Comparison of robot-assisted surgery, laparoscopic-assisted surgery, and conventional open surgery for the treatment of gastric cancer A network meta-analysis

Yuan Liu
The Affiliated Wuxi People's Hospital of Nanjing Medical University
Zhiqiang Tian
The Affiliated Wuxi People's Hospital of Nanjing Medical University
Wei Shen (shenweijs@outlook.com)
The Affiliated Wuxi People's Hospital of Nanjing Medical University

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Systematic Review

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Abstract

Objective

To systematically evaluate the predictive efficacy of robotic-assisted distal gastrectomy (RG) with D2 lymphadenectomy.

Methods

Through PubMed, Embase, Cochrane Library, Ovid, and other databases, the English literature comparing three surgical procedures of conventional open distal gastrectomy, laparoscopic-assisted distal gastrectomy, and robot-assisted distal gastrectomy published from 2015 to December 2021 were collected. The included literature's quality was evaluated using the Newcastle-Ottawa Scale (NOS) and Jadad scale, and Meta-analysis was performed using Review Manager 5.4 and R-Studio software.

Results

A total of 13,724 patients were included in 29 publications. Meta-analysis showed that among the three had surgical modalities, the robotic-assisted treatment took the longest time in terms of operative time and was most likely to cause postoperative intestinal obstruction, but performed best in terms of length of hospital stay and had the best postoperative results in preventing abdominal infection, bleeding, anastomotic leakage, pneumonia, and overall postoperative complications.

Conclusion

Robotic-assisted distal gastrectomy is safe and feasible. Patients have an excellent postoperative prognosis, but there are still some problems with the robotic-assisted treatment itself and more aspects to be considered clinically. We expect to improve robotic technology and promote the development of minimally invasive surgery in the future.

Introduction

Gastric cancer is a highly prevalent malignancy, mainly in China, Korea, and Japan. Over the past few decades, significant advances have been made in surgical techniques to treat gastric cancer. The transition from conventional open distal gastrectomy to laparoscopic procedures has evolved to robotic-assisted treatment.

Minimally invasive surgical techniques have evolved since Kitano et al. first used laparoscopic procedures to treat gastric cancer. [1]The use of laparoscopic techniques for the treatment of gastric cancer has also spread worldwide and is now well established and widely used to eradicate early gastric cancer. However, laparoscopic treatment of advanced gastric cancer has its drawbacks, mainly the increased extent of resection and more complex lymph node dissection in advanced gastric cancer, which further increases the requirement for anatomical precision, which to a certain extent limits the development of minimally invasive surgery. The introduction of robotic-assisted technology is undoubtedly a significant advance in minimally invasive surgery, breaking through the limitations of laparoscopic techniques. However, robotic distal gastrectomy has only been widely used in clinical practice in recent years, and further research is needed on its efficacy and patient prognosis after surgery.

The sample size of today's studies on robotic-assisted therapy is small, and most of them are predominantly single-center. Network Meta-analysis addresses the limitations of this part of the study well by integrating different studies and combining direct and indirect comparisons to provide a more useful reference for selecting different surgical approaches. This study compared several outcome indicators related to operative time, hospital stay, and postoperative complications between three surgical approaches, namely, conventional open distal gastrectomy, laparoscopic-assisted distal gastrectomy, and robot-assisted distal gastrectomy, as also studied by Yi Wang et al.[2]However, their study only compared laparoscopic and robotic-assisted treatment. This study compared the three surgical modalities, included multiple outcome indicators, more rationally evaluated the differences between the different surgical modalities, more accurately assessed the advantages and disadvantages of robot-assisted distal gastric cancer radical surgery, and provided an evidence-based medical basis for clinical work.

Materials And Methods

Study registration

The protocol for this systematic review was registered on INPLASY (Unique ID number). The registration number: INPLASY2021120121.

Study selection

We searched all English-language literature from PubMed, Embase, Cochrane Library, Ovid, and other literature databases for transcatheter, laparoscopic-assisted treatment, and da Vinci robot-assisted D2 distal gastrectomy for gastric cancer. At the same time, the references included in the literature were searched to supplement the relevant literature. English search terms had Robot gastrectomy, Da Vinci Robot, laparoscopy, laparoscopic, stomach neoplasms, gastric cancer, gastric carcinoma, and stomach cancer. The search period is from 2015 to December 2021.

Inclusion criteria

Study type: RCT or non-RCT-based literature, language limited to English. Subjects: Patients with a postoperative pathological or cytological confirmation of gastric cancer. Outcome indicators: The direct observation was patients' postoperative symptoms and complications (including postoperative pneumonia, anastomotic leakage, and ileus, etc.), and the second observation was patients' operative time and length of hospital stay. Control measures: Three surgical procedures included conventional open distal gastrectomy, laparoscopic-assisted distal gastrectomy, and robot-assisted distal gastrectomy.

Exclusion criteria

Type of study: Literature that does not account for the kind of study or where the type of study does not match. Type of literature: literature that does not match the kind of literature, such as reviews, meta-analyses, non-comparative studies, conference reports, etc. Outcome indicators: literature from which valid outcome data could not be extracted and literature in which the hands studied in the literature did not match. Control measures: literature with only a single surgical procedure or no surgical procedure for comparison. Subjects: literature that included patients with comorbid other malignancies or who could not tolerate surgery. Additional screening criteria: literature with too small a sample size or poor experimental design.

Literature screening, quality assessment, and data extraction

Two researchers carried out the selection, quality assessment, and data extraction, with any disputes being resolved with a third researcher. The software NoteExpress was used to complete the literature screening. The researcher reads the full text and extracts the data. Basic information extracted included author, publication date, title, study type, sample size, intervention method, etc. The primary outcome indicators extracted include the incidence of ileus, abdominal infection, abdominal bleeding, anastomotic leakage, pneumonia, and total complications following surgery. The secondary outcome indicators had the operation time and the postoperative hospital stay of patients. Where data were lacking, they were supplemented by contacting the original authors by telephone or email. The included literature was evaluated for methodological quality according to the NOS scale and the JADAD scale.

Data analysis

Direct meta-analysis was performed using Review Manager 5.4 software to draw forest plots, with effect sizes odds ratio (OR) and 95% confidence interval (CI) expressed for dichotomous variable information; and mean difference (MD) and 95% confidence interval (CI) expressed for continuous varying effect sizes.

A network meta-analysis was performed using R-Studio software (JAGS 4.3.0). The net relationship between the interventions was plotted. A χ^2 test and I^2 quantification were performed to determine the magnitude of heterogeneity. When $I^2 \leq 50\%$, heterogeneity was ignored; $I^2 > 50\%$-70%, there was moderate heterogeneity; $I^2 > 70\%$ was high heterogeneity, and a random-effects model was required. Draw forest plots and ranked probability plots to compare the advantages and disadvantages of various surgical approaches.

Results

Selected studies

The researchers obtained 8586 publications through a preliminary database search (Pubmed 2492; Cochrane Library 906; EMBASS 3714; Ovid 1474), removed duplicates 4416 by NoteExpress software, excluded systematic reviews, reviews, and other literature, as well as studies with inconsistent content or inconsistent control, measures 4102 by reading the abstracts, banned 39 literature with conflicting outcome indicators after reading the complete text, and finally included 29 publications, as detailed in Fig. 1.

Literature characteristics and quality assessment

There were nine RCTs, of which all nine were rated as high quality according to the JADAD scale for methodological quality. There were 20 cohort studies, of which 6 scored a eight on the NOS scale, and the others were also of high quality. The literature included 13724 patients, of whom 6985 were treated with laparoscopic-assisted distal gastrectomy; 1359 with robot-assisted distal gastrectomy; and 5380 with conventional open distal gastrectomy, as shown in Tables 1, 2, and 3.

Table 1
Characteristics of the selected studies.

Author	Area	Year	Type of GC	Number	Age	Sex	Type of study
Zheng-Yan, L[3]	China	2021	LDG	516	54.63 ± 11.85	M333F183	non RCT
			RDG	516	55.10 ± 10.24	M354F162	
Zheng, L[4]	China	2016	LDG	23	76.6 ± 4.6	M17F6	non RCT
			ODG	27	80.0 ± 5.4	M15F12	
Zhang, Y[5]	China	2015	LDG	86	Average 62	M57F29	non RCT
			ODG	86	Average 61	M61F25	
Wang, Z[6]	China	2019	LDG	222	59.4 ± 12.4	M144F78	RCT
			ODG	220	60.6 ± 10.2	M133F87	
Wang, J. B[7]	China	2020	LDG	190	57.7 ± 10.7	M134F56	non RCT
			ODG	190	58.3 ± 10.2	M131F59	
Wang, H[8]	China	2019	LDG	414	56.03 ± 12.74	M276F138	non RCT
			ODG	355	54.37 ± 11.44	M229F126	
Song, J. H[9]	Korea	2020	LDG	40	58.1 ± 11.6	M25F15	non RCT
			RDG	40	56.4 ± 12.8	M24F16	
Seo, W. J[10]	Korea	2020	LDG	261	62.0 ± 11.5	M147F114	non RCT
			RDG	241	57.2 ± 12.1	M131F100	
Qian, C. L[11]	China	2015	LDG	50	70–86	M26F24	non RCT
			ODG	50	70–88	M30F20	

Author	Area	Year	Type of GC	Number	Age	Sex	Type of study
Park, Y. K[12]	Korea	2018	LDG	100	Average 58.6	M69F31	RCT
			ODG	96	Average 60.1	M65F31	
Li, Z[13]	China	2019	LDG	45	Average 59	M31F14	non RCT
			ODG	50	Average 61	M45F15	
Lee, J[14]	Korea	2016	LDG	1205	56.5 ± 12.0	M721F484	non RCT
			ODG	1205	56.5 ± 12.0	M721F484	
Lee, H. J[15]	Korea	2019	LDG	460	59.9 ± 10.8	M333F127	RCT
			ODG	458	59.5 ± 11.6	M321F137	
Kim, S. H[16]	Korea	2019	LDG	60	62.5 ± 14.2	M38F22	non RCT
			ODG	60	62.4 ± 10.4	M41F19	
Katai, H[17]	Japan	2020	LDG	457	Average 63	M289F168	RCT
			ODG	455	Average 64	M275F180	
Katai, H[18]	Japan	2017	LDG	457	Average 63	M289F168	RCT
			ODG	455	Average 64	M275F180	
Isobe, T[19]	Japan	2021	LDG	50	69.3 ± 1.4	M34F16	non RCT
			RDG	50	69.2 ± 1.4	M31F19	
Inokuchi, M[20]	Japan	2018	LDG	45	Average 82	M29F16	non RCT
			ODG	25	Average 83	M15F10	
Hyung, W. J[21]	America	2020	LDG	492	59.8 ± 11	M351F141	RCT

Author	Area	Year	Type of GC	Number	Age	Sex	Type of study
			ODG	482	59.4 ± 11.5	M335F147	
Hu, Y[22]	China	2016	LDG	519	56.5 ± 10.4	M380F139	RCT
			ODG	520	55.8 ± 11.1	M346F174	
Hong, S. S[23]	Korea	2016	LDG	232	55.0 ± 13.0	M156F76	non RCT
			RDG	232	53.7 ± 11.5	M154F78	
Hikage, M[24]	Japan	2018	LDG	160	Average 65	M104F56	non RCT
			RDG	109	Average 64	M62F47	
Garbarino,G.M[25]	Italy	2020	LDG	34	70.9 ± 10.7	M23F11	non RCT
			ODG	34	71.1 ± 9.1	M21F13	
Fujiya, K[26]	Japan	2018	LDG	59	-	M36F23	non RCT
			ODG	59	-	M38F21	
Cianchi, F[27]	Italy	2016	LDG	41	Average 74	M19F22	non RCT
			RDG	30	Average 73	M14F16	
Chen, Q[28]	China	2018	LDG	35	57.9 ± 10.4	M25F10	non RCT
			ODG	39	60.3 ± 11.4	M29F10	
Lin,J.X[29]	China	2016	LDG	213	60 ± 12	M152F60	non RCT
			ODG	213	59 ± 12	M148F65	
Li, Z[30]	China	2016	LDG	377	54.2 ± 11.4	M247F130	RCT
			ODG	301	55.3 ± 12.5	M194F107	

Author	Area	Year	Type of GC	Number	Age	Sex	Type of study
Lu, J[31]	China	2021	LDG	142	59.3 ± 11.3	M90F52	RCT
			RDG	141	59.4 ± 10.2	M94F47	

Table 2

Assessment of the quality of the studies using the NOS scale

Study	Selection	Comparability	Outcome	Score
Zheng-Yan, L2021[3]	□□□	□□	□□	7
Zheng, L2016[4]	□□□	□□	□□□	8
Zhang, Y2015[5]	□□□	□□	□□	7
Wang, J. B2020[7]	□□□	□□	□□□	8
Wang, H2019[8]	□□□	□□	□□□	8
Song, J. H2020[9]	□□□	□□	□□	7
Seo, W. J2020[10]	□□□	□□	□□	7
Qian, C. L2015[11]	□□□	□□	□□	7
Lin, J. X2016[29]	□□□	□□	□□□	8
Li, Z2016[30]	□□□	□□	□□□	8
Lee, J2016[14]	□□□	□□	□□□	8
Kim, S. H2019[16]	□□□	□□	□□	7
Isobe, T2021[19]	□□□	□□	□□	7
Inokuchi, M2018[20]	□□□	□□	□□	7
Hong, S. S2016[23]	□□□	□□	□□	7
Hikage, M2018[24]	□□□	□□	□□	7
Garbarino, G. M2020[25]	□□□	□□	□□	7
Fujiya, K2018[26]	□□□	□□	□□	7
Cianchi, F2016[27]	□□□	□□	□□	7
Chen, Q2018[28]	□□□	□□	□□	7

Table 3
Assessment of the quality of the studies using the JADAD scale

Study	Random sequence production	Allocation concealment	Blinding method	Withdrawal	Score
Wang, Z2019[6]	2	1	0	1	4
Park, Y. K2018[12]	2	1	0	1	4
Lu, J2021[31]	2	1	0	1	4
Li, Z2019[13]	2	1	1	1	5
Lee, H. J2019[15]	2	1	0	1	4
Katai, H2020[17]	2	1	0	1	4
Katai, H2017[18]	2	1	0	1	4
Hyung, W. J2020[21]	2	1	0	1	4
Hu, Y2016[22]	2	1	0	1	4

Network plot

In total, the study included the operation time, the postoperative hospital stay, the incidence of postoperative ileus, postoperative anastomotic leakage, postoperative abdominal infection, postoperative abdominal hemorrhage, postoperative pneumonia, and the total postoperative complications. A mesh relationship diagram illustrates the sample size and relationship between the different surgical modalities in the eight outcome indicators, which can be seen in Figure 2.

Direct Meta-analysis

Meta-analysis results in terms of operative time showed that LDG took more operative time compared to ODG (MD=31.7, 95% CI =16.93 to 46.47). Compared to RDG, LDG took less time to operate (MD = -32.16, 95% CI = -44.38 to -19.94). Meta-analysis results regarding the postoperative hospital stay showed that patients in the LDG group had a shorter hospital stay than the ODG group (MD = -1.27, 95% CI = -1.93 to -0.61). There was no statistical significance between RDG and LDG (MD = 0.04, 95% CI = -0.88 to 0.97). Meta-analysis results in terms of the incidence of postoperative bowel obstruction showed no statistical significance between ODG and LDG (OR = 0.76, 95% CI = 0.52 to 1.14) and between LDG and RDG (OR = 0.78, 95% CI = 0.35 to 1.73). Meta-analysis results regarding the incidence of postoperative abdominal infection showed no statistical significance between ODG and LDG (OR = 1.18, 95% CI = 0.55 to 2.50) and between LDG and RDG (OR = 1.85, 95% CI = 0.74 to 4.62). Meta-analysis results regarding the incidence of postoperative abdominal hemorrhage showed no statistical significance between ODG and LDG (OR = 1.02, 95% CI = 0.40 to 2.60) and between LDG and RDG (OR = 2.35, 95% CI = 0.78 to 7.13). Meta-analysis results in terms of the incidence of postoperative pneumonia showed no statistical significance between ODG and LDG (OR = 0.91, 95% CI = 0.65 to 1.26). The incidence of postoperative pneumonia was higher in LDG than RDG (OR=1.77, 95% CI =1.08 to 2.88). Meta-analysis results regarding postoperative anastomotic leakage incidence showed no statistical significance between ODG and LDG (OR=1.35, 95% CI =0.84 to 2.19) and between LDG and RDG (OR=1.28, 95% CI =0.51 to 3.23). Meta-analysis results of total postoperative complication rates showed no statistical significance between ODG and LDG (OR=0.92, 95% CI =0.75 to 1.11), and between LDG and RDG (OR=1.08, 95% CI =0.79 to 1.50), as seen in Figure 3.

Network meta-analysis

Operative time

A total of 19 publications and 7,402 patients were involved. Using a random-effects model, there was significant heterogeneity between ODG and LDG (I^2 = 95.6%) and between RDG and LDG (I^2 = 90.9%). Compared to ODG, LDG (MD =32, 95% CI =16 to 47) and RDG (MD =67, 95% CI =38 to 97) took more time to operate, and compared to LDG, RDG (MD =35, 95% CI =9.8-61) took more time to use, as shown in Figure 4. Concerning operative time for the different surgical procedures, the ranking results were RDG (99.5%), LDG (99.5%), ODG (99.9%), as shown in Figure 5.

Postoperative hospital stay

The study involved a total of 15 publications and 6500 patients. There was moderate heterogeneity between ODG and LDG (I^2 = 69.4%) and significant heterogeneity between RDG and LDG (I^2 = 92.7%), using a random-effects model. Length of stay was longer for ODG (MD = 1.3, 95% CI = 0.41-2.3) compared to LDG. Compared to RDG, ODG (MD = 1.4, 95% CI = 0.029-28) had a longer length of stay, with no significant difference between LDG and RDG ($p > 0.05$), as can be seen in Figure 4. Concerning the length of stay by surgical modality, the ranked results were ODG (97.5%), LDG (53.4%), and RDG (53.4%), as can be This can be seen in Figure 5.

Postoperative ileus

A total of 19 papers and 8341 patients were involved. Of these, there was no significant heterogeneity between studies (I^2=0). There were no statistically significant differences between the studies ($P > 0.05$). Concerning the incidence of postoperative bowel obstruction by surgical approach, the ranked results were RDG (48.3%), ODG (42.3%), and LDG (63.5%), as shown in Figure 5.

Postoperative abdominal infection

A total of 8 papers and 3401 patients were involved. There was no significant heterogeneity between the studies (I^2=0). There were no statistically significant differences between the studies ($P > 0.05$). Concerning the incidence of postoperative abdominal infections by surgical approach, the ranked results were LDG (59.1%), ODG (44.1%), and RDG (73.3%), as shown in Figure 5.

Postoperative abdominal hemorrhage

A total of 8 papers and 3551 patients were involved. There was no significant heterogeneity between studies ($I^2 < 50\%$). There were no statistically significant differences between the studies ($P > 0.05$). Concerning the incidence of postoperative abdominal hemorrhage by surgical approach, the ranked results were ODG (52.2%), LDG (52.8%), and RDG (84.5%), as shown in Figure 5.

Postoperative pneumonia

A total of 17 papers and 8,164 patients were involved. Of these, there was no significant heterogeneity between studies ($I^2 < 50\%$). The incidence of postoperative pneumonia was higher in ODG (OR = 2.4, 95% CI = 1.1-6.5) and LDG (OR = 1.9, 95% CI = 1.0-4.2) compared to RDG, with no significant differences between the other studies ($p > 0.05$), as shown in Figure 4. The ranked probability plots show ranked results for ODG (82.1%), LDG (80.9%)), and RDG (97.5%), as shown in Figure 5.

Postoperative anastomotic leakage

Outcome indicators such as anastomotic leakage were included in 17 papers, comprising 7,807 patients. There was no significant heterogeneity between the studies ($I^2 < 50\%$) and no statistically significant differences ($p > 0.05$). Regarding the incidence of postoperative anastomotic fistula by surgical approach, the ranked results were LDG (58.3%), ODG (43.8%), and RDG (57.2%), as shown in Figure 5.

Total postoperative complications

The studies involved a total of 12 papers and 4803 patients. There was moderate heterogeneity between ODG and LDG ($I^2 = 53.9\%$) and no significant heterogeneity between the other studies ($I^2 < 50\%$). There were no statistically significant differences between the studies ($P > 0.05$). Regarding the incidence of postoperative complications by surgical modality, the ranked results were ODG (73.2%), LDG (58.5%), and RDG (60.2%), as shown in Figure 5.

Discussion

Surgery is still the only means of eradicating gastric cancer. With the development of minimally invasive surgery, surgical techniques are also advancing. Radical surgery for gastric cancer is mainly applied under open and laparoscopic procedures. Countries like Japan and Korea have made laparoscopic adjuvant treatment routines for extreme gastric cancer. In recent years, da Vinci robot-assisted treatment has also become an alternative surgical procedure for cancer treatment. However, robotic adjuvant therapy for radical surgery for distal gastric cancer is controversial, mainly in four areas.

The first is the extent to which surgery can eradicate gastric cancer, including the patient's postoperative tumor recurrence rate and postoperative survival rate. Robot-assisted treatment allows the surgeon to observe the anatomy around the tumor more clearly and apply the surgeon's skills to a greater extent compared to laparoscopy. While eradicating gastric cancer, the lymph node clearance is expanded, thus reducing the tumor recurrence rate and improving the patient's postoperative survival rate. Some long-term follow-up studies also point to the effectiveness of robotic adjuvant therapy comparable to laparoscopic adjuvant treatment in terms of postoperative survival rates.[32]However, as too little literature on survival and recurrence rates after gastric cancer was included in this study, no outcome indicators on survival were used. We look forward to more literature on this topic in the future to improve this study.

Secondly, regarding the simplicity and ease of the surgical approach, this study included mainly outcome indicators such as operative time. This meta-analysis showed that open distal gastrectomy required the shortest operative time and robotic-assisted treatment took the longest. The most significant aspect affecting operative time was the type of surgery. The literature included in this study used radical resection of distal gastric cancer, with no differences in the kind of surgery. However, preoperative robotic-assisted treatment required assembly of the robotic system, adding additional preparation time, and intraoperative robotic-assisted distal gastric cancer resection was technically more complex, requiring precise identification of the location of large vessels in the abdominal cavity and the extent of resection and lymph node dissection. Moreover, laparoscopic and robotic-assisted techniques are the latest minimally invasive surgical techniques that require more skill from surgeons unfamiliar with them and take more time to use minimally invasive techniques. More surgeons will become skilled in this technique as minimally invasive surgery evolves and robot-assisted therapy becomes more widely available worldwide.

The other side of the coin is the patient's postoperative recovery. The current study used postoperative hospital stay to assess the three surgical modalities. This meta-analysis showed that patients treated with robotic assistance spent the shortest hospital stay. Still, there was no statistical difference between the two groups using laparoscopy and those using robotics, suggesting that the more advanced technology may not have contributed to a faster recovery.

The last aspect is the patient's postoperative adverse symptoms and complications. The results of this Meta-analysis show that robotic-assisted treatment is the most effective in preventing postoperative abdominal infections, postoperative bleeding, postoperative anastomotic leakage, postoperative pneumonia, and overall postoperative complications. The endoscopic system used in robot-assisted treatment provides a higher resolution three-dimensional surgical image, allowing the surgeon to visualize the anatomy around the tumor accurately, and the robot arm is more flexible and more accessible for the surgeon to operate, reducing unnecessary intraoperative strain on the gastrointestinal tract and avoiding complications such as abdominal bleeding and anastomotic leakage.[33]On the other hand, the robotic-assisted technique operates through tiny incisions, which reduces the degree of damage to the body, reduces the systemic inflammatory response, and avoids systemic complications such as pneumonia.

Conclusion

Robotic-assisted distal gastrectomy is a safe and effective surgical procedure with a good prognosis for patients with few postoperative complications. Still, more aspects need to be considered clinically to select the appropriate surgical approach. We look forward to further improvements in robotic technology in the future to facilitate its dissemination worldwide.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analysed during this study are included in this published article [and its supplementary information files].

Competing interests

The authors declare that they have no competing interests

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Author contributions

TZQ, HXJ and LWT conceived and designed experiments. TZQ and HXJ analyzed data and wrote the manuscript. LWT performed the in vitro and in vivo studies. Pathology support, tissue provision, and collection of patient information were accomplished by SCC and GL. JJH assisted in experimental design and data evaluation. ZL, HZP and WLX supervised the project. All authors have read and approved the manuscript.

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References

1. Yakoub, D., et al., Laparoscopic-assisted distal gastrectomy for early gastric cancer: is it an alternative to the open approach? Surg Oncol, 2009. 18(4): p. 322–33.
2. Wang, Y., et al., A systematic review and meta-analysis of robot-assisted versus laparoscopically assisted gastrectomy for gastric cancer. Medicine (Baltimore), 2017. 96(48): p. e8797.
3. Zheng-Yan, L., et al., Morbidity and short-term surgical outcomes of robotic versus laparoscopic distal gastrectomy for gastric cancer: a large cohort study. Surg Endosc, 2021. 35(7): p. 3572–3583.
4. Zheng, L., et al., Laparoscopy-assisted versus open distal gastrectomy for gastric cancer in elderly patients: a retrospective comparative study. Surg Endosc, 2016. 30(9): p. 4069–77.
5. Zhang, Y., et al., Long-term follow-up after laparoscopic versus open distal gastrectomy for advanced gastric cancer. Int J Clin Exp Med, 2015. 8(8): p. 13564–70.
6. Wang, Z., et al., Short-term surgical outcomes of laparoscopy-assisted versus open D2 distal gastrectomy for locally advanced gastric cancer in North China: a multicenter randomized controlled trial. Surg Endosc, 2019. 33(1): p. 33–45.
7. Wang, J.B., et al., Well-designed retrospective study versus small-sample prospective study in research-based on laparoscopic and open radical distal gastrectomy for advanced gastric cancer. Surg Endosc, 2020. 34(10): p. 4504–4515.
8. Wang, H., et al., Long-term outcomes of laparoscopy-assisted distal gastrectomy versus open distal gastrectomy for gastric cancer: a 10-year single-institution experience. Surg Endosc, 2019. 33(1): p. 135–144.
9. Song, J.H., et al., D2 Lymph Node Dissections during Reduced-port Robotic Distal Subtotal Gastrectomy and Conventional Laparoscopic Surgery Performed by a Single Surgeon in a High-volume Center: a Propensity score-matched Analysis. J Gastric Cancer, 2020. 20(4): p. 431–441.
10. Seo, W.J., et al., Reduced-port totally robotic distal subtotal gastrectomy for gastric cancer: 100 consecutive cases in comparison with conventional robotic and laparoscopic distal subtotal gastrectomy. Sci Rep, 2020. 10(1): p. 16015.
11. Qian, C.L., et al., Analysis of safety of laparoscopy-assisted distal gastrectomy on elderly patients. Journal of Shanghai Jiaotong University (Medical Science), 2015. 35(12): p. 1915–1918.
12. Park, Y.K., et al., Laparoscopy-assisted versus Open D2 Distal Gastrectomy for Advanced Gastric Cancer: Results From a Randomized Phase II Multicenter Clinical Trial (COACT 1001). Ann Surg, 2018. 267(4): p. 638–645.
13. Li, Z., et al., Assessment of Laparoscopic Distal Gastrectomy After Neoadjuvant Chemotherapy for Locally Advanced Gastric Cancer: A Randomized Clinical Trial. JAMA Surg, 2019. 154(12): p. 1093–1101.
14. Lee, J.H., et al., Comparison of the long-term results of patients who underwent laparoscopy versus open distal gastrectomy. Surg Endosc, 2016. 30(2): p. 430–436.
15. Lee, H.J., et al., Short-term Outcomes of a Multicenter Randomized Controlled Trial Comparing Laparoscopic Distal Gastrectomy With D2 Lymphadenectomy to Open Distal Gastrectomy for Locally Advanced Gastric Cancer (KLASS-02-RCT). Ann Surg, 2019. 270(6): p. 983–991.

16. Kim, S.H., et al., Oncologic Outcomes after Laparoscopic and Open Distal Gastrectomy for Advanced Gastric Cancer: Propensity Score Matching Analysis. J Gastric Cancer, 2019. 19(1): p. 83–91.
17. Katai, H., et al., Survival outcomes after laparoscopy-assisted distal gastrectomy versus open distal gastrectomy with nodal dissection for clinical stage IA or IB gastric cancer (JCOG0912): a multicentre, non-inferiority, phase 3 randomised controlled trial. Lancet Gastroenterol Hepatol, 2020. 5(2): p. 142–151.
18. Katai, H., et al., Short-term surgical outcomes from a phase III study of laparoscopy-assisted versus open distal gastrectomy with nodal dissection for clinical stage IA/IB gastric cancer: Japan Clinical Oncology Group Study JCOG0912. Gastric Cancer, 2017. 20(4): p. 699–708.
19. Isobe, T., et al., Robotic versus laparoscopic distal gastrectomy in patients with gastric cancer: a propensity score-matched analysis. BMC Surg, 2021. 21(1): p. 203.
20. Inokuchi, M., et al., Laparoscopic Distal Gastrectomy is Feasible in Very Elderly Patients as Compared with Open Distal Gastrectomy. J Invest Surg, 2018. 31(6): p. 539–545.
21. Hyung, W.J., et al., Long-Term Outcomes of Laparoscopic Distal Gastrectomy for Locally Advanced Gastric Cancer: The KLASS-02-RCT Randomized Clinical Trial. J Clin Oncol, 2020. 38(28): p. 3304–3313.
22. Hu, Y., et al., Morbidity and Mortality of Laparoscopic Versus Open D2 Distal Gastrectomy for Advanced Gastric Cancer: A Randomized Controlled Trial. J Clin Oncol, 2016. 34(12): p. 1350–7.
23. Hong, S.S., et al., Can Robotic Gastrectomy Surpass Laparoscopic Gastrectomy by Acquiring Long-Term Experience? A Propensity Score Analysis of a 7-Year Experience at a Single Institution. J Gastric Cancer, 2016. 16(4): p. 240–246.
24. Hikage, M., et al., Comparison of Surgical Outcomes Between Robotic and Laparoscopic Distal Gastrectomy for cT1 Gastric Cancer. World J Surg, 2018. 42(6): p. 1803–1810.
25. Garbarino, G.M., et al., Laparoscopic versus open distal gastrectomy for locally advanced gastric cancer in middle-low-volume centers in Western countries: a propensity score matching analysis. Langenbecks Arch Surg, 2020. 405(6): p. 797–807.
26. Fujiya, K., et al., Feasibility of Laparoscopic Distal Gastrectomy for Stage I Gastric Cancer in Patients Outside of Clinical Trials. J Gastrointest Surg, 2018. 22(10): p. 1665–1671.
27. Cianchi, F., et al., Robotic vs laparoscopic distal gastrectomy with D2 lymphadenectomy for gastric cancer: a retrospective comparative mono-institutional study. BMC Surg, 2016. 16(1): p. 65.
28. Chen, Q., et al., Evaluation of early surgical outcomes, acute inflammatory response and oncological outcomes in patients undergo totally laparoscopic distal gastrectomy: A prospective comparison with open distal gastrectomy. International Journal of Clinical and Experimental Medicine, 2018. 11(11): p. 12264–12274.
29. Lin, J.X., et al., [Surgical outcomes after laparoscopy-assisted distal gastrectomy and open distal gastrectomy for patients with advanced gastric cancer: a case-control study using a propensity score method]. Zhonghua Wai Ke Za Zhi, 2016. 54(10): p. 755–760.

30. Li, Z., et al., [Efficacy comparison of laparoscopic versus open distal gastrectomy with D2 lymph dissection for advanced gastric cancer]. Zhonghua Wei Chang Wai Ke Za Zhi, 2016. 19(5): p. 530–4.
31. Lu, J., et al., Assessment of Robotic Versus Laparoscopic Distal Gastrectomy for Gastric Cancer: A Randomized Controlled Trial. Ann Surg, 2021. 273(5): p. 858–867.
32. Coratti, A., et al., Robot-assisted surgery for gastric carcinoma: Five years follow-up and beyond: A single western center experience and long-term oncological outcomes. Eur J Surg Oncol, 2015. 41(8): p. 1106–13.
33. Caruso, S., et al., Laparoscopic and robot-assisted gastrectomy for gastric cancer: Current considerations. World J Gastroenterol, 2016. 22(25): p. 5694–717.

Figures

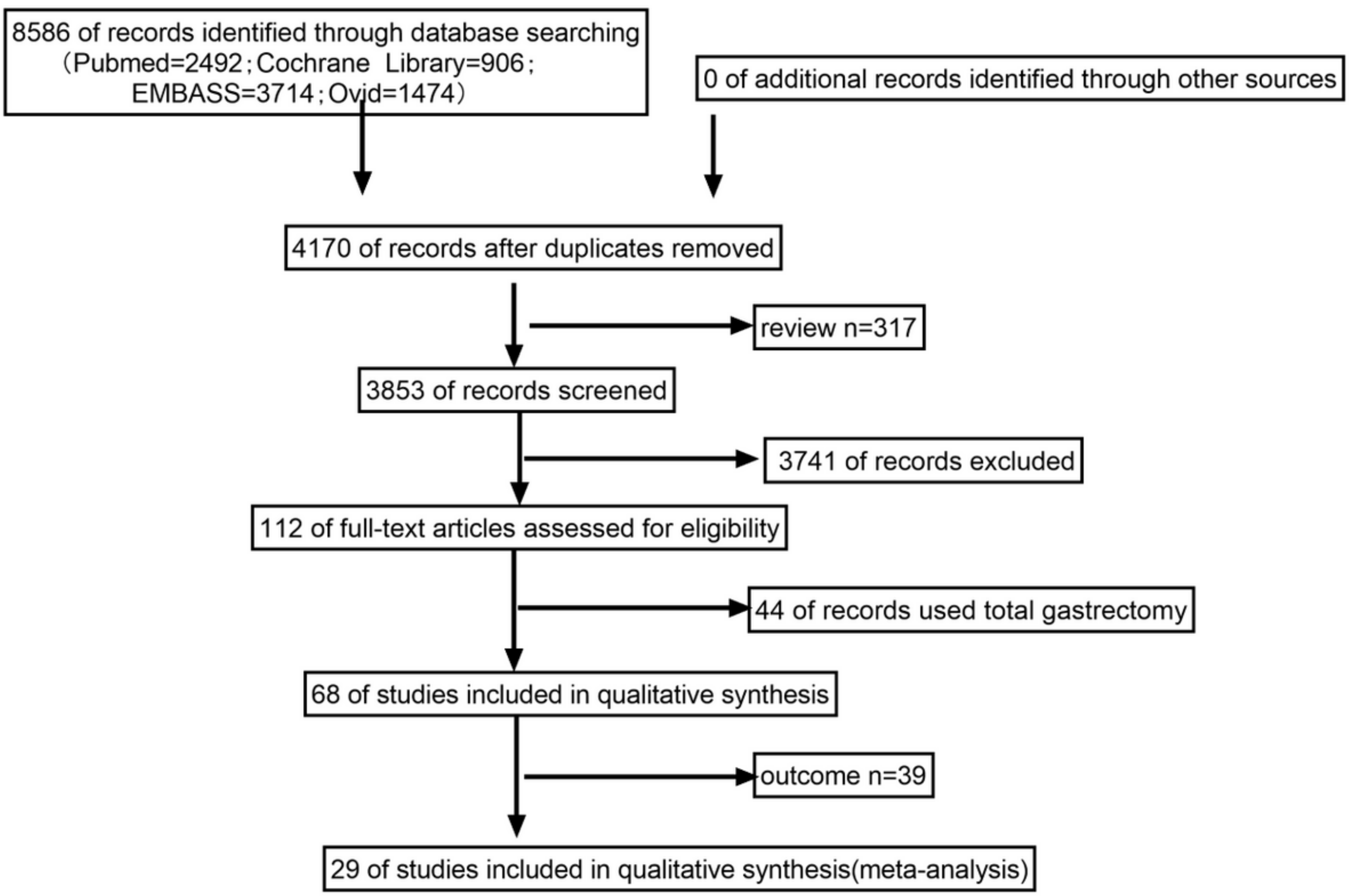

Figure 1

The flow of information for this review

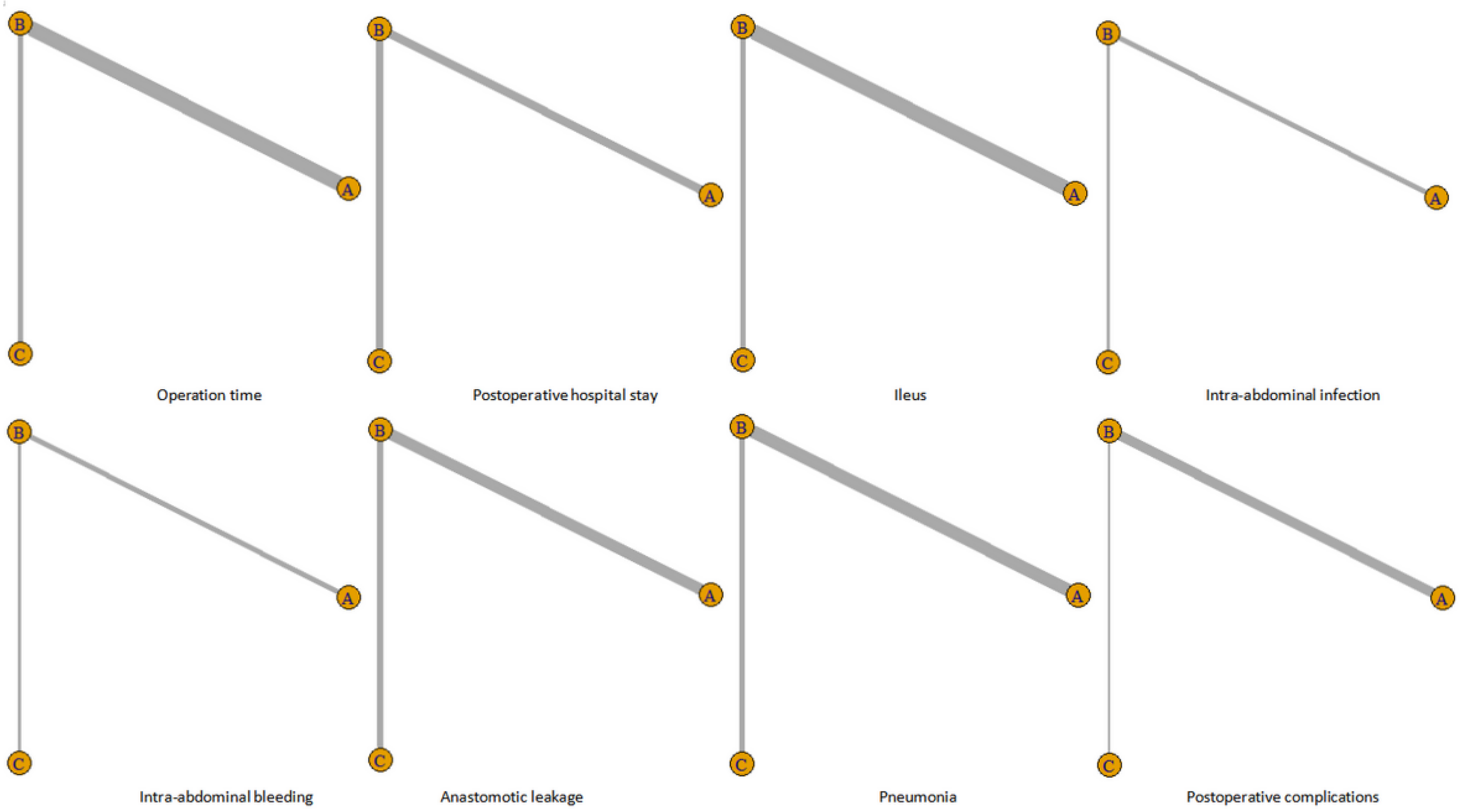

Figure 2

Network plot（A=ODG，B=LDG，C=RDG）

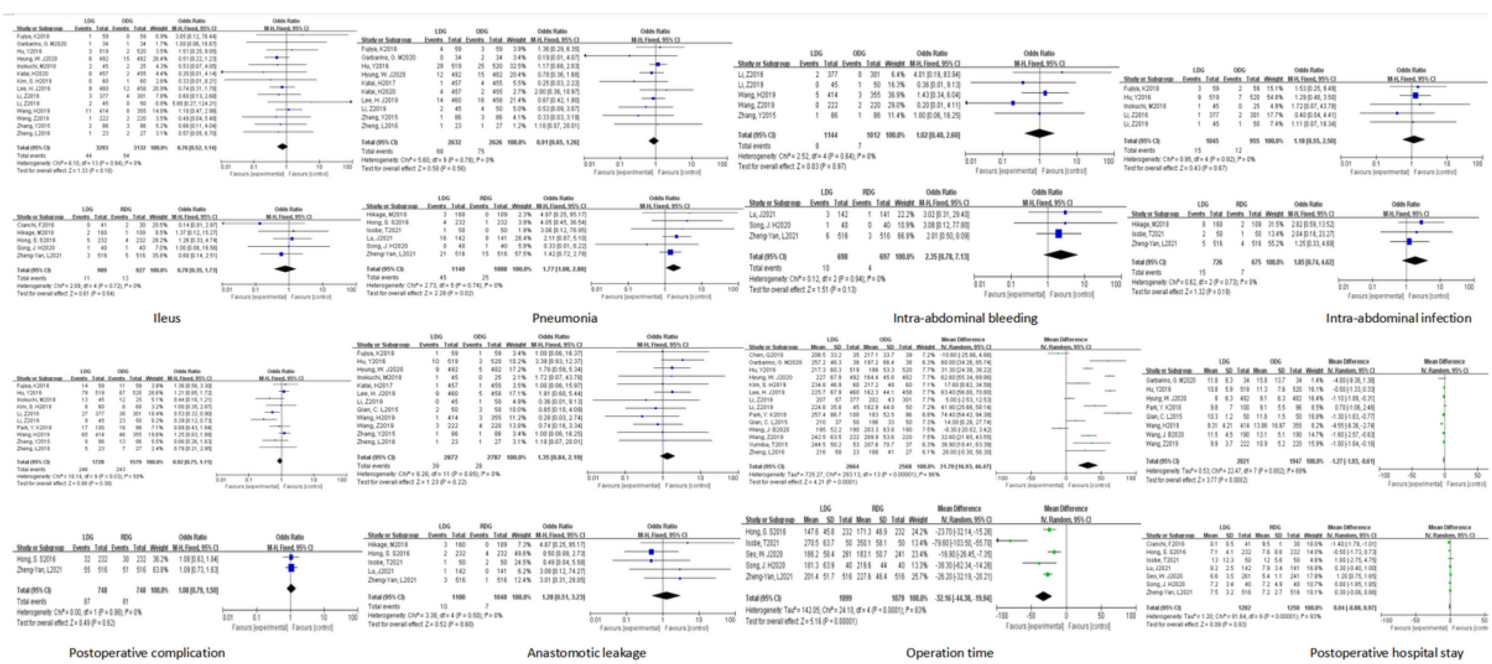

Figure 3

Forest plots from the direct meta-analysis

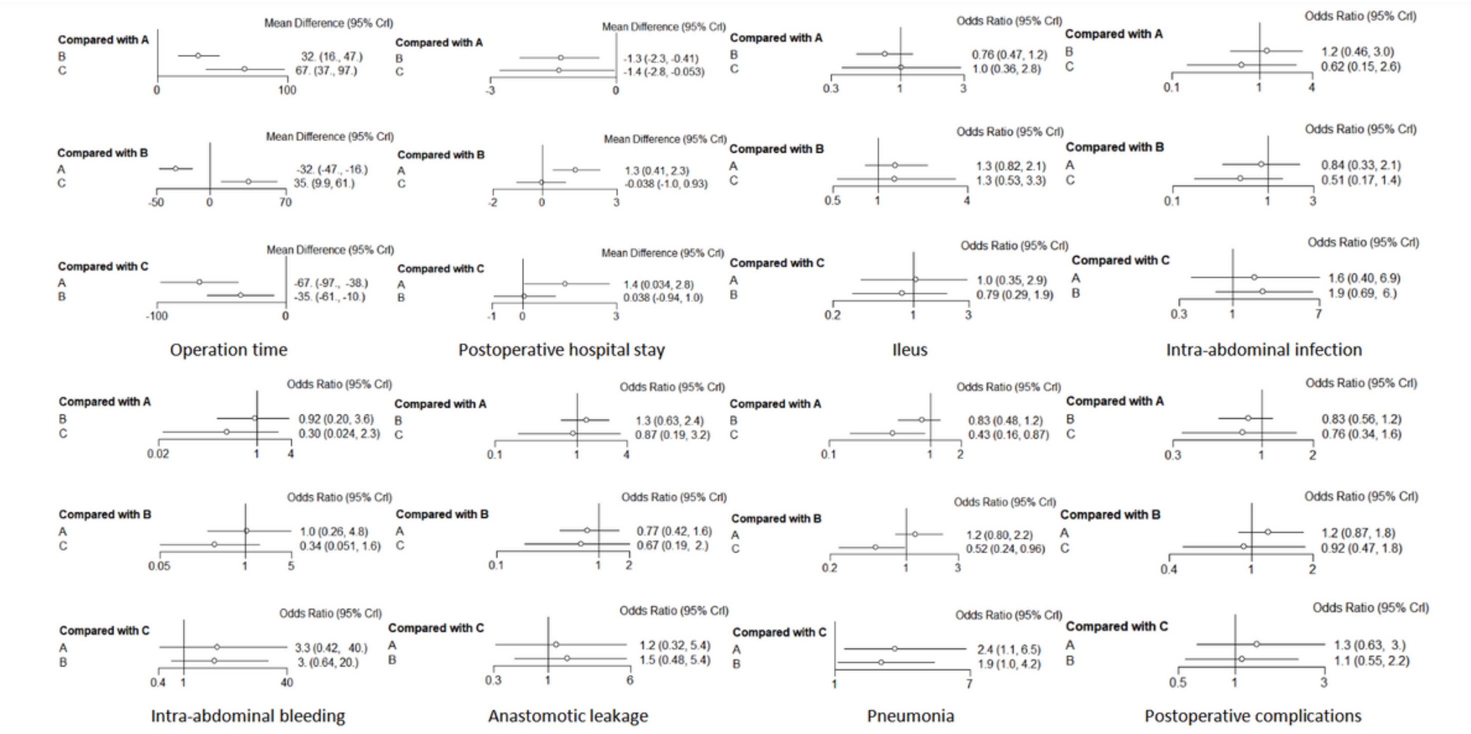

Figure 4

Forest plots from network meta-analysis

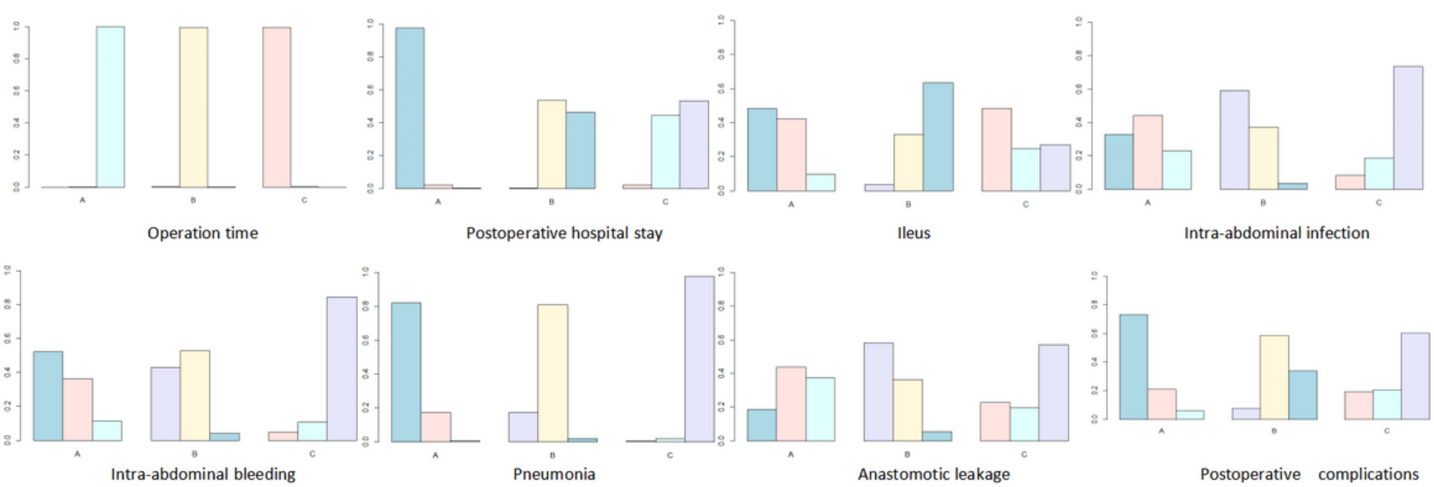

Figure 5

Results of rank probability