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SCIENTIFIC REVIEW

A Systematic Review and Network-Meta-Analysis of Gastro-Enteric Reconstruction Techniques Following Pancreatoduodenectomy to Reduce Delayed Gastric Emptying

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Abstract

Introduction This network meta-analysis aimed to identify the reconstruction technique associated with lowest rates of DGE following pancreatoduodenectomy (PD) from randomised controlled trials (RCTs).

Methods A systematic literature search of PubMed, Embase and MEDLINE databases was carried out using the PRISMA framework to identify all RCTs comparing reconstruction techniques of gastrojejunostomy after PD, with overall DGE as the primary endpoint. The primary outcome measure was overall DGE. Secondary outcomes were grade B/C DGE, duration of nasogastric tube, time to solid food intake, overall and grade B/C pancreatic fistula, bile leaks, reoperation, length of hospital stay and in-hospital mortality.

Results The search strategy identified eight RCTs including 761 patients. Six RCTs compared antecolic (n = 291 patients) and retrocolic Billroth II (n = 289 patients) reconstruction (n = 6 studies), and two RCTs compared antecolic Billroth II (n = 92 patients) and Roux-en-Y (n = 89 patients) reconstruction. Overall, antecolic Billroth II ranked best for overall and grade B/C DGE, bile leak, surgical site infection, length of stay and in-hospital mortality. Roux-en-Y was best for overall and grade B/C pancreatic fistula.

Conclusion Antecolic Billroth II gastroenteric reconstruction is associated with the lowest rates of delayed gastric emptying after PD amongst the currently available techniques of gastrojejunostomy reconstructions.

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Introduction

Following pancreaticoduodenectomy (PD), delayed gastric emptying (DGE) remains one of the most frequent post-operative complications ranging between 14 and 40% [1–4], associated with increased hospital length of stay [5], need for parenteral nutrition, increased hospitals costs [6–8] and hospital readmissions [9]. The exact mechanism of DGE after PD is not well understood however the configuration of gastroenteric reconstruction may influence the likelihood of developing DGE [10–12].

Several gastroenteric reconstruction techniques are currently in use including antecolic Billroth II reconstruction, retrocolic Billroth II reconstruction and a Roux-en-Y reconstruction route of gastroenteric anastomosis [13–15]. The Roux-en-Y reconstruction is frequently used with a view to isolate the pancreatojejunostomy [13, 14] and the gastroenteric anastomosis [15–17], hence attempting to reduce incidence of postoperative pancreatic fistula as well as DGE. Previous meta-analyses comparing antecolic and retrocolic reconstruction showed reduced rates of DGE with an antecolic gastroenteric anastomosis [13, 14]. Further RCTs comparing Roux-en-Y reconstruction with antecolic reconstruction showed comparable DGE rates between the two reconstruction techniques [16, 17]. In both studies, the gastroenteric anastomosis was performed through an antecolic route.

To date, it remains unclear about the best technique for gastroenteric reconstruction following PD to reduce DGE. This systematic review and network meta-analysis aimed at comparing different gastroenteric reconstruction techniques to identify the technique with the lowest rates of DGE.

Methods

Search strategy

The study was registered with the PROSPERO database at inception (Registration CRD42019 135718). The PubMed, Embase, MEDLINE and Cochrane library databases were searched using the PRISMA [18] framework by two independent investigators (SKK and SP). The search was completed on 04 May 2019. The search terms used were 'delayed gastric emptying' and 'trials', 'randomised' or 'randomised controlled trial', and 'Whipple procedure' or 'Pancreaticoduodenectomy' or 'Whipple surgery' individually or in combination. Supplementary Table 1 summarises the search terms used. A 'related articles' function was used to capture recent reviews on the topic, and a further manual search of reference lists was carried out to make the search comprehensive.

Inclusion and exclusion criteria

Inclusion criteria were: (1) randomised controlled trials (RCTs) comparing gastroenteric reconstruction technique in patients undergoing PD, where overall DGE was the primary endpoint and (2) studies published in the English language. Exclusion criteria were: (1) non-randomised controlled studies and case reports and (2) publications with a heterogeneous patient population with a combination of other types of pancreatic resections, i.e. distal pancreatectomy which could not be separated from those of patients undergoing PD. The identified abstracts from the search were reviewed by two authors (SKK and SP). Full-text article review of potentially relevant abstracts was conducted. A further manual search of the references of the included articles was performed to identify potentially relevant studies. Any disagreement regarding the included articles between the two authors (SKK, SP) was resolved after discussion with the co-authors.

Study outcomes

The primary outcome was overall delayed gastric emptying (DGE) defined according to the International Study Group of Pancreatic Surgery (ISGPS) [4]. Secondary outcome measures were grade B/C DGE, time to starting solids and liquids, duration of nasogastric tube, overall complications, overall (grade A, B and C pancreatic fistula) [19] and grade B/C pancreatic fistula [20], postoperative pancreatic haemorrhage [21], intraabdominal abscess and length of stay.

Data extraction

One author (SKK) retrieved data on study characteristics, patient demographics, types of reconstruction techniques and relevant clinical outcomes. The drawings of the methods of reconstruction for the techniques evaluated are presented in three included articles [16, 22, 23].

Assessment of methodological quality

The Cochrane Risk of Bias tool for randomised controlled trials was used to assess the methodological quality of included studies [24]. The Cochrane Risk of Bias tool is a domain-based evaluation which allows assessment of selection bias, performance bias, detection bias, attrition bias and reporting bias separately.

Statistical analysis

The statistical analysis of the network meta-analysis was carried out according to the recommendations of the Cochrane Library and PRISMA guidelines [18]. Odds ratios (ORs) were used for analysis of categorical variables. A random effects (DerSimonian–Laird method) model was preferred for the reporting the outcomes of the meta-analysis. Publication bias was assessed by visually inspecting the funnel plots of included studies. A network meta-analysis comparing the type's reconstruction techniques was conducted by pooling the included studies. A network map was obtained for each individual outcome with graphical representations of treatments (nodes) and

comparisons (lines). The network maps with closed loops were then entered into the network analyses. Direct and indirect treatment effects were compared after inconsistency was excluded in the networks. This was performed by examining for overall inconsistency throughout the entire network and then by the fitting of node splitting models checking for loop inconsistency, within all three-way treatment comparison loops [25]. The null hypothesis was accepted when P values were $> .05$, assuming consistency and networks were entered into consistency modelling and network plots were generated. The network plots were further supplemented with interval plots of pooled effect estimates. P-score was used to rank the reconstruction techniques using the *netmeta* package, as reported previously to be similar to the surface under the cumulative ranking areas for all outcomes. The probability of superiority of each treatment was assessed using the P-score [26–28]. Statistical significance was considered when $P < 0.05$. R Foundation Statistical software (R 3.2.1) was used to perform the statistical analyses [29, 30].

Results

Study characteristics

Eight studies comparing all relevant gastroenteric reconstruction techniques after PD were included (Fig. 1). The baseline data on the randomised trials are presented in Table 1 and Supplementary Table 2. These eight studies contributed 761 patients for analysis. Six studies [23, 31–35] comprising 580 patients compared antecolic and retrocolic Billroth II reconstruction and two studies [16, 17] comprising 181 patients compared antecolic Billroth II with Roux-en-Y reconstruction. One study was a multi-centre study [23], while the others were single-centre studies [16, 17, 31–35]. Six studies reported pylorus preserving PD (PPPD) [17, 23, 31, 33–35], of which in four studies all patients had PPPD [9, 17, 33–35]. The remaining two studies only included classical PD [32], and another only included subtotal stomach-preserving pancreaticoduodenectomy (SSPPD) [16]. The summary of the Cochrane Risk of Bias assessment is presented in Supplementary Table 3.

Delayed gastric emptying

Primary outcome measure

The results of all pairwise comparisons of the different reconstruction techniques for all postoperative outcomes are summarised in Table 2. Overall delayed gastric emptying was reported in all studies comprising 761 patients. Antecolic Billroth II reconstruction ranked first followed by Roux-en-Y reconstruction (Table 3). Grade B/C delayed gastric emptying was reported in six studies comprising 657 patients. Antecolic Billroth II reconstruction ranked first followed by Roux-en-Y (Table 3). A funnel plot for the risk of bias presented in Fig. 2 shows a symmetrical plot indicating minimal risk of bias.

Time to solid and liquid diets

Secondary outcome measures

Time to solid and time to liquid diets were reported in six and two studies, respectively; hence, the latter outcome was not included in the network meta-analysis. There were no significant differences in reconstruction techniques between antecolic Billroth II and retrocolic Billroth II (MD: − 0.57 days, $CI_{95\%}$: − 2.47 to 1.34, $P = 0.6$) and Roux-en-Y (MD: − 3.50 days, $CI_{95\%}$: − 7.41 to 0.41, $P = 0.079$) for time to solid diets. Antecolic Billroth II was ranked first followed by retrocolic Billroth II for time to solid diet (Table 3).

Duration of nasogastric (NG) tube

Duration of NG tube was reported in six studies. There were no significant differences in duration of NG tube in reconstruction techniques between antecolic Billroth II reconstruction and retrocolic Billroth II reconstruction (MD: 0.06 days, $CI_{95\%}$: − 0.62 to 0.74, $P = 0.9$) for the duration of NG tube. Retrocolic Billroth II reconstruction ranked first followed by antecolic Billroth II for the duration of NG tube (Table 3).

Postoperative pancreatic fistula

Overall POPF was reported in all included studies. Roux-en-Y was ranked first followed by antecolic Billroth II for overall POPF (Table 3). Grade B/C POPF was reported in five studies. Roux-en-Y was ranked first followed by antecolic Billroth II for grade B/C POPF (Table 3).

Postpancreatectomy haemorrhage (PPH)

Overall postoperative pancreatic haemorrhage was reported in four studies. There were no significant differences in reconstruction techniques between antecolic Billroth II and retrocolic Billroth II (OR: 0.79, $CI_{95\%}$: 0.30–2.04, $P = 0.7$) and Roux-en-Y (OR: 1.76, $CI_{95\%}$: 0.33–9.36, $P = 0.5$) for the rates of PPH. Roux-en-Y reconstruction ranked first followed by antecolic Billroth II reconstruction for overall PPH (Table 3).

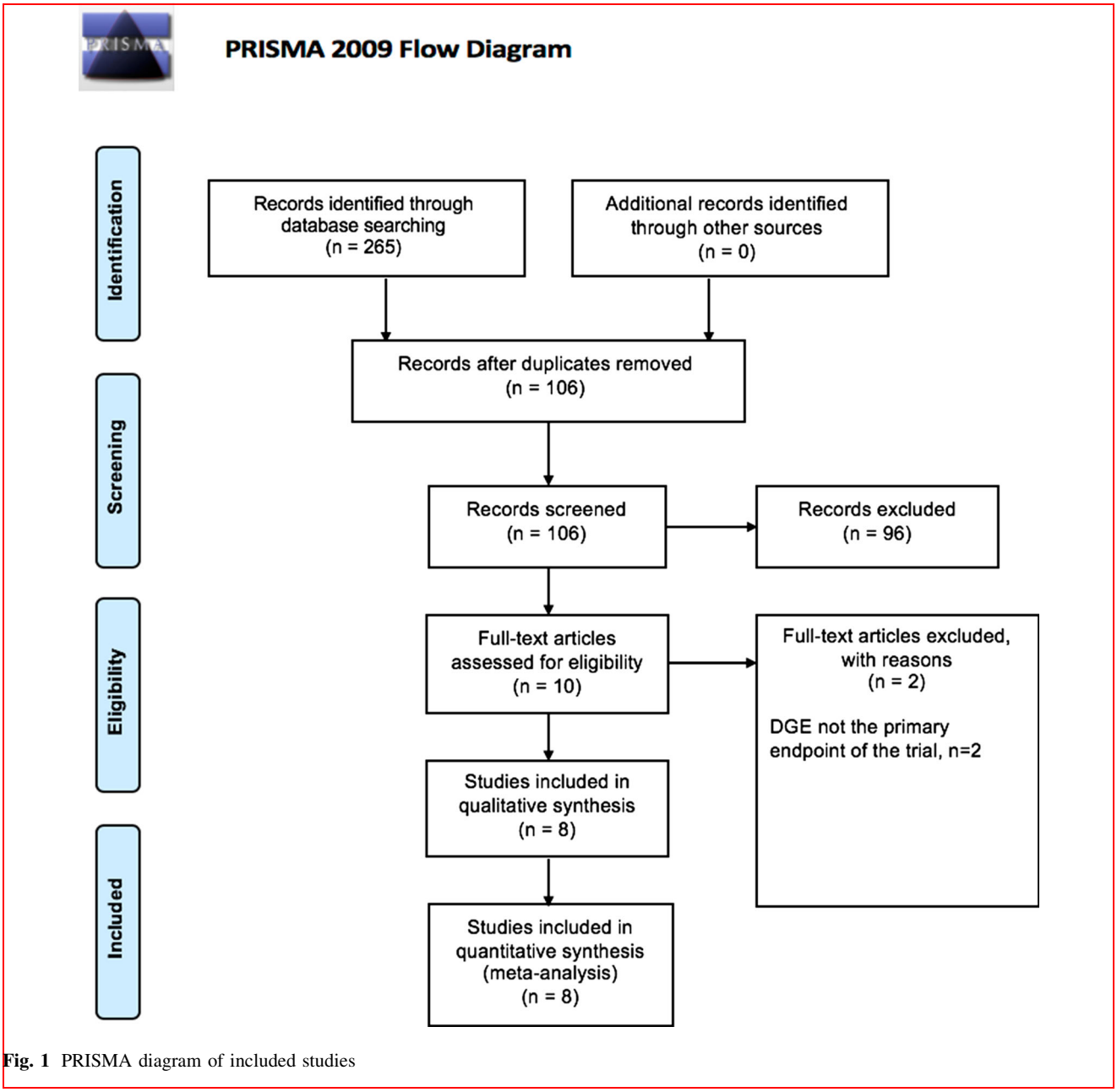

Fig. 1 PRISMA diagram of included studies

Overall complications

Overall complications were reported in three studies. There were no significant differences in reconstruction techniques between antecolic Billroth II and retrocolic Billroth II (OR: 1.20, $CI_{95\%}$: 0.67–2.16, $P = 0.6$) and Roux-en-Y (OR: 0.62, $CI_{95\%}$: 0.24–1.63, $P = 0.3$). Antecolic Billroth II was ranked first followed by Roux-en-Y for overall complications (Table 3).

Other postoperative outcomes

Bile leak, surgical site infection, reoperation, in-hospital mortality and length of stay were also evaluated as presented in Tables 2, 3. There were no significant differences in any of the reconstruction techniques on these outcomes. Antecolic Billroth II were ranked first for all these outcomes except reoperation for which Roux-en-Y was ranked first.

Table 1 Characteristics of included studies

Study ID	Group 1	Group 2	Number of patients (n)		Age (years)		Male (%)		BMI		PPPD (%)		Malignancy	
			Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Tani 2006 [34]	Billroth II—antecolic	Billroth II—retrocolic	20	20	63.1 (9.2)	66.7 (12.2)	55	50	NR	NR	100	100	80	80
Kurahara 2011 [32]	Billroth II—retrocolic	Billroth II—antecolic	22	24	62.3 (12.6)	67.6 (11.6)	73	67	23.3 (4.8)	22.9 (2.8)	0	0	NR	NR
Gangavatiker 2011 [31]	Billroth II—antecolic	Billroth II—retrocolic	32	36	52.8 (11.6)	50.8 (10.6)	72	72	NR	NR	NR	NR	84	89
Shimoda 2013 [17]	Billroth II—antecolic	Roux-en-Y	52	49	66.5 (9.8)	65.7 (11.1)	72	57	20.9 (2.9)	22.1 (5.2)	100	100	88	90
Tamandl 2013 [33]	Billroth II—antecolic	Billroth II—retrocolic	36	28	67.1 (55.7–75.3)	65.4 (55.6–70.6)	47	43	NR	NR	100	100	78	71
Eshuis 2014 [23]	Billroth II—antecolic	Billroth II—retrocolic	121	125	65.2 (10.3)	65.4 (9.0)	54	69	25.3 (4.2)	24.6 (3.8)	84	77	88	80
Imamura 2014 [35]	Billroth II—antecolic	Billroth II—retrocolic	58	58	70.0 (36.0–86.0)	69.0 (46.0–86.0)	62	55	21.8 (15.7–29.0)	21.3 (14.7–29.3)	100	100	79	85
Busquets 2019 [16]	Billroth II—antecolic	Roux-en-Y	40	40	65·6 (10·9)	68·1 (11·7)	60	60	26·1 (6·6)	26·6 (4. 6)	0	0	97	92

Discussion

This is the first network meta-analysis of randomised controlled trials to evaluate incidence of DGE after various gastroenteric reconstruction techniques following PD. This study only included RCTs where overall DGE was the primary endpoint allowing reliable assessment of well-powered RCTs. In this review, three reconstruction techniques were evaluated such as antecolic or retrocolic Billroth II and Roux-en-Y. Antecolic Billroth II reconstruction was found to be the best technique for overall and grade B/C DGE. This observation is a result of including RCTs where DGE was the primary endpoint, limiting inclusion of more studies where POPF was the primary endpoint [22, 36]. Antecolic Billroth II was also ranked first for other outcomes such as intraabdominal abscess, bile leaks, surgical site infection, in-hospital mortality and length of stay.

Several technical variations of gastroenteric reconstruction have been previously proposed based on the extent of gastroduodenal resection, such as PD with pyloric preservation [37], pyloric ring resection [10, 38] or subtotal gastric preservation [39], yet none have demonstrated superiority in reducing DGE. The most commonly reported reconstruction technique of anastomoses after PD technique is a single-loop reconstruction, whereby the pancreatojejunostomy, hepaticojejunostomy and the gastroenteric anastomosis with a Billroth II reconstruction are performed sequentially [40–42]. Furthermore, various modifications of the reconstruction to reduce the incidence of DGE have been described in the literature. A gastroenteric anastomosis with Roux-en-Y separating it from pancreatojejunostomy has been associated with lower rates of DGE [43]. Murakami et al. demonstrated lower rates of DGE after Roux-en-Y reconstruction compared to Billroth I [43]. Similarly, Barakat et al. also reported a lower incidence of DGE for Roux-en-Y compared with Billroth II reconstruction (10% vs 57%) [10]. Other modifications to the reconstruction including addition of a Braun enteroenterostomy to the Roux-en-Y reconstruction have shown a further reduction of DGE rates [44, 45]. However, these studies are non-randomised, limiting their validity. The two RCTs comparing Roux-en-Y reconstruction with Billroth II antecolic reconstruction reported conflicting results with one trial showing comparable DGE rates [16], while the other reported significantly lower DGE rates with Billroth II antecolic reconstruction compared to Roux-en-Y reconstruction (6% vs 20%).[17].

While DGE remains an important complication after PD, its aetiology remains largely unknown, and management is difficult. Published RCTs suggest a role for the type of gastroenteric reconstruction in the prevention of DGE.

Table 2 Summary of postoperative outcomes

Comparisons	*n*	NMA or MD ($CI_{95\%}$)	*P* value
Overall DGE			
BII—antecolic: BII—retrocolic	6	0.60 (0.30–1.19)	0.147
BII—antecolic: Roux-en-Y	2	0.56 (0.17–1.81)	0.342
BII—retrocolic: Roux-en-Y	0	0.93 (0.24–3.63)	0.923
Grade B/C DGE			
BII—antecolic: BII—retrocolic	4	0.75 (0.33–1.67)	0.497
BII—antecolic: Roux-en-Y	2	0.53 (0.17–1.70)	0.283
BII—retrocolic: Roux-en-Y	0	0.71 (0.17–2.93)	0.650
Time to solid[a]			
BII—antecolic: BII—retrocolic	5	− 0.57 (− 2.47 to 1.34)	0.569
BII—antecolic: Roux-en-Y	1	− 3.50 (− 7.41 to 0.41)	0.079
BII—retrocolic: Roux-en-Y	0	− 2.93 (− 7.28 to 1.42)	0.188
Duration of nasogastric tube[a]			
BII—antecolic: BII—retrocolic	6	0.06 (− 0.62 to 0.74)	0.872
Overall POPF			
BII—antecolic: BII—retrocolic	6	0.98 (0.65–1.48)	0.930
BII—antecolic: Roux-en-Y	2	1.51 (0.76–3.02)	0.244
BII—retrocolic: Roux-en-Y	0	1.54 (0.69–3.44)	0.296
Grade B/C POPF			
BII—antecolic: BII—retrocolic	4	0.85 (0.50–1.42)	0.553
BII—antecolic: Roux-en-Y	1	1.24 (0.34–4.43)	0.755
BII—retrocolic: Roux-en-Y	0	1.46 (0.37–5.79)	0.602
Overall PPH			
BII—antecolic: BII—retrocolic	3	0.79 (0.30–2.04)	0.670
BII—antecolic: Roux-en-Y	1	1.76 (0.33–9.36)	0.518
BII—retrocolic: Roux-en-Y	0	2.24 (0.33–15.28)	0.417
Overall complications			
BII—antecolic: BII—retrocolic	2	1.20 (0.67–2.16)	0.553
BII—antecolic: Roux-en-Y	1	0.62 (0.24–1.63)	0.333
BII—retrocolic: Roux-en-Y	0	0.51 (0.17–1.59)	0.240
Intraabdominal abscess			
BII—antecolic: BII—retrocolic	6	0.94 (0.52–1.67)	0.846
BII—antecolic: Roux-en-Y	1	0.86 (0.27–2.75)	0.811
BII—retrocolic: Roux-en-Y	0	0.92 (0.25–3.37)	0.908
Bile leak			
BII—antecolic: BII—retrocolic	6	0.88 (0.37; 2.13)	0.787
Surgical site infection			
BII—antecolic: BII—retrocolic	5	0.88 (0.57; 1.35)	0.573
Reoperation			
BII—antecolic: BII—retrocolic	3	0.53 (0.24; 1.21)	0.124
BII—antecolic: Roux-en-Y	1	1.54 (0.24; 9.75)	0.661
BII—retrocolic: Roux-en-Y	0	2.88 (0.38; 21.67)	0.310
In-hospital Mortality			
BII—antecolic: BII—retrocolic	3	0.61 (0.22; 1.66)	0.343
BII—antecolic: Roux-en-Y	1	0.19 (0.01; 4.09)	0.283
BII—retrocolic: Roux-en-Y	0	0.31 (0.01; 7.94)	0.502
Length of stay[a]			
BII—antecolic: BII—retrocolic	3	− 4.34 (− 12.28 to 3.60)	0.288
BII—antecolic: Roux-en-Y	2	− 3.53 (− 12.71 to 5.65)	0.460
BII—retrocolic: Roux-en-Y	0	0.81 (− 11.32 to 12.95)	0.904

[a]Denotes continuous variable reported as mean difference

Table 3 Ranking of postoperative outcomes

	1st	2nd	3rd
Overall DGE	BII—antecolic, $P = 0.881$	Roux-en-Y, $P = 0.312$	BII—retrocolic, $P = 0.306$
Grade B/C DGE	BII—antecolic, $P = 0.809$	BII—retrocolic, $P = 0.460$	Roux-en-Y, $P = 0.231$
Time to solid food	BII—antecolic, $P = 0.840$	BII—retrocolic, $P = 0.594$	Roux-en-Y, $P = 0.007$
Duration of nasogastric tube	BII—antecolic, $P = 0.571$	BII—retrocolic, $P = 0.429$	
Overall POPF	Roux-en-Y, $P = 0.866$	BII—antecolic, $P = 0.330$	BII—retrocolic, $P = 0.304$
Grade B/C POPF	Roux-en-Y, $P = 0.666$	BII—antecolic, $P = 0.555$	BII—retrocolic, $P = 0.279$
Overall PPH	Roux-en-Y, $P = 0.770$	BII—antecolic, $P = 0.471$	BII—retrocolic, $P = 0.259$
Overall complications	BII—retrocolic, $P = 0.803$	BII—antecolic, $P = 0.552$	Roux-en-Y, $P = 0.145$
Intraabdominal abscess	BII—antecolic, $P = 0.594$	BII—retrocolic, $P = 0.481$	Roux-en-Y, $P = 0.425$
Bile leak	BII—antecolic, $P = 0.609$	BII—retrocolic, $P = 0.392$	
Surgical site infection	BII—antecolic, $P = 0.726$	BII—retrocolic, $P = 0.274$	
Reoperation	Roux-en-Y, $P = 0.763$	BII—antecolic, $P = 0.629$	BII—retrocolic, $P = 0.109$
In-hospital mortality	BII—antecolic, $P = 0.845$	BII—retrocolic, $P = 0.462$	Roux-en-Y, $P = 0.193$
Length of stay	BII—antecolic, $P = 0.816$	Roux-en-Y, $P = 0.389$	BII—retrocolic, $P = 0.295$

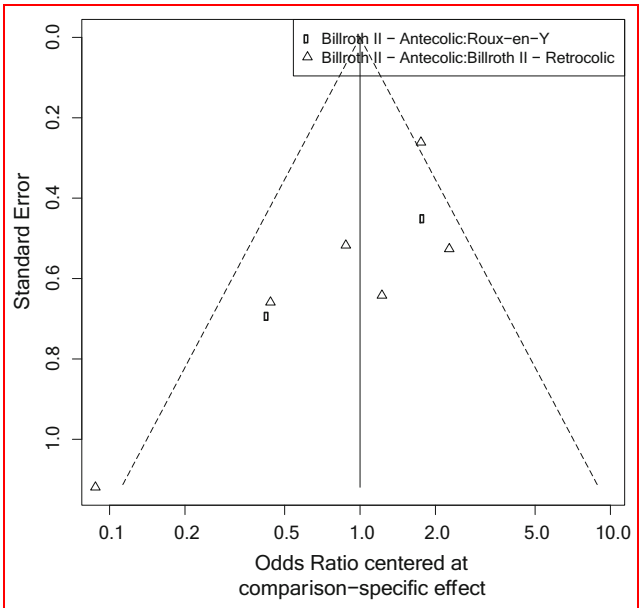

Fig. 2 Funnel plot for risk of bias in main outcome for delayed gastric emptying

The present study appears to demonstrate that an antecolic Billroth II gastroenteric reconstruction after PD is associated with a lower incidence of postoperative DGE. The high incidence of clinically relevant DGE in patients developing a POPF after PD suggests that the prevention of such complications is paramount in reducing the incidence of DGE. The theoretical reason for increased DGE with retrocolic Billroth II technique is that the reduced motility may be secondary to decreased venous drainage of the jejunal limb from a retrocolic reconstruction which in turn can lead to oedema of the jejunal limb itself and the gastrojejunal anastomosis, thereby effecting gastric emptying [46, 47]. An antecolic gastrojejunostomy theoretically avoids the mechanical problems as the descending jejunal loop is likely to more mobile than a retrocolic reconstruction [48].

This study has several limitations to the present review. It only includes eight RCTs comparing three different techniques. This highlights the need for further studies evaluating the types of gastroenteric reconstruction in reducing the incidence of DGE. Furthermore, the studies included in this review differ in the method of PD used, i.e. classical PD, PPPD and SSPPD, which limits assessment of the best technique. This does emphasise the importance of standardising the resection technique in future RCTs.

Conclusion

In summary, this network meta-analysis highlights that single-loop antecolic Billroth II reconstruction appears to be the best technique to reduce the incidence of DGE after pancreatoduodenectomy.

Author Contribution All authors listed in this manuscript meet the authorship requirements set out by the International Committee of Medical Journal Editors (ICMJE).

Compliance with Ethical Standards

Conflict of interest All authors declare no conflict of interest.

References

1. Malleo G, Crippa S, Butturini G et al (2010) Delayed gastric emptying after pylorus-preserving pancreaticoduodenectomy: validation of International Study Group of Pancreatic Surgery classification and analysis of risk factors. HPB (Oxford) 12(9):610–618
2. Malleo G, Vollmer CM Jr (2016) Postpancreatectomy complications and management. Surg Clin North Am 96(6):1313–1336
3. Park JS, Hwang HK, Kim JK et al (2009) Clinical validation and risk factors for delayed gastric emptying based on the International Study Group of Pancreatic Surgery (ISGPS) classification. Surgery 146(5):882–887
4. Wente MN, Bassi C, Dervenis C et al (2007) Delayed gastric emptying (DGE) after pancreatic surgery: a suggested definition by the International Study Group of Pancreatic Surgery (ISGPS). Surgery 142(5):761–768
5. Tanaka M (2005) Gastroparesis after a pylorus-preserving pancreatoduodenectomy. Surg Today 35(5):345–350
6. Schaefer CJ (1995) (1995) Cost and outcome of the Whipple procedure. Ann Surg 222(2):211–212
7. Gordon TA, Burleyson GP, Tielsch JM et al (1995) The effects of regionalization on cost and outcome for one general high-risk surgical procedure. Ann Surg 221(1):43–49
8. Edge SB, Schmieg RE Jr, Rosenlof LK et al (1993) Pancreas cancer resection outcome in American University centers in 1989–1990. Cancer 71(11):3502–3508
9. Ahmad SA, Edwards MJ, Sutton JM et al (2012) Factors influencing readmission after pancreaticoduodenectomy: a multi-institutional study of 1302 patients. Ann Surg 256(3):529–537
10. Barakat O, Cagigas MN, Bozorgui S et al (2016) Proximal Roux-en-y gastrojejunal anastomosis with pyloric ring resection improves gastric emptying after pancreaticoduodenectomy. J Gastrointest Surg 20(5):914–923
11. Cordesmeyer S, Lodde S, Zeden K et al (2014) Prevention of delayed gastric emptying after pylorus-preserving pancreatoduodenectomy with antecolic reconstruction, a long jejunal loop, and a jejuno-jejunostomy. J Gastrointest Surg 18(4):662–673
12. Courvoisier T, Donatini G, Faure JP et al (2015) Primary versus secondary delayed gastric emptying (DGE) grades B and C of the International Study Group of Pancreatic Surgery after pancreatoduodenectomy: a retrospective analysis on a group of 132 patients. Updates Surg 67(3):305–309
13. Joliat GR, Labgaa I, Demartines N et al (2016) Effect of antecolic versus retrocolic gastroenteric reconstruction after pancreaticoduodenectomy on delayed gastric emptying: a meta-analysis of six randomized controlled trials. Dig Surg 33(1):15–25
14. Imamura M, Kimura Y, Ito T et al (2016) Effects of antecolic versus retrocolic reconstruction for gastro/duodenojejunostomy on delayed gastric emptying after pancreatoduodenectomy: a systematic review and meta-analysis. J Surg Res 200(1):147–157
15. Zhou Y, Lin J, Wu L et al (2015) Effect of antecolic or retrocolic reconstruction of the gastro/duodenojejunostomy on delayed gastric emptying after pancreaticoduodenectomy: a meta-analysis. BMC Gastroenterol 15:68
16. Busquets J, Martin S, Fabregat J et al (2019) Randomized trial of two types of gastrojejunostomy after pancreatoduodenectomy and risk of delayed gastric emptying (PAUDA trial). Br J Surg 106(1):46–54
17. Shimoda M, Kubota K, Katoh M et al (2013) Effect of billroth II or Roux-en-Y reconstruction for the gastrojejunostomy on delayed gastric emptying after pancreaticoduodenectomy: a randomized controlled study. Ann Surg 257(5):938–942
18. Liberati A, Altman DG, Tetzlaff J et al (2009) The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. BMJ 339:b2700
19. Bassi C, Dervenis C, Butturini G et al (2005) Postoperative pancreatic fistula: an international study group (ISGPF) definition. Surgery 138(1):8–13
20. Bassi C, Marchegiani G, Dervenis C et al (2017) The 2016 update of the International Study Group (ISGPS) definition and grading of postoperative pancreatic fistula: 11 Years After. Surgery 161(3):584–591
21. Wente MN, Veit JA, Bassi C et al (2007) Postpancreatectomy hemorrhage (PPH): an International Study Group of Pancreatic Surgery (ISGPS) definition. Surgery 142(1):20–25
22. Tani M, Kawai M, Hirono S et al (2014) Randomized clinical trial of isolated Roux-en-Y versus conventional reconstruction after pancreaticoduodenectomy. Br J Surg 101(9):1084–1091
23. Eshuis WJ, van Eijck CH, Gerhards MF et al (2014) Antecolic versus retrocolic route of the gastroenteric anastomosis after pancreatoduodenectomy: a randomized controlled trial. Ann Surg 259(1):45–51
24. Higgins JP, Altman DG, Gotzsche PC et al (2011) The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ 343:d5928
25. Dias S, Welton NJ, Caldwell DM et al (2010) Checking consistency in mixed treatment comparison meta-analysis. Stat Med 29(7–8):932–944
26. Neupane B, Richer D, Bonner AJ et al (2014) Network meta-analysis using R: a review of currently available automated packages. PLoS ONE 9(12):e115065
27. Rucker G, Schwarzer G (2015) Ranking treatments in frequentist network meta-analysis works without resampling methods. BMC Med Res Methodol 15:58
28. Simillis C, Lal N, Thoukididou SN et al (2019) Open versus laparoscopic versus robotic versus transanal mesorectal excision for rectal cancer: a systematic review and network meta-analysis. Ann Surg 270(1):59–68
29. Kamarajah SK, Bundred J, Tan BHL (2018) Body composition assessment and sarcopenia in patients with gastric cancer: a systematic review and meta-analysis. Gastric Cancer 22(1):10–22
30. Kamarajah SK, Sonnenday CJ, Cho CS, et al. (2019) Association of adjuvant radiotherapy with survival after margin-negative resection of pancreatic ductal adenocarcinoma: a propensity-matched national cancer database (ncdb) analysis. Ann Surg. https://doi.org/10.1097/SLA.0000000000003242
31. Gangavatiker R, Pal S, Javed A et al (2011) Effect of antecolic or retrocolic reconstruction of the gastro/duodenojejunostomy on delayed gastric emptying after pancreaticoduodenectomy: a randomized controlled trial. J Gastrointest Surg 15(5):843–852
32. Kurahara H, Shinchi H, Maemura K et al (2011) Delayed gastric emptying after pancreatoduodenectomy. J Surg Res 171(2):e187–e192
33. Tamandl D, Sahora K, Prucker J et al (2014) Impact of the reconstruction method on delayed gastric emptying after pylorus-preserving pancreaticoduodenectomy: a prospective randomized study. World J Surg 38(2):465–475
34. Tani M, Terasawa H, Kawai M et al (2006) Improvement of delayed gastric emptying in pylorus-preserving pancreaticoduodenectomy: results of a prospective, randomized, controlled trial. Ann Surg 243(3):316–320
35. Imamura N, Chijiiwa K, Ohuchida J et al (2014) Prospective randomized clinical trial of a change in gastric emptying and nutritional status after a pylorus-preserving pancreaticoduodenectomy: comparison between an antecolic and a vertical retrocolic duodenojejunostomy. HPB (Oxford) 16(4):384–394
36. Senda Y, Shimizu Y, Natsume S et al (2018) Randomized clinical trial of duct-to-mucosa versus invagination pancreaticojejunostomy after pancreatoduodenectomy. Br J Surg 105(1):48–57

37. Iqbal N, Lovegrove RE, Tilney HS et al (2008) A comparison of pancreaticoduodenectomy with pylorus preserving pancreaticoduodenectomy: a meta-analysis of 2822 patients. Eur J Surg Oncol 34(11):1237–1245
38. Hackert T, Bruckner T, Dorr-Harim C et al (2013) Pylorus resection or pylorus preservation in partial pancreatico-duodenectomy (PROPP study): study protocol for a randomized controlled trial. Trials 14:44
39. Huang W, Xiong JJ, Wan MH et al (2015) Meta-analysis of subtotal stomach-preserving pancreaticoduodenectomy vs pylorus preserving pancreaticoduodenectomy. World J Gastroenterol 21(20):6361–6373
40. Christians KK, Tsai S, Tolat PP et al (2013) Critical steps for pancreaticoduodenectomy in the setting of pancreatic adenocarcinoma. J Surg Oncol 107(1):33–38
41. Winter JM, Cameron JL, Campbell KA et al (2006) J Gastrointest Surg 10(9):1199–1210 **(discussion 1210–1211)**
42. Yeo CJ, Cameron JL, Sohn TA et al (1990s) Six hundred fifty consecutive pancreaticoduodenectomies in the 1990s: pathology, complications, and outcomes. Ann Surg 226(3):248–257 **(discussion 257–260)**
43. Murakami Y, Uemura K, Sudo T et al (2008) An antecolic Roux-en Y type reconstruction decreased delayed gastric emptying after pylorus-preserving pancreatoduodenectomy. J Gastrointest Surg 12(6):1081–1086
44. Hochwald SN, Grobmyer SR, Hemming AW, Curran E, Bloom DA, Delano M, Behrns KE, Copeland EM, Vogel SB (2010) Braun enteroenterostomy is associated with reduced delayed gastric emptying and early resumption of oral feeding following pancreaticoduodenectomy. J Surg Oncol 101(5):351–355
45. Xu B, Meng H, Qian M, Gu H, Zhou B, Song Z (2015) Braun enteroenterostomy during pancreaticoduodenectomy decreases postoperative delayed gastric emptying. Am J Surg 209(6):1036–1042
46. Bar-Natan M, Larson GM, Stephens G et al (1996) Delayed gastric emptying after gastric surgery. Am J Surg 172(1):24–28
47. Park YC, Kim SW, Jang JY et al (2003) Factors influencing delayed gastric emptying after pylorus-preserving pancreatoduodenectomy. J Am Coll Surg 196(6):859–865
48. Paraskevas KI, Avgerinos C, Manes C et al (2006) Delayed gastric emptying is associated with pylorus-preserving but not classical Whipple pancreaticoduodenectomy: a review of the literature and critical reappraisal of the implicated pathomechanism. World J Gastroenterol 12(37):5951–5958