versus extracorporeal anastomosis in laparoscopic right hemicolectomy for cancer: a case control study. J Laparoendosc Adv Surg Tech A 2013;23:414–7.

[9] Gerbaud F, Valverde A, Danoussou D, Goasguen N, Oberlin O, Lupinacci RM. Experience with transitioning from laparoscopic to robotic right colectomy. JSLS 2019;23:e2019.

[10] Tagliabue F, Burati M, Chiarelli M, et al. Robotic vs laparoscopic right colectomy – the burden of age and comorbidity in perioperative outcomes: an observational study. World J Gastrointest Surg 2020; 12:287–97.

[11] Lujan HJ, Plasencia G, Rivera BX, et al. Advantages of robotic right colectomy with intracorporeal anastomosis. Surg Laparosc Endosc Percutan Tech 2018;28:36–41.

[12] Widmar M, Keskin M, Strombom P, et al. Lymph node yield in right colectomy for cancer: a comparison of open, laparoscopic and robotic approaches. Colorectal Dis 2017;19:888–94.

[13] Guerrieri M, Campagnacci R, Sperti P, Belfiori G, Gesuita R, Ghiselli R. Totally robotic vs 3D laparoscopic colectomy: a single centers preliminary experience. World J Gastroenterol 2015;21:13152–9.

[14] Park JS, Choi GS, Park SY, Kim HJ, Ryuk JP. Randomized clinical trial of robot-assisted versus standard laparoscopic right colectomy. Br J Surg 2012;99:1219–26.

[15] Wells G, Shea B, O'Connell D, Peterson J, Welch V, Losos M, Tugwell P. The Newcastle–Ottawa Scale (NOS) for assessing the quality of nonrandomised studies in meta-analyses.

[16] Takashi A, Hiroya K, Masashi U, et al. Learning curve for standardized laparoscopic surgery for colorectal cancer under supervision: a single-center experience. Surg Endosc 2011;25:1409–14.

[17] Parisi A, Scrucca L, Desiderio J, et al. Robotic right hemicolectomy: analysis of 108 consecutive procedures and multidimensional assessment of the learning curve. Surg Oncol 2017;26:28–36.

[18] Hellan M, Anderson C, Pigazzi A. Extracorporeal versus intracorporeal anastomosis for laparoscopic right hemicolectomy. JSLS 2009;13:312–7.

[19] Hewitt PM, Ip SM, Kwok SP, et al. Laparoscopic-assisted vs. open surgery for colorectal cancer: comparative study of immune effects. Dis Colon Rectum 1998;41:901–9.

[20] Kuhry E, Jeekel J, Bonjer HJ. Effect of laparoscopy on the immune system. Semin Laparosc Surg 2004;11:37–44.

[21] Ordemann J, Jacobi CA, Schwenk W, Stosslein R, Muller JM. Cellular and humoral inflammatory response after laparoscopic and conventional colorectal resections. Surg Endosc 2001;15:600–8.