Postoperative outcomes in robotic gastric resection compared with laparoscopic gastric resection in gastric cancer: A meta-analysis and systemic review

Muhammad Ali1,2,3 | Yang Wang1,3 | Jianyue Ding1,3 | Daorong Wang1,2

1Department of Gastrointestinal Surgery, Northern Jiangsu People's Hospital, Yangzhou, China
2General Surgery Institute of Yangzhou, Yangzhou University, Yangzhou, China
3Medical College of Yangzhou University, Yangzhou, China

Correspondence
Daorong Wang, Department of Gastrointestinal Surgery, Northern Jiangsu People's Hospital, No. 98 Nantong West Rd, Yangzhou, Jiangsu Province, 225001, China. Email: wdaorong666@sina.com and dralishah512@gmail.com

Abstract

Background: Robotic gastrectomy is a commonly used procedure for early gastric cancer and it also overcomes the limitation of laparoscopic. However, the complications of robotic gastrectomy (RG) still need to be assessed. Our study was designed to compare postoperative complications of RG with laparoscopic gastrectomy (LG).

Materials and Methods: A meta-analysis and systemic review were prospectively collected using the PubMed, Cochrane Library, and MEDLINE database of published studies by comparing the RG and LG with gastric cancer up to December 2021. To evaluate the postoperative outcomes, odds ratios were calculated for Dichotomous data and the mean difference with 95% confidence interval (CI) was calculated for continuous data, and measured by the random-effect model.

Results: Thirty-two retrospective studies describing 13,585 patients (4484 RG and 9101 LG) satisfied the inclusion criteria. A statistically significant result was in blood loss (MD = −17.97, 95% CI: −25.61 to 10.32, p < 0.001), Clavien–Dindo grade III (odds ratio (OR) = 0.60, 95% CI: 0.48–0.76, p < 0.01), and harvested lymph node (MD = 2.62, 95% CI: 2.14–3.11, p < 0.001). There was no significant difference between robotic gastrectomy surgery (RGS) and laparoscopic gastrectomy surgery (LGS) regarding distal resection margin (DRM), proximal resection margin (PRM), conversion rate, anastomotic leakage, and overall complications.

Conclusion: Having significant outcomes in Clavien–Dindo grade III, and blood loss, harvested lymph nodes are more common in RGS, and they also help in increasing the quality of life.

KEYWORDS
gastric cancer, laparoscopic gastrectomy, robotic gastrectomy

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1 | INTRODUCTION

Gastric cancer at present is still a leading cause of health problems and death due to cancer and it is the 5th most regularly identified cancer around the globe.¹ The standard treatment for gastric cancer is surgical resection and open gastrectomy with lymph node dissection takes the main course in cancer treatment. Laparoscopic gastrectomy (LG) slowly spread worldwide and it was primarily informed in 1994 by Kitano et al.² The comparison between open and laparoscopic surgery for gastric cancer of various clinical trials has shown similar outcomes.³⁻⁵ However, laparoscopic surgery shows some sort of limitations such as the reduced sense of touch, lack of flexibility, two-dimensional motion, and narrow movement range of the instrument. Also, LG requires a long learning pathway in lymph node dissection and causes physical stress.⁶

In the meantime, Hashizume et al. were the first to perform robotic gastrectomy (RG) in 2003.⁷ Recently, RG has got an attractive technique to cure gastric carcinoma. A study of nonrandomized trials and meta-analysis has definite that robotic gastrectomy surgery (RGS) over laparoscopic gastrectomy surgery (LGS) for gastric carcinoma can recover short-term and long-term results and assuming, it will improve the operative and surgical results.⁸ Distinguish studies between RG and LG have been informed of the patient's quality of life after minimal invasive surgery (MIS).⁹⁻¹³ These studies were not randomized controlled trials, so there is still controversy between RG and LG.

RGS has been stated to overcome the limitation of LGS and offers new features like wide-ranging tremor filtering, HD vision magnification with 3D stereoscopic, self-determination of device motion, upgraded surgeon dexterity, and a shorter learning curve.¹³,¹⁴ Robotic gastrectomy was testified to be correlated with a lesser extent of operative blood loss and shorter clinic stay than LG.¹⁵,¹⁶

Therefore, the postoperative complication of RGS comparison to LGS management in early-stage gastric carcinoma had not been evaluated yet.

2 | MATERIALS AND METHODS

2.1 | Study strategy

We performed this study according to PRISMA and AMSTAR guidelines as shown in Figure 1. The MiNORS measure indicates the value of detailed studies that are meticulously satisfactory to little heterogeneity concerning their quality, with an average score of 22 (range: 19–23) as present in Table 1.

2.2 | PICO

2.2.1 | Population

SCOPUS, Cochrane Library, and PubMed database for articles available until December 2021.

2.2.2 | Intervention

Having significant results in RGS, the Clavien–Dindo classification shows the most practicable and high-quality approach for gastric cancer, with better surgical results due to the lesser number of patients in Clavien–Dindo grade III.
| n. | Author       | Yr.  | Region | Study period | Study design | Surgical extension | Sample size | Abbreviations  |
|----|--------------|------|--------|--------------|--------------|---------------------|-------------|----------------|
| 1  | Kim HI       | 2016 | Korea  | 2011–2012    | P            | D, T                | 185 185 23 | RG LG MINOR    |
| 2  | Suda         | 2015 | Japan  | 2009–2012    | R            | D, T                | 88 438 22  | KG               |
| 3  | Kim YW       | 2015 | Korea  | 2009–2001    | P            | D                   | 87 288 20  | KG               |
| 4  | Kim KM       | 2012 | Korea  | 2005–2010    | P            | D, T                | 436 861 23 | KG               |
| 5  | Kang         | 2012 | Korea  | 2008–2011    | P            | D, T                | 100 282 22 | KG               |
| 6  | Eom          | 2011 | Korea  | 2009–2010    | P            | D                   | 30 62 22   | KG               |
| 7  | Woo          | 2011 | Japan  | 2005–2009    | P            | D, T                | 236 591 23 | KG               |
| 8  | Yoon         | 2011 | Korea  | 2009–2011    | R            | T                   | 36 65 23   | KG               |
| 9  | Son SY       | 2012 | Korea  | 2007–2011    | R            | D, P, T             | 21 42 19   | KG               |
| 10 | Hyun         | 2013 | Korea  | 2009–2010    | P            | D, T                | 38 83 22   | KG               |
| 11 | Kim HI       | 2013 | Korea  | 2003–2009    | P            | D, T                | 172 481 22 | KG               |
| 12 | Huang        | 2014 | Taiwan | 2008–2014    | P            | D, T                | 72 73 22   | KG               |
| 13 | Junfeng      | 2014 | China  | 2010–2013    | R            | D, P, T             | 120 394 23 | KG               |
| 14 | Son T        | 2014 | Korea  | 2003–2010    | P            | T                   | 51 58 22   | KG               |
| 15 | Han          | 2015 | Korea  | 2008–2013    | R            | PPG                 | 68 68 23   | KG               |
| 16 | Lee          | 2015 | Korea  | 2003–2010    | P            | D                   | 133 267 21 | KG               |
| 17 | Park         | 2015 | Korea  | 2009–2011    | P            | D, T                | 145 612 19 | KG               |
| 18 | Cianchi      | 2016 | Italy  | 2008–2015    | P            | D                   | 30 41 21   | KG               |
| 19 | Hong         | 2016 | Korea  | 2008–2015    | P            | D                   | 232 232 22 | KG               |
| 20 | Nakauchi M   | 2016 | Japan  | 2009–2012    | R            | D, T                | 84 437 23  | KG               |
| 21 | Okumura      | 2016 | Japan  | 2003–2010    | P            | D, T                | 370 132 22 | KG               |
| 22 | Shen         | 2016 | China  | 2011–2014    | R            | D, T                | 93 330 21  | KG               |
| 23 | Obama k      | 2017 | Korea  | 2005–2009    | P            | D, T                | 315 525 23 | KG               |
| 24 | Parisi       | 2017 | Italy  | 2015–2016    | P            | D, T                | 151 151 21 | KG               |
| 25 | Yang         | 2017 | Korea  | 2009–2015    | P            | D, T                | 173 511 21 | KG               |
| 26 | Gao Y        | 2018 | China  | 2011–2014    | P            | D, P, T             | 163 339 21 | KG               |
| 27 | Li Z         | 2018 | China  | 2013–2017    | P            | D, T                | 112 112 23 | KG               |
| 28 | Liu          | 2018 | China  | 2017–2017    | R            | D, T                | 100 135 21 | KG               |
| 29 | Lu           | 2018 | China  | 2016–2017    | P            | D, T                | 101 303 20 | KG               |
| 30 | Wang WJ      | 2018 | China  | 2016–2018    | P            | D, T                | 223 223 23 | KG               |
| 31 | Alhoassaini  | 2019 | Korea  | 2005–2017    | R            | T                   | 25 30 23   | KG               |
| 32 | Kong         | 2019 | China  | 2016–2017    | R            | D, P, T             | 294 750 23 | KG               |

**Abbreviations:** D, distal gastrectomy; P, prospectively collected data; T, total gastrectomy; Yr, year.
2.2.3 | Comparison

We considered studies that compared RGS with LGS for gastric cancer and focused on postoperative complications.

2.2.4 | Outcome

Having significant outcomes in Clavien–Dindo grade III, and blood loss, harvested lymph nodes are more common in RGS, and they also help in increasing the quality of life.

2.2.5 | Inclusion criteria

Retrospective studies involving the RGS comparison with LGS for gastric carcinoma. English language full-text article containing at least one of the following postoperative complications; blood loss, conversion rate, DRM, PRM, Clavien–Dindo grade III, HLN, anastomosis leakage, and overall complication.

2.2.6 | Exclusion criteria

Articles about robotic or laparoscopic surgery that did not provide a comparison, evaluations that did not address complications, reviews, case reports, animal studies, and letters were all omitted.

2.3 | Data collection and methodology

We systematically explored the literature by SCOPUS, Cochrane Library, and PubMed database for articles available until December 2021. Our research work included the keywords “Robotic gastrectomy,” “laparoscopic gastrectomy,” and “gastric cancer.” Our search is limited to humans and English language articles.

2.4 | Statistical analysis

RevMan 5.4 was implemented for statistical meta-analysis. Summative figures are arranged according to descriptive analysis and we set the confidence interval (CI) at 95%. Outcomes are reported for dichotomous as odds ratios (OR) and 95% CI through Mantel–Haenszel way and continuous variables as mean difference (MD) through generic inverse variance way. Continuous data, standard deviation (SD), and mean were reported in median and range. We set statistically significant at \( p < 0.05 \), Q statistics were used to assess the treatment effects of heterogeneity, and \( I^2 \) was assessed for the total variation studies as shown in Table 3.

| Table 2 Postoperative complications |
|-----------------------------------|
| Postoperative outcome | Types of surgery | Observation n. | Studies involved |
| Blood loss | RG | 3921 | 103.6 | 27 |
| | LG | 8539 | 120.5 |
| Conversion rate | RG | 2899 | 0.857 | 21 |
| | LG | 6415 | 2.62 |
| Overall complication | RG | 4484 | 16.5 | 32 |
| | LG | 9101 | 34 |
| Anastomotic leakage | RG | 3275 | 2.375 | 24 |
| | LG | 6890 | 5.83 |
| Clavien–Dindo Grade ≥ III | RG | 2851 | 5.9 | 19 |
| | LG | 5022 | 16.84 |
| DRM | RG | 1468 | 6.69 | 11 |
| | LG | 3257 | 6.51 |
| PRM | RG | 1519 | 4.51 | 12 |
| | LG | 3315 | 4.35 |
| HLN | RG | 3813 | 39.77 | 28 |
| | LG | 7691 | 34.37 |

Abbreviations: DRM, distal resection margin; HLN, harvested lymph node; LG, laparoscopic gastrectomy; n, mean; PRM, proximal resection margin; RG, robotic gastrectomy.

3 | RESULTS

3.1 | Studies and patient characteristics

A total of 645 articles were found from PubMed, Scopus, MEDLINE, and Cochrane Library with the search word “robotic gastrectomy,” “laparoscopic gastrectomy,” and “gastric cancer.” After screening articles, 307 were excluded because of doubling, screened titles, abstracts, and not in English 81 were removed, and a total of 257 full-text articles were retrieved from which 257 articles with “no comparison between RG versus LG,” “proximal gastrectomy only,” “case reports,” “conference study,” “literature,” and “editorial” were removed. A flow illustration of the research course is shown in Figure 1. Thirty-two retrospective studies were included, in which 13,585 patient descriptions are shown in Table 1 and postoperative complications are shown in Table 2. All the articles were nonrandomized trials, in which 4484 patients experienced RG for GC, while 9101 went through LG for GC.

3.2 | Postoperative outcomes

We set the statistical \( p < 0.05 \), Q statistics were used to assess the treatment effects of heterogeneity, and \( I^2 \) was assessed for the total variation studies as shown in Table 3.
### Table 3: Result of the meta-analysis

| Outcome                      | No. of studies | Sample size | Heterogeneity | Overall effect size | 95% CI of overall effect | p value |
|------------------------------|----------------|-------------|---------------|---------------------|--------------------------|---------|
| Overall complications        | 32             | 9101 4484   | 33            | 0.04                | 0.87                     | 0.77, 0.98 | 0.02   |
| Blood loss                   | 27             | 8539 3921   | 89            | <0.001              | -17.97                   | -25.61, -10.32 | <0.001 |
| Anastomosis leakage          | 24             | 6890 3275   | 0             | 0.98                | 0.86                     | 0.63, 1.18 | 0.35   |
| Clavien-Dindo grade III      | 19             | 5022 2851   | 29            | 0.12                | 0.60                     | 0.48, 0.76 | <0.001 |
| DRM                          | 11             | 3257 1468   | 80            | <0.001              | 0.13                     | -0.05, 0.32 | 0.15   |
| PRM                          | 12             | 3315 1519   | 0             | 0.55                | 0.07                     | -0.07, 0.22 | 0.30   |
| HLN                          | 28             | 7691 3813   | 77            | <0.001              | 2.62                     | 2.14, 3.11 | <0.001 |
| Conversion rate              | 21             | 6415 2899   | 12            | 0.33                | 0.71                     | 0.38, 1.33 | 0.29   |

Abbreviations: CI, confidence interval; DRM, distal resection margin; HLN, harvested lymph node; LG, laparoscopy gastrectomy; MD, mean difference; OR, odds ratio; PRM, proximal resection margin; RG, robotic gastrectomy.

![Image](image-url)

**Figure 2 (A, B)** Forest graph and funnel graph for blood loss
3.3 | Blood loss

Meta-analysis results showed a marked rise in the total amount of blood loss following the LG group compared with RG (MD = −17.97, 95% CI: −25.61 to 10.32, \( p < 0.001 \)) as shown in Figure 2A,B.

3.4 | Conversion rate

The overall conversion rate was 0.6% (18/2899) to open surgery (OS) in the RG group and 0.86% (55/6415) in the LG group. In this study, the conversion rate following OS was statistically not significant in 21 different trials within the two groups (OR = 0.71, 95% CI: 0.38–1.33, \( p = 0.29 \)) as shown in Figure 3A,B.

3.5 | Overall complication

An overall complication has been found in multiple 32 studies. The proportion rate for overall complications was 11.8% (529/4484) in the RG group and 11.9% (1086/9101) in the LG group. The result for this study proposed a statistically significant (OR = 0.87, 95% CI: 0.77–0.98, \( p = 0.02 \)) as shown in Figure 4A,B.

3.6 | Clavien–Dindo classification grade III

The frequency rate of complication in the nineteen retrospective studies reported that Clavien–Dindo grade > III in the RG group was...
3.9% (112/2851) and LG group was 6.3% (320/5022). The rate is lesser in RG as compared with LG (OR = 0.60, 95% CI: 0.48–0.76, \( p < 0.01 \)) as shown in Figure 5A,B.

3.7 | Anastomotic leakage

Overall anastomotic leakage was found in 24 studies. Therefore, the RG group was 1.7% (57/3275) and the LG group was 2.03% (140/6890). Our study did not show the most significant change in the anastomotic leakage (OR = 0.86, 95% CI: 0.63–1.18, \( p = 0.35 \)) as shown in Figure 6A,B.

3.8 | Distal margin

Eleven out of 32 studies informed the DRM. The mean difference in the robotic gastrectomy was found at 6.69 while LG was 6.5. Our study indicated that there is no significant (MD = 0.13, 95% CI: –0.05 to 0.32, \( p = 0.15 \)) as shown in Figure 7A,B.

3.9 | Proximal margin

Following 32 studies the PRM was reported in 12. The mean distance in RG was 4.5 while LG was 4.4. There is no statistical
difference seen in RG with comparison to LG group, a mean difference (MD = 0.07, 95% CI: −0.07 to 0.22, \(p = 0.30\)) as shown in Figure 8A,B.

3.10 | Harvested lymph node

Our study reported a raised number of the HLN in RG compared with LG (MD = 2.62, 95% CI: 2.14−3.11, \(p < 0.001\)). However, our data showed statistically significant as shown in Figure 9A,B.

4 | DISCUSSION

Over the past years, surgical resection has been the only quality treatment method for gastric cancer. Following the laparoscopic use for gastric carcinoma highly increased in the developing world. Because of certain limitations in laparoscopic surgery, robotic surgery was developed to overcome the practical limitations of laparoscopy. However, robotic surgical resection is still slow due to technical problems, complications, and inefficient procedures. A recent randomized clinical trial study also described that there is no significant reduction of
infectious complications in RG compared with LG for gastric cancer. Furthermore, fewer studies focus on robotic gastrectomy and LG postoperative complications. Therefore, we performed a relevant meta-analysis and compared the two approaches following the treatment of gastric cancer.

We analyzed the overall complication, blood loss, conversion rate, Clavien–Dindo grade III, anastomotic leakage, DRM, PRM, and HLN. Specifically, we find a significant difference in blood loss, Clavien–Dindo grade III, and harvested lymph nodes between the two approaches.

Our study informed that the practice of robotic surgery is related to a significant blood loss reduction. Therefore, intraoperative blood loss and the resultant reduced perioperative plasma transfusions are related to improved short-term clinical management, which shows a correlation to upgraded long-term oncological consequences.

Our meta-analysis exposed that the conversion rate following OS was not significant concerning the necessity for reoperation and postsurgical mortality rate. At the same time, the MIS gastrectomy reported several adhesions, quality precisions to technical difficulties, and extensive damage to adjacent organs.

Overall complications did not expose any statistically significant outcome. However, the robotic group showed 11.8%, and
the laparoscopic group showed 11.9%. We also analyzed the complication according to Clavien–Dindo grade > III. It allows us to evaluate the surgical outcomes in medical practice, and this is a simple, objective, reproducible, and good worldwide tool for evaluating postoperative progression. We examined grade III postoperative complication as it is the most challenging following the quality of life, clinical assistance, and improved survival. However, our study showed a lower rate in RG of 3.9% compared with LG at 6.3%.9,11,20,24,39–42

This study showed that anastomosis leakage was almost the same in both groups, but our result’s statistical value is not significant. In our meta-analysis, laparoscopic and robotic approaches for DRM were 6.5% and 6.7% and in PRM were 4.4% and 4.5%, respectively. Furthermore, the previous meta-analysis also described distal and proximal resection margins are not statistically significant but did not provide any specific bias study data.50 So, our study concluded that it may be because of the fewer study data as shown in Figures 7B and 8B. Anyhow, still need more clinical studies on it.

The extent of lymph node recovery in the laparoscopic and robotic gastrectomy’s statistically significant, but we have seen an increased rate of the harvested lymph node in RGS as compared with LGS.10,11,19–25,32 A previous meta-analysis also concluded that lymph nodes are more harvested in RG as

![Forest graph and funnel graph for distal resection margin](image-url)
compared with LG but did not provide specific bias study data on it. In our meta-analysis, we concluded that it may be due to a biased study as shown in Figure 9B. As a result, additional clinical trials are required.

In our study, all the articles assessed the comparison between robotic and LG. To our knowledge, this is the first study that specifically compared postoperative outcomes. Though, there are many limitations. All the detailed studies are retrospective and nonrandomized. Variable quantity analysis showed heterogeneity owing to the retrospective analysis’s characteristics and the different surgeons used altered surgical skills according to regional dissimilarity. Anyhow, more clinical research on a large scale in postoperative complications is required to know a better outcome for long-term survival.

5 | CONCLUSION

It concludes that the practice of robotic gastrectomy is the most feasible and quality technique for gastric carcinoma, with improved surgical outcomes due to harvested lymph nodes, Clavien–Dindo grade III, and intraoperative blood loss as compared with LG. However, it still needs to be
testified with additional clinical trials. Furthermore, long-lived oncological consequences must be the main issue for further studies.

AUTHOR CONTRIBUTION
Conceptualization, literature review, protocol development, title, and abstract review, full-text review, data extraction, manuscript writing, revision, and submission: Muhammad Ali. Data collection and revision: Yang Wang and Jianyue Ding. Study direction and final revision: Daorong Wang.

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CONFLICT OF INTEREST
The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT
The data are available via referenced articles. Any further data regarding the article can be made available upon sensible request to the corresponding author.

TRANSPARENCY STATEMENT
The lead author (manuscript guarantor) affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.
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