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Review article

Comparison of Billroth I, Billroth II, and Roux-en-Y reconstructions following distal gastrectomy: A systematic review and network meta-analysis

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ABSTRACT

Major surgical treatment for distal gastric cancer include Billroth I (BI), Billroth II (BII), and Roux-en-Y (RY). Since the optimal reconstruction methods remains inconclusive, we aimed to compare these treatments in terms of intraoperative and postoperative course after distal gastrectomy with a systematic review and random-effects network meta-analysis. We searched PubMed, Web of Knowledge, Ovid's database for prospective, randomized, controlled trials comparing the outcomes of BI, BII, and RY reconstruction after distal gastrectomy until January 2020. From the included studies, operative time, intraoperative blood loss, postoperative hospital stay, endoscopic findings and complications were extracted as the short- and long-term outcomes of reconstructions. The network meta-analysis was performed with R 3.5.2 software as well as "gemtc" and "forestplot" packages. Twelve randomized controlled trials (RCTs) involving 1662 patients were included. RY reconstruction has a lower risk and degree of remnant gastritis than BI and BII reconstructions(OR 0.40, 95%Crl: 0.24–0.64; OR 0.36, 95% Crl: 0.16–0.83, respectively). BI reconstruction method took significantly less time to perform as compared to BII and RY reconstruction (WMD 20, 95% Crl: 0.18–41; WMD 30, 95% Crl: 14–25, respectively). No differences in intraoperative blood loss, time to resumed oral intake, postoperative hospital stay, reflux oesophagitis and complications among the three reconstructions. The RY reconstruction after distal gastrectomy was more effective in preventing remnant gastritis than Billroth I and Billroth II reconstruction, although RY reconstruction was considered as technical complexity.

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Comparación de las reconstrucciones Billroth I, Billroth II y Roux-en-Y después de la gastrectomía distal: una revisión sistemática y un metaanálisis de red

R E S U M E N

Palabras clave:
Cáncer gástrico
Gastrectomía distal
Billroth I
Billroth II
Roux-en-Y

El tratamiento quirúrgico principal para el cáncer gástrico distal incluye Billroth I (BI), Billroth II (BII) y Roux-en-Y (RY). Dado que los métodos de reconstrucción óptimos no son concluyentes, nuestro objetivo fue comparar estos tratamientos en términos de curso intraoperatorio y postoperatorio después de la gastrectomía distal con una revisión sistemática y un metaanálisis de red de efectos aleatorios. Se realizaron búsquedas en PubMed, Web of Knowledge, la base de datos de Ovid para ensayos prospectivos, aleatorizados y controlados que comparan los resultados de la reconstrucción de BI, BII y RY después de la gastrectomía distal hasta enero de 2020. De los estudios incluidos, tiempo operatorio, pérdida de sangre intraoperatoria, postoperatorio la estancia hospitalaria, los hallazgos endoscópicos y las complicaciones se extrajeron como resultados a corto y largo plazo de las reconstrucciones. El metaanálisis de red se realizó con el software R 3.5.2, así como con los paquetes «gemtc» y «forestplot». se incluyeron 12 ensayos controlados aleatorios (ECA) con 1.662 pacientes. La reconstrucción RY tiene un menor riesgo y grado de gastritis remanente que las reconstrucciones BI y BII (OR: 0,40; 95% Crl: 0,24-0,64; OR: 0,36; 95% Crl: 0,16-0,83, respectivamente). El método de reconstrucción BI tardó significativamente menos tiempo en realizarse en comparación con la reconstrucción BII y RY (WMD 20; 95% Crl: 0,18-41; WMD 30; 95% Crl: 14-25, respectivamente). No hay diferencias en la pérdida de sangre intraoperatoria, el tiempo para reanudar la ingesta oral, la estancia hospitalaria postoperatoria, la esofagitis por reflujo y las complicaciones entre las 3 reconstrucciones. La reconstrucción RY después de la gastrectomía distal fue más efectiva para prevenir la gastritis remanente que la reconstrucción BI y BII, aunque la reconstrucción RY se consideró de mayor complejidad técnica.

Introduction

Gastric cancer is the fifth most common cancer and the third most common cause of death from cancer.[1] It is responsible for over 1,000,000 new cases in 2018, with an estimated 783,000 deaths worldwide.[1]

Complete surgical resection is the main method of curative treatment. Billroth I (BI), Billroth II (BII), and Roux-en-Y (RY) are all acceptable options.[2] The BI reconstruction has been commonly performed, because of its technical simplicity, with only one anastomotic site and maintaining physiological intestinal continuity.[3,4] Billroth II reconstruction solves the problem of anastomotic tension, but it may increase the incidence of postoperative alkaline reflux gastritis, esophagitis, and anastomotic ulcers because of the changes in normal physiological pathways.[5,6] RY reconstruction was chosen to prevent postoperative alkaline reflux gastritis and esophagitis of the remnant stomach after distal gastrectomy(DG).[7,8] However, RY also has complications, such as Roux limb stasis, internal hernia, and intestinal obstruction.[9] Thus, the choice of reconstruction after distal gastrectomy remains controversial.

In our meta-analysis, we included trials that compared two or three reconstructions after distal gastrectomy. We excluded studies if they contained only one or none of the three strategies or did not use randomization for treatment allocation.

Materials and methods

Search strategy

PubMed, Web of Knowledge, Ovid's database were searched before January 2020 with the following combination of keywords and their variants: ''Roux-en-Y'', ''Billroth I'', ''Billroth II'', ''distal gastrectomy'' and ''randomized clinical trial''. The reference lists of relevant studies were checked manually to locate any missing studies.

Study selection

Identified studies were assessed for eligibility for inclusion in the review by scrutinizing the titles, abstracts and keywords of every record retrieved. Studies were restricted to those published in English and Chinese. Clinical studies concerning comparisons of any aspects between the BI, BII and RY for DG were also included.

Data extraction

Two coauthors (LY and JH) independently selected studies for inclusion and exclusion and reached consensus when they did not agree in the initial assignment. The following variables were recorded: authors, journal and year of publication, number of patients, age, operation time, blood loss, postoperative hospital

stay, time to resumed oral intake, reflux oesophagitis, remnant gastritis and total complications. If necessary, the corresponding authors of studies were contacted to obtain supplementary information.

Quality assessment

The quality of the trials was assessed in the light of Cochrane Handbook for Systematic Reviews of Interventions version 5.1.0.[10] The scale consists of three items, randomization, blinding, and description of the withdrawals and dropouts. Studies with a score of 3–5 were considered to be of high quality.

In view of that the trials which did not cover the outcomes of completely randomized patients were regarded as suffering from bias because of incomplete outcome data and thus they were excluded from further analysis.

Statistical analysis

The network meta-analyses using the Bayesian Methods[11] was performed in Stata 15 (Stata Corp), JAGS and R (version x64 3.5.2) with the gemtc package (version: 0.8–2) and rjags package (version: 4–6) with a random-effect model. The inconsistency of our results was confirmed by the node-splitting method and its Bayesian p value,[12] comparing the direct and the indirect estimates for each comparison. p-value <0.05 indicates a significant inconsistency. For categorical data, treatment effects were expressed as odds ratios (ORs) and 95% confidence intervals (95%CIs). For continuous data, treatment effects were expressed as standardized mean differences (SMDs) and 95%CIs. Surface under the cumulative ranking curve (SUCRA) was used to calculate the hierarchy of treatments for each intervention. The SUCRA value ranges from 0 to 1, and a higher SUCRA value indicates a better efficacy.[13]

Results

Study characteristics

After a comprehensive inspection, 12 randomized controlled trials (RCTs)[2,9,14–23] were included in our network meta-analysis(NMA) (Fig. 1). Among them, two studies[2,14] have same study populations. Two studies simultaneously compared BI, BII, and RY anastomoses; one study compared BI and BII anastomoses; two studies compared BII and RY anastomoses; and six studies compared BI and RY anastomoses. In total, 1662 patients were included in our analysis: 610 were treated with BI anastomosis; 304 were treated with BII anastomosis; and 748 were treated with RY anastomosis. Patient demographics for the 12 studies are presented in Table 1.

Three nodes were compared in the network graph, in which the size of the nodes was associated with the number of patients undergoing a certain type of anastomosis, and the thickness of the lines was related to the number of direct comparisons between 2 reconstruction methods.

NMA results

Operative time was extracted from 9 studies,[2,9,15–17,19–22] The NMA results (Fig. 2) showed that BI reconstruction had a significantly shorter operative time than (WMD 20, 95% Crl: 0.18–41) and RY(WMD 30, 95% Crl: 14–25) reconstruction. SUCRA plots indicated that RY reconstruction had the highest probability of being the worst method for reducing operative time (SUCRA = 6.7%), while BI reconstruction had the highest probability of being the best method (SUCRA = 99.6%), followed by BII (SUCRA = 43.7%) (Table 2). The results of comparisons of operative blood loss, hospital stay and time to resumed oral intake in our network meta-analysis suggested there were no significant differences among the 3 procedures (Table 3).
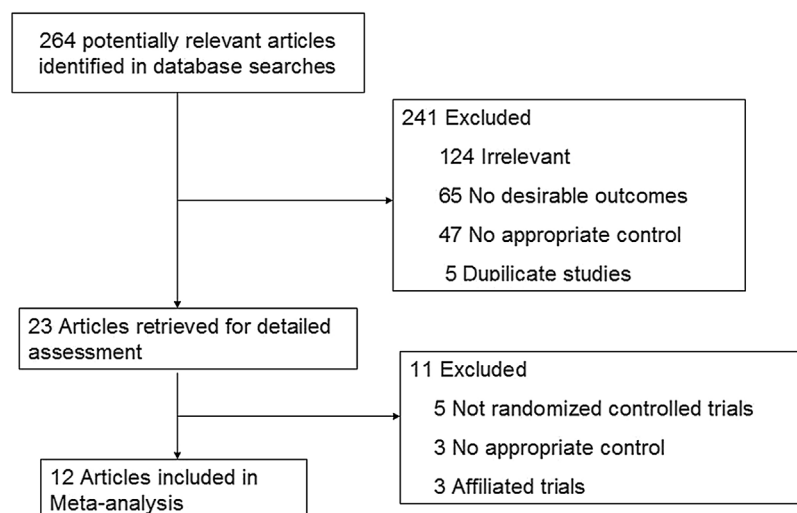

Fig. 1 – Flowchart of the results of the literature search.

Table 1 – Summary and comparison of baseline characteristics between BI, BII and RY.												
Author, Year	Country	No. of patients	Sex (male/female)	Mean age(year)	Mean Tumor size (cm)	Histological type (Poor, undifferentiated/ Moderate, Well)	Stage (Stage I/II/III/IV)	pT stage (T0–T2/ T3–T4)	pN stage (N0–N1/ N2–N3)	Adjuvant chemotherapy	Study design	Quality score
Hirao, 2012[2] or Imamura, 2012[14]	Japan	332	BI:105/58 RY:115/54	BI:65 RY:65	BI:2.9 RY:3.0	–	BI: 133/23/7/0 RY: 130/24/10/5	–	–	BI:143 RY:144	RCT	3/5
Ishikawa, 2005[9]	Japan	50	BI:19/7 RY:17/7	BI:61 RY:64	BI:4.2 RY:5.9	–	BI: 13/12/1/0 RY: 9/10/5/0	BI:25/1 RY:19/5	–	–	RCT	3/5
Lee, 2012[15]	Korea	148	BI:31/18 BII:42/10 RY:28/19	BI:60 BII:59.7 RY:58.5	–	–	–	–	–	–	RCT	4/5
Nakamura, 2016[16]	Japan	122	BI:40/20 RY:45/17	BI:66 RY:67	–	BI:35/25 RY:38/24	BI: 44/8/8/0 RY:45/8/9/0	BI:50/10 RY:52/10	BS:48/12 NBS:47/15	BI:14 RY:15	RCT	3/5
Takiguchi, 2012[17]	Japan	268	BI:105/58 RY:113/53	BI:64.5 RY:64.1	BI:2.9 RY:2.9	–	BI: 115/15/2/0 RY:114/14/7/1	–	–	–	RCT	3/5
Choi 2017[18]	Korea	40	BI:16/4 RY:10/10	BI:62.4 RY:62.8	–	–	–	BI:20/0 RY:19/1	–	–	RCT	3/5
Ren 2019[19]	China	180	BI:32/28 BII:39/21 RY:36/24	BI:47.14 BII:47.60 RY:47.86	BI:5.34 BII:5.38 RY:5.96	BI:16/44 BII: 14/46 RY: 17/43	–	BI:47/13 BII:48/12 RY:46/14	–	–	RCT	3/5
YangK 2017[20]	China	140	BI:40/30 RY:47/23	BI:56.3 RY:54.9	BI:3.6 RY:4.4	BI:57/13 RY:60/10	BI: 30/14/23/3 RY:22/19/25/4	BI:39/31 RY:33/37	BI:40/30 RY:40/30	BI:33 RY:44	RCT	3/5
Chareton 1996[21]	France	62	BI:20/10 BII:22/10	BI:71.5 BII:70.6	–	–	–	–	–	–	RCT	3/5
YangD 2017[22]	China	158	BII:54/25 RY:60/19	BII:61.8 RY:58	–	–	BII: 2/27/50/0 RY:3/31/45/0	–	–	–	RCT	3/5
So 2017[23]	Singapore	162	BII:46/35 RY:45/36	BII:62 RY:64.5	–	–	BII: 29/22/26/4 RY:25/27/26/3	–	–	BII:31 RY:31	RCT	5/5
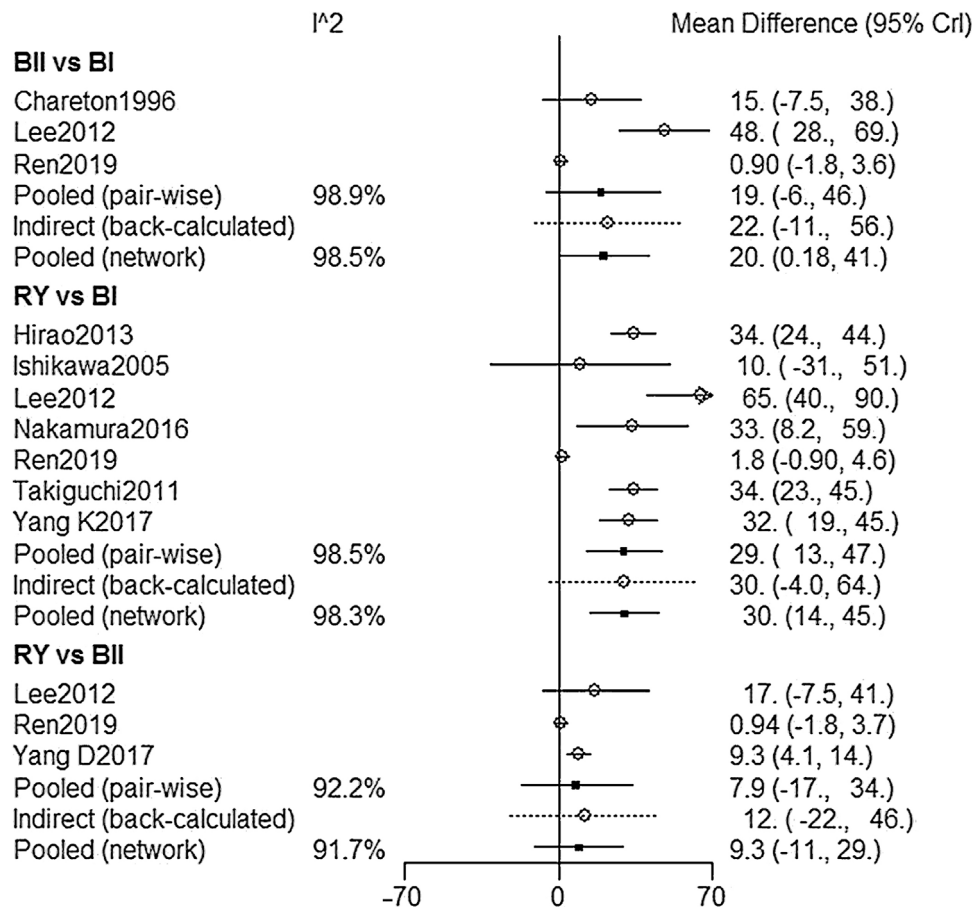
Fig. 2 – Forest plot for comparison of surgical characteristics: operative time.

Reconstruction type	Operative time	Intraoperative blood loss	Hospital stay	Time to resumed oral intake	Reflux oesophagitis	Remnant gastritis	Total complications
BI	0.996	0.816	0.201	0.193	0.253	0.32	0.789
BII	0.437	0.425	0.859	0.861	0.424	0.181	0.37
RY	0.067	0.26	0.439	0.446	0.822	1	0.341

Table 2 – Surface under the cumulative ranking curve (SUCRA) results for all outcomes.

NMA indicated that RY reconstruction had significant superiority over B-I and B-II reconstruction in remnant gastritis (OR 0.40, 95%Crl: 0.24–0.64; OR 0.36, 95% Crl: 0.16–0.83, respectively) (Fig. 3A). SUCRA plots indicated that RY reconstruction had the highest probability of being the best method for reducing remnant gastritis (SUCRA = 100%), while BII reconstruction had the highest probability of being the worst method (SUCRA = 18.1%), followed by BI (SUCRA = 32%) (Table 2). The results of comparisons of reflux oesophagitis (Fig. 3B) in our network meta-analysis suggested there were no significant differences among the 3 reconstructions.

A total of 8 studies[9,14–16,18,20,22,23] were included to compare the overall complications. The overall complication rates of BI, BII, and RY were 17.8%, 18.8%, and 20.4%, respectively. According to our NMA results, there were no significant difference among BI, BII and RY (Fig. 4). Five of eight studies were analyzed for the severity of complications with Clavien-

Dindo Classification.[24] Similar to the overall complications, there was no significant difference in grade I–II and grade III–IV complications between these three reconstructions (Table 3).

Node-spitting results

The node-spitting analysis was performed to confirm the consistency between direct and indirect comparisons. There was no significant difference in the comparison of BI, BII, and RY (p > 0.05) in terms of consistency, and the consistency model was finally adopted (Table 3).

Discussion

Up to now, we have three main techniques for anastomosis between the residual stomach and the intestine—BI, BII and

Table 3 – Summary of pair-wise meta-analysis and network meta-analysis results for the 3 reconstruction methods.

Treatment comparisons	Results of pair-wise meta-analysis (OR/WMD)	I^2 (%)	Results of network meta-analysis (OR/WMD)	I^2 (%)	Results of node-splitting analysis for consistency (p)
Operation time					
B-II vs. B-I	19(−6,46)	98.9	20(0.18,41)	98.5	0.893
RY vs. B-I	29(13,47)	98.5	30(14,45)	98.3	0.862
RY vs. B-II	7.9(−17,34)	92.2	9.3(−11,29)	91.7	0.437
Blood loss					
B-II vs. B-I	2.7(−26,45)	59.1	6.5(−18,39)	53.1	0.924
RY vs. B-I	8.0(−9.2,30)	57.7	8.3(−8.1,31)	57.8	–
RY vs. B-II	0.84(−24,28)	0	1.8(−25,26)	0	–
Time to resumed oral intake					
B-II vs. B-I	−0.21(−2.9,2.4)	–	−0.29(−2.5,2.3)	–	–
RY vs. B-I	−0.074(−1.1,1.8)	24.8	−0.069(−1.2,1.9)	25.0	–
RY vs. B-II	0.30(−2.3,2.9)	–	0.23(−2,2.8)	–	–
Hospital stay					
B-II vs. B-I	1.9(−1.7,5.2)	99.5	1.7(−1.7,5.1)	99.6	–
RY vs. B-I	2.3(−0.015,5.2)	98.7	2.1(−0.18,5.1)	98.9	–
RY vs. B-II	0.1(−4.1,4.6)	96.3	0.39(−2.9,4.5)	96.3	0.556
Remnant gastritis					
B-II vs. B-I	1.4(0.3,6.6)	0	1.1(0.44,2.6)	0	0.815
RY vs. B-I	0.39(0.22,0.64)	23.6	0.4(0.24,0.64)	23.0	–
RY vs. B-II	0.38(0.15,1.0)	0	0.36(0.16,0.83)	0	–
Reflux oesophagitis					
B-II vs. B-I	0.71(0.19,2.8)	0	0.88(0.27,3.0)	0	–
RY vs. B-I	0.63(0.26,1.6)	58.7	0.59(0.26,1.4)	58.5	–
RY vs. B-II	0.36(0.039,3.4)	0	0.67(0.18,2.6)	0	0.436
Overall complications					
B-II vs. B-I	1.8(0.21,13)	0	1.2(0.49,3.4)	0	–
RY vs. B-I	1.1(0.59,2.1)	42.4	1.2(0.63,2.1)	42.2	–
RY vs. B-II	0.97(0.39,2.3)	0	0.94(0.4,2.0)	0	–
Complications grade I-II					
RY vs. B-I	1.8(0.62,6)	0	1.8(0.61,5.6)	0	–
RY vs. B-II	0.83(0.26,2.7)	0	0.84(0.26,2.6)	0	–
Complications grade III-IV					
RY vs. B-I	1.7(0.31,16)	28.2	2(0.32,16)	28.3	–
RY vs. B-II	1.7(0.4,6.5)	43.1	1.7(0.39,6.8)	42.8	–

RY. The ideal gastrointestinal reconstruction surgery should minimize the incidence of postoperative complications and improve quality of life.[25] To our knowledge, BI reconstruction has usually been applied after DG for gastric cancer due to its simplicity and less operating time. BII or RY have been preferred in patients with a stump stomach or a duodenum shortened by extensive resection to ensure the safety of surgical margins.
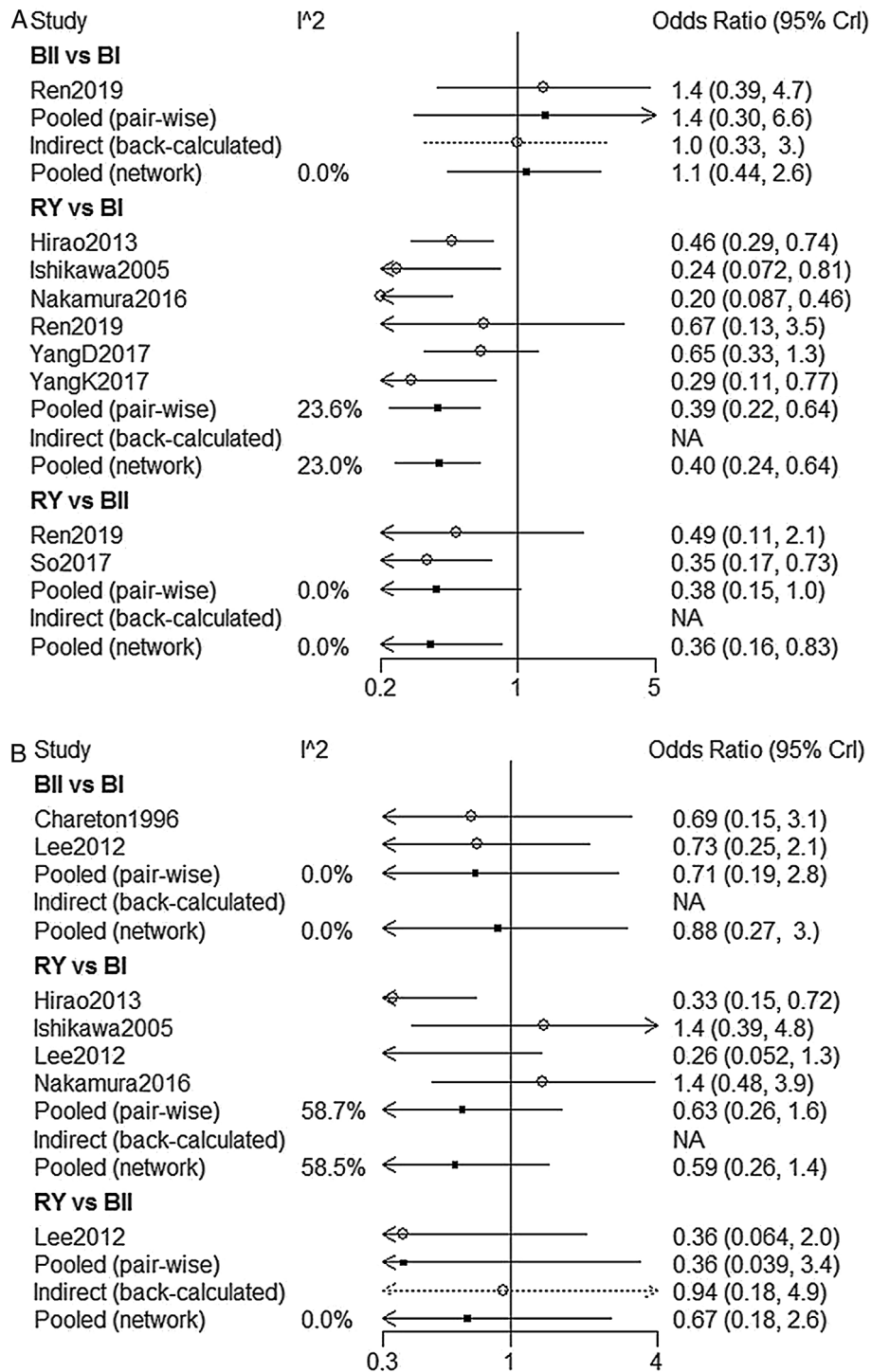
BI reconstruction was associated with a significant reduction in operation time as compared with BII and RY reconstruction. We also evaluated data regarding intraoperative blood loss, hospital stay and time to resumed oral intake, and no significant difference in either of these parameters among the three groups was found. It may be largely due to the use of gastrointestinal stapling devices and the refinement of technique.

The main advantage of the RY reconstruction was thought to be the prevent secretions from the biliary tract and pancreas from reaching the gastric and esophageal mucosa. Previous studies indicated that the RY reconstruction was more

effective at preventing postoperative reflux esophagitis and remnant gastritis.[26,27] Our NMA demonstrated that RY reconstruction was superior to BI and BII in terms of frequency of remnant gastritis, which was consistent with previous reports.[28] However, there was no statistical difference in reflux esophagitis among the 3 groups, a finding that was proven to be similar with previous reports.[9,15,16,29] The reason for this discrepancy may be that reflux esophagitis are caused by acid reflux rather than bile reflux. On the contrary, remnant gastritis was related with bile reflux while RY technique significantly reduced the risk of bile reflux.[30,31]

In the light of the Clavien-Dindo classification, the grade III–IV complications required surgical, endoscopic or radiological intervention, and even life-threatening. Although the RY reconstruction was a more complex procedure requiring additional anastomosis, the risk of overall complications and grade III–IV severe complications did not increase.

This review does have some limitations and hence the results should be interpreted with a degree of caution. First,

A Study   I^2   Odds Ratio (95% Crl)
  BII vs BI
  Ren2019   1.4 (0.39, 4.7)
  Pooled (pair-wise)   1.4 (0.30, 6.6)
  Indirect (back-calculated)   1.0 (0.33, 3.)
  Pooled (network)   0.0%   1.1 (0.44, 2.6)
  RY vs BI
  Hirao2013   0.46 (0.29, 0.74)
  Ishikawa2005   0.24 (0.072, 0.81)
  Nakamura2016   0.20 (0.087, 0.46)
  Ren2019   0.67 (0.13, 3.5)
  YangD2017   0.65 (0.33, 1.3)
  YangK2017   0.29 (0.11, 0.77)
  Pooled (pair-wise)   23.6%   0.39 (0.22, 0.64)
  Indirect (back-calculated)   NA
  Pooled (network)   23.0%   0.40 (0.24, 0.64)
  RY vs BII
  Ren2019   0.49 (0.11, 2.1)
  So2017   0.35 (0.17, 0.73)
  Pooled (pair-wise)   0.0%   0.38 (0.15, 1.0)
  Indirect (back-calculated)   NA
  Pooled (network)   0.0%   0.36 (0.16, 0.83)
                          0.2   1   5

B Study   I^2   Odds Ratio (95% Crl)
  BII vs BI
  Chareton1996   0.69 (0.15, 3.1)
  Lee2012   0.73 (0.25, 2.1)
  Pooled (pair-wise)   0.0%   0.71 (0.19, 2.8)
  Indirect (back-calculated)   NA
  Pooled (network)   0.0%   0.88 (0.27, 3.)
  RY vs BI
  Hirao2013   0.33 (0.15, 0.72)
  Ishikawa2005   1.4 (0.39, 4.8)
  Lee2012   0.26 (0.052, 1.3)
  Nakamura2016   1.4 (0.48, 3.9)
  Pooled (pair-wise)   58.7%   0.63 (0.26, 1.6)
  Indirect (back-calculated)   NA
  Pooled (network)   58.5%   0.59 (0.26, 1.4)
  RY vs BII
  Lee2012   0.36 (0.064, 2.0)
  Pooled (pair-wise)   0.36 (0.039, 3.4)
  Indirect (back-calculated)   0.94 (0.18, 4.9)
  Pooled (network)   0.0%   0.67 (0.18, 2.6)
                          0.3   1   4

Fig. 3 – Forest plot for comparison of postoperative endoscopic findings: (A) Remnant gastritis, (B) Reflux oesophagitis.

the size of the included studies was relatively small, and the insufficiency of direct evidence might lead to inconsistency in some comparison items. Second, it was important to mention that we were unable to analyze important outcomes such as body weight change, amount of ingested food and overall survival due to a lack of original literature. Additionally, the included studies lasted for a long period and the improvement of treatment technique may influence our outcomes. We would therefore propose well-designed RCTs with adequate follow-up and emphasis on assessing important outcomes to clarify ambiguities surrounding the use of these reconstruction methods.
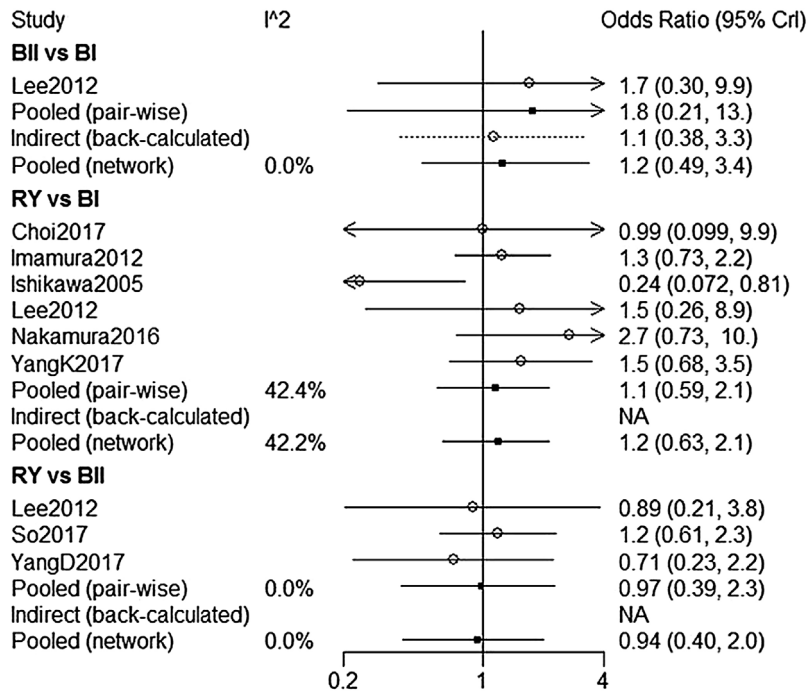
Fig. 4 – Forest plot for comparison of complications: overall complications.

Conclusions

The R-Y reconstruction was more effective in preventing remnant gastritis than BI and BII reconstruction. BI reconstruction could be considered as the substitute in consideration of technical simplicity. However, the results of the present study should be verified by long-term follow-up of these patients, and additional randomized control studies are warranted to determine the clinical efficacy of 3 reconstruction in DG.

Statement of ethics

All analysis were based on previous published studies, thus no ethical approval and patient consent are required.

Disclosure statement

The authors disclose that there are no direct or indirect financial relationships.

Author contributions

Haitao Jiang reviewed and screened the articles included in our meta-analysis; Yujie Li performed the analysis and drafted the manuscript; Tianfei Wang designed the study and edited the manuscript.

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Conflict of interest

The authors declare no conflicts of interest.

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REFERENCES

1. Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin. 2018;68:394–424.
2. Hirao M, Takiguchi S, Imamura H, Yamamoto K, Kurokawa Y, Fujita J, et al. Comparison of Billroth I and Roux-en-Y reconstruction after distal gastrectomy for gastric cancer: one-year postoperative effects assessed by a multi-institutional RCT. Ann Surg Oncol. 2013;20:1591–7.

3. Yoshino K. History of gastric cancer surgery. Nihon Geka Gakkai Zasshi. 2000;101:855–60.

4. Weil PH, Buchberger R. From Billroth to PCV: a century of gastric surgery. World J Surg. 1999;23:736–42.

5. In Choi C, Baek DH, Lee SH, Hwang SH, Kim DH, Kim KH, et al. Comparison between Billroth-II with Braun and Roux-en-Y reconstruction after laparoscopic distal gastrectomy. J Gastrointest Surg. 2016;20:1083–90.

6. Shim JH, Oh S, Yoo HM, et al. Roux-en-Y gastrojejunostomy after totally laparoscopic distal gastrectomy: comparison with Billorth II reconstruction. Surg Laparosc Endosc Percutan Tech. 2014;24:448–51.

7. Osugi H, Fukuhara K, Takada N, Takemura M, Kinoshita H. Reconstructive procedure after distal gastrectomy to prevent remnant gastritis. Hepatogastroenterology. 2004;51:1215–8.

8. Kauer WK, Peters JH, DeMeester TR, Feussner H, Ireland AP, Stein HJ, et al. Composition and concentration of bile acids reflux into the esophagus of patients with gastroesophageal reflux disease. Surgery. 1997;122:874–81.

9. Ishikawa M, Kitayama J, Kaizaki S, Nakayama H, Ishigami H, Fujii S, et al. Prospective randomized trial comparing Billroth I and Roux-en-Y procedures after distal gastrectomy for gastric carcinoma. World J Surg. 2005;29:1415–20.

10. Higgins J, Green S. Cochrane Handbook for Systematic Reviews of Interventions. Available from: http://www.cochrane-handbook.org/ [accessed 13.11.12].

11. Lumley T. Network meta-analysis for indirect treatment comparisons. Stat Med. 2002;21:2313–24.

12. Dias S, Welton NJ, Caldwell DM, Ades AE. Checking consistency in mixed treatment comparison meta-analysis. Stat Med. 2010;29:932–44.

13. Salanti G, Ades AE, Ioannidis JP. Graphical methods and numerical summaries for presenting results from multiple-treatment meta-analysis: an overview and tutorial. J Clin Epidemiol. 2011;64:163–71.

14. Imamura H, Takiguchi S, Yamamoto K, Hirao M, Fujita J, Miyashiro I, et al. Morbidity and mortality results from a prospective randomized controlled trial comparing Billroth I and Roux-en-Y reconstructive procedures after distal gastrectomy for gastric cancer. World J Surg. 2012;36:632–7.

15. Lee MS, Ahn SH, Lee JH, Park DJ, Lee HJ, Kim HH, et al. What is the best reconstruction method after distal gastrectomy for gastric cancer? Surg Endosc. 2012;26:1539–47.

16. Nakamura M, Nakamori M, Ojima T, Iwahashi M, Horiuchi T, Kobayashi Y, et al. Randomized clinical trial comparing long-term quality of life for Billroth I versus Roux-en-Y reconstruction after distal gastrectomy for gastric cancer. Br J Surg. 2016;103:337–47.

17. Takiguchi S, Yamamoto K, Hirao M, Imamura H, Fujita J, Yano M, et al. A comparison of postoperative quality of life and dysfunction after Billroth I and Roux-en-Y reconstruction following distal gastrectomy for gastric cancer: results from a multi-institutional RCT. Gastric Cancer. 2012;15:198–205.

18. Choi YY, Noh SH, An JYA. Randomized controlled trial of Roux-en-Y gastrojejunostomy vs. gastroduodenostomy with respect to the improvement of type 2 diabetes mellitus after distal gastrectomy in gastric cancer patients. PLOS ONE. 2017;12:e0188904.

19. Ren Z, Wang WX. Comparison of Billroth I Billroth II, and Roux-en-Y reconstruction after totally laparoscopic distal gastrectomy: a randomized controlled study. Adv Ther. 2019;36:2997–3006.

20. Yang K, Zhang WH, Liu K, Chen XZ, Zhou ZG, Hu JK. Comparison of quality of life between Billroth-I and Roux-en-Y anastomosis after distal gastrectomy for gastric cancer: a randomized controlled trial. Sci Rep. 2017;7:11245.

21. Chareton B, Landen S, Manganas D, Meunier B, Launois B. Prospective randomized trial comparing Billroth I and Billroth II procedures for carcinoma of the gastric antrum. J Am Coll Surg. 1996;183:190–4.

22. Yang D, He L, Tong WH, Jia ZF, Su TR, Wang Q. Randomized controlled trial of uncut Roux-en-Y vs Billroth II reconstruction after distal gastrectomy for gastric cancer: which technique is better for avoiding biliary reflux and gastritis? World J Gastroenterol. 2017;23:6350–6.

23. So JB, Rao J, Wong AS, Chan YH, Pang NQ, Tay AYL, et al. Roux-en-Y or Billroth II reconstruction after radical distal gastrectomy for gastric cancer: a multicenter randomized controlled trial. Ann Surg. 2018;267:236–42.

24. Dindo D, Demartines N, Clavien PA. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg. 2004;240:205–13.

25. Piessen G, Triboulet JP, Mariette C. Reconstruction after gastrectomy: which technique is best? J Visc Surg. 2010;147:e273–83.

26. Fukuhara K, Osugi H, Takada N, Takemura M, Higashino M, Kinoshita H. Reconstructive procedure after distal gastrectomy for gastric cancer that best prevents duodenogastroesophageal reflux. World J Surg. 2002;26:1452–7.

27. Shinoto K, Ochiai T, Suzuki T, Okazumi S, Ozaki M. Effectiveness of Roux-en-Y reconstruction after distal gastrectomy based on an assessment of biliary kinetics. Surg Today. 2003;33:169–77.

28. Xiong JJ, Altaf K, Javed MA, Nunes QM, Huang W, Mai G, et al. Roux-en-Y versus Billroth I reconstruction after distal gastrectomy for gastric cancer: a meta-analysis. World J Gastroenterol. 2013;19:1124–34.

29. Kojima K, Yamada H, Inokuchi M, Kawano T, Sugihara K. A comparison of Roux-en-Y and Billroth-I reconstruction after laparoscopy-assisted distal gastrectomy. Ann Surg. 2008;247:962–7.

30. Collard JM, Romagnoli R. Roux-en-Y jejuna loop and bile reflux. Am J Surg. 2000;179:298–303.

31. Montesani C, D'Amato A, Santella S, Pronio A, Giovannini C, Cristaldi M, et al. Billroth I versus Billroth II versus Roux-en-Y after subtotal gastrectomy. Prospective randomized study Hepatogastroenterology. 2002;49:1469–73.