

To Roux or not to Roux: a comparison between Roux-en-Y and Billroth II reconstruction following partial gastrectomy for gastric cancer

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Abstract

Background Although the extent of resection frequently dictates the method of reconstruction following distal subtotal gastrectomy, it is unclear whether Roux-en-Y gastrojejunostomy compared with Billroth II gastrojejunostomy is associated with superior perioperative outcomes.

Methods Patients who underwent resection for gastric cancer with Roux-en-Y or Billroth II reconstruction between 2000 and 2012 in seven academic institutions (US Gastric Cancer Collaborative) were identified. Patients who underwent total gastrectomy, gastric wedge, or palliative resections (metastatic disease or R2 resections) were excluded.

Results Of a total of 965 patients, 447 met the inclusion criteria. A comparison between the Roux-en-Y ($n = 257$) and Billroth II ($n = 190$) groups demonstrated no differences in patient and tumor characteristics, except for Billroth II patients having a higher proportion of antral tumors (71 % vs. 50 %, $p < 0.001$). Roux-en-Y operations were slightly longer (244 min vs. 212 min, $p < 0.001$) and associated with somewhat higher blood loss (243 ml vs. 205 ml, $p = 0.033$). However, there were no significant differences in the length of hospital stay (8 days vs. 7 days), readmission rate (17 % vs. 18 %), 90-day mortality (5.1 % vs. 4.7 %), incidence (39 % vs. 41 %) and severity of complications, dependency on jejunostomy tube feeding at discharge (13 % vs. 12 %), same-patient decrease in serum albumin level from the preoperative to the postoperative value at 30, 60, and 90 days, receipt of adjuvant therapy (50 % vs. 53 %), or 5-year survival (44 % vs. 41 %).

Conclusions Although long-term quality-of-life parameters were not compared, this study did not show an advantage of Roux-en-Y gastrojejunostomy over Billroth II gastrojejunostomy in short-term perioperative outcomes. Both techniques should be regarded as equally acceptable reconstructive options following partial gastrectomy for gastric cancer.

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Introduction

Gastric cancer is the second leading cause of cancer-related death globally, accounting for nearly 10 % of all cancer-related deaths [1]. Surgery remains the cornerstone of

treatment and provides the only chance for long-term survival. There are three ways to establish gastrointestinal continuity after gastrectomy: Billroth I (B1), Billroth II (B2), and Roux-en-Y (RY) reconstruction. The impact of the type of reconstruction after partial gastrectomy on perioperative outcomes has been a subject of intense study. Two prospective randomized trials from Japan have assessed outcomes between B1 and RY reconstructions after gastrectomy for gastric cancer, reporting variable results on perioperative morbidity and functional outcomes. In one study [2], both B1 and RY patients had similar weight loss (9.1 % vs. 9.7 %) and median albumin level (both 4.2 mg/dl; $p = 0.18$) 1 year after gastrectomy. However, the other study [3] showed the B1 group to have inferior postoperative outcomes, with higher rates of anastomotic leakage (5 % vs. 0 %), anastomotic stricture (6 vs. 1 %), intra-abdominal abscess (3 % vs. 0 %), and wound infection (5 % vs. 1 %). In addition, both studies showed the incidence of bile reflux gastritis to be higher in the B1 group (31 % vs. 21 % and 48 % vs. 26 %) on the basis of endoscopy performed 1 year postoperatively [2, 3]. Furthermore, a subsequent randomized trial of 159 patients from Korea comparing all three reconstruction types showed that although bile reflux gastritis was significantly less common 1 year after RY reconstruction (compared with B1 or B2 reconstruction), a comparison of quality-of-life and nutritional parameters 1 year postoperatively revealed no differences between the three groups [4]. Lastly, the latest results (12–21 years) of a prospective randomized study from Chile comparing B2 and RY reconstruction after gastrectomy for benign disease showed a higher incidence of gastroesophageal reflux symptoms after B2 reconstruction versus RY reconstruction (33 % vs. 3 %), endoscopic appearance of short-segment Barrett's esophagus (25 % vs. 3 %), and histologically proven intestinal metaplasia (21 % vs. 3 %) [5].

Although B1 and RY reconstruction are preferable reconstruction techniques in Eastern countries [6, 7], B2 and RY reconstruction appear more prevalent choices in Western countries [8]. There has been no study from the West comparing surgical outcomes on the basis of the type of reconstruction after resection of gastric cancer. The objective of this study was to determine if the type of reconstruction after partial gastrectomy for gastric cancer has an impact on perioperative and long-term oncologic outcomes.

Methods

The study cohort included patients who underwent either RY reconstruction or B2 reconstruction after partial gastrectomy for gastric adenocarcinoma between 2000 and

2012 at one of seven academic centers participating in the US Gastric Cancer Collaborative: Emory University, Johns Hopkins University, Stanford University, Ohio State University, University of Wisconsin, Wake Forest University, and Washington University in St Louis. Data on patient demographics, clinicopathologic characteristics, perioperative outcomes, and overall survival were collected. Postoperative morbidity was graded with use of the modified Clavien-Dindo classification of surgical complications [9]. The seventh edition of the American Joint Committee on Cancer's staging manual was used to determine the stage [10]. Patients were dichotomized into two groups on the basis of the type of reconstruction performed to restore gastrointestinal continuity after partial gastrectomy: RY versus B2 gastrojejunostomy. Partial gastrectomies include distal gastrectomy (less than 50 % of the stomach resected) and subtotal gastrectomy (more than 50 % of the stomach but not the entire stomach resected). The following patients were excluded from analysis: patients who underwent palliative resections (R2 or in the presence of stage 4 disease), patients who underwent total gastrectomy (as RY reconstruction is typically used in this case), patients who underwent wedge resection of the stomach (no reconstruction required), and patients who underwent B1 reconstruction.

Continuous variables are presented as mean and standard deviation and were compared by Student's *t* test. Categorical variables are presented as observed counts and percentages within each subgroup and were compared by Pearson's chi-square test or Fisher's exact test. Comparisons of preoperative and postoperative albumin level changes (within the same patient) were calculated and compared by a paired *t* test. Survival time was calculated from the date of gastric resection to the date of death or last documented follow-up. Overall survival and the time to recurrence were calculated by the Kaplan–Meier method and compared by the log-rank test. Statistical analyses were performed with SPSS version 23.0 (IBM, Chicago, IL, USA) and STATA version 13.1 (StataCorp, College Station, TX, USA). Each participating site obtained institutional review board approval for this multi-institutional study.

Results

Demographic and preoperative characteristics

Of the 965 patients captured by the US Gastric Cancer Collaborative, the following patient groups were excluded: 398 patients who underwent total gastrectomy, 101 patients with stage 4 disease at presentation, 14 patients who underwent R2 resections, 12 patients who underwent wedge resections, and 17 patients who underwent B1

reconstruction. After exclusion of the aforementioned patients (some of them had overlapping exclusion criteria), 447 patients (47 %) met the inclusion criteria, with B2 reconstructions being performed in 190 patients (43 %) and RY reconstructions being performed in 257 patients (57 %); see Table 1. The demographic characteristics of patients who underwent RY and B2 reconstructions are detailed in Table 2. There were no differences in age, sex, American Society of Anesthesiologists class, comorbidities, and race between the B2 and RY groups. Preoperative nutritional status (i.e., albumin level) was similar between patients who underwent B2 reconstruction versus RY reconstruction. Slightly more patients in the RY group underwent preoperative neoadjuvant chemotherapy (17 % vs. 10 %, $p = 0.032$).

Operative and pathologic results

Subtotal gastrectomies were more commonly associated with RY reconstruction (78.6 % vs. 59.5 %, $p < 0.001$). Tumors of the antrum constituted 71 % of B2 reconstructions and 50 % of RY reconstructions ($p < 0.001$). Moreover, RY reconstruction was associated with a slightly longer operation time (mean 244 min vs. 212 min, $p < 0.001$) and intraoperative blood loss (243 ml vs. 205 ml, $p = 0.033$) than B2 reconstruction. Regardless of the type of reconstruction selected for restoration of gastrointestinal continuity, the number of lymph nodes harvested was marginally higher in the RY group than in the B2 group (range 0–63 lymph nodes vs. 0–42 lymph nodes; median 17 lymph nodes vs. 15 lymph nodes; mean 18 lymph nodes vs. 16 lymph nodes, $p = 0.050$); however, the rates of D2 lymphadenectomy (63.4 % vs. 61.9 %) and multivisceral resections (12.1 % vs. 13.2 %) were comparable. The rate of placement of feeding jejunostomy tubes was similar between the two groups.

There were no differences in the distribution of the American Joint Committee on Cancer stage, T category, and N category between the two groups. The rates of R0 resections (94.5 % vs. 91 %) were similar between the two

groups. There were no differences in tumor differentiation, lymphovascular invasion, perineural invasion, and presence of signet ring cells; however, more patients in the RY group had diffuse histologic type (35.5 % vs. 22.4 %, $p = 0.015$).

Postoperative outcomes

Postoperative outcomes between RY and B2 reconstructions are shown in Table 3. The rates of any complication, a major complication (Clavien grade 3 or more), 30 and 90-day mortality, and reoperation were similar between the two groups. Of the 22 % of patients who had a jejunostomy tube placed intraoperatively, there were no differences in the proportion of patients who were discharged with long-term tube feeding (13 % vs. 12 %, $p = 0.109$). The rates of postoperative adjuvant therapy were similar between the two groups (50.2 % vs. 53.3 %, $p = 0.530$).

To control for the fact that sometimes the method of reconstruction is dictated by the extent of gastric resection (surgeons would more commonly perform RY reconstruction after subtotal gastrectomy and B2 reconstruction after distal gastrectomy), we performed subgroup analyses separately on distal gastrectomy and subtotal gastrectomy patients (Table 4). This demonstrated no differences in postoperative morbidity, mortality, or decline in nutritional status (i.e., postoperative decrease in serum albumin level) between patients undergoing either RY reconstruction or B2 reconstruction.

Survival analysis

Overall survival between RY and B2 groups was comparable (5-year overall survival rate 44 % vs. 40.7 %, $p = 0.177$; Fig. 1a). Similarly, the time to recurrence was similar between the two groups ($p = 0.121$; Fig. 1b). When we stratified survival by stage, there were no differences in survival between patients who underwent B2 reconstruction and patients who underwent RY reconstruction: Stage 1 (5-year overall survival rate 69.6 % vs. 51.1 %, $p = 0.454$), Stage 2 (5-year overall survival rate 36.7 % vs.

Table 1 Distribution of patients undergoing Billroth II reconstruction and Roux-en-Y reconstruction and median lymph node count in seven US institutions

Institution	Billroth II ($n = 190$)	Roux-en-Y ($n = 257$)	Median lymph node count ^a
Emory University	42	50	17 (10–23)
Johns Hopkins University	27	23	15 (10–27)
Ohio State University	28	45	18 (13–25)
Stanford University	25	60	17 (11–25)
Wake Forest University	13	28	13 (5–18)
Washington University in St Louis	45	39	14 (7–21)
University of Wisconsin	10	12	13 (10–20)

^a The interquartile range is given in *parentheses*

Table 2 Clinicopathologic characteristics of patients undergoing Roux-en-Y reconstruction versus Billroth II reconstruction after partial gastrectomy for gastric cancer

	Billroth II (n = 190)	Roux-en-Y (n = 257)	p
Preoperative characteristics			
Mean age (years)	67 (12 ^a)	65 (13 ^a)	0.182
Male sex	102 (53.7 %)	147 (57.2 %)	0.460
ASA class ≥ 3	127 (69 %)	159 (63.9 %)	0.262
Mean BMI (kg/m ²)	25.9 (6.4 ^a)	26.2 (5.6 ^a)	0.620
Race			0.525
White	108 (56.8 %)	144 (56.7 %)	
Asian	31 (16.3 %)	33 (13 %)	
Other	51 (26.8 %)	77 (30.3 %)	
Any comorbidity	113 (59.5 %)	158 (61.5 %)	0.668
Cardiovascular disease	104 (55.0 %)	138 (54.3 %)	0.096
Pulmonary disease	20 (10.6 %)	34 (13.4 %)	0.372
Diabetes	35 (18.5 %)	51 (20 %)	0.696
Mean preoperative albumin level (mg/dl)	3.7 (0.6 ^a)	3.7 (0.6 ^a)	0.946
History of <i>Helicobacter pylori</i> infection (n = 329)	29 (21 %)	36 (18.9 %)	0.643
Preoperative weight loss	74 (39.2 %)	100 (40.2 %)	0.831
History of smoking	78 (41.9 %)	96 (38.9 %)	0.519
Neoadjuvant chemotherapy	19 (10 %)	44 (17 %)	0.032
Operative and pathologic characteristics			
Tumor location			
Fundus	12 (6.4 %)	16 (6.4 %)	
Body	42 (22.5 %)	110 (43.7 %)	<0.001
Antrum	133 (71.1 %)	126 (50.0 %)	
Extent of gastrectomy			
Subtotal	113 (59.5 %)	202 (78.6 %)	<0.001
Distal <50 %	77 (40.5 %)	55 (21.4 %)	
T category			
T0	0 (0 %)	5 (2.0 %)	0.137
T1	56 (30.3 %)	76 (29.8 %)	
T2	27 (14.6 %)	37 (14.5 %)	
T3	49 (26.5 %)	82 (32.2 %)	
T4	53 (28.6 %)	55 (21.6 %)	
Mean tumor size (cm)	4.3 (2.8 ^a)	4.1 (2.5 ^a)	0.535
Lymph node involvement	115 (61.5 %)	137 (53.3 %)	0.085
Mean number of lymph nodes harvested	16 (10 ^a)	18 (11 ^a)	0.050
Mean number of positive lymph nodes	4 (6 ^a)	3 (5 ^a)	0.068
N category			
N0	72 (38.3 %)	119 (46.3 %)	
N1	44 (23.4 %)	52 (20.2 %)	0.336
N2	36 (19.1 %)	38 (14.8 %)	
N3	36 (19.1 %)	48 (13.7 %)	
D2 nodal dissection	117 (61.9 %)	163 (63.4 %)	0.743
AJCC stage			
I	60 (32.4 %)	89 (35.3 %)	
II	51 (27.6 %)	75 (29.8 %)	0.554
III	74 (40 %)	88 (34.9 %)	

Table 2 continued

	Bilroth II (<i>n</i> = 190)	Roux-en-Y (<i>n</i> = 257)	<i>p</i>
Grade			
Well	15 (8.3 %)	15 (6.0 %)	
Moderate	48 (26.7 %)	56 (22.3 %)	0.309
Poor	117 (65.0 %)	180 (71.7 %)	
Lymphovascular invasion (<i>n</i> = 394)	65 (39.6 %)	87 (37.8 %)	0.753
Perineural invasion (<i>n</i> = 320)	38 (26.2 %)	53 (30.3 %)	0.421
Diffuse histology (<i>n</i> = 297)	28 (22.4 %)	61 (35.5)	0.015
Signet ring cell type	72 (38.9 %)	107 (42.6 %)	0.491
Mean operation duration (min)	212 (87 ^a)	244 (84 ^a)	<0.001
Mean estimated blood loss (ml)	205 (151 ^a)	243 (195 ^a)	0.033
Jejunostomy tube placement	35 (13.2 %)	41 (16 %)	0.413
Peritoneal drain placement	63 (33.3 %)	109 (42.4 %)	0.052
Laparoscopic (vs. open)	20 (10.6 %)	20 (7.8 %)	0.676
Intraoperative blood transfusion	20 (10.5 %)	26 (10.1 %)	0.877
Any blood transfusion	38 (20.2 %)	50 (19.5 %)	0.859
Other organs resected	25 (13.2 %)	31 (12.1 %)	0.729
R0 resection (vs. R1)	171 (91 %)	241 (94.5 %)	0.152

AJCC American Joint Committee on Cancer, ASA American Society of Anesthesiologists, BMI body mass index

^a Standard deviation

48.1 %, $p = 0.096$), and Stage 3 (5-year overall survival rate 25.1 % vs. 32.3 %, $p = 0.440$).

Discussion

This is the first multi-institutional study from the West evaluating outcomes of gastric cancer resection on the basis of the type of reconstruction performed to restore gastrointestinal continuity. The results of the study suggest that RY reconstruction after partial gastrectomy for gastric cancer has perioperative outcomes similar to those of B2 reconstruction in terms of morbidity, mortality, and nutritional impairment. As expected, important oncologic surrogates of the quality of resection such as the extent of lymphadenectomy, and margin status remain similar regardless of the type of gastrointestinal reconstruction, a fact that most likely accounts for the similar long-term outcomes (survival and recurrence) noted between the two groups.

Postoperative complications leading to malnutrition, such as delayed gastric emptying, anastomotic leak, or dumping syndrome, may require enteral nutritional support, prolong hospital stay, and increase health care costs [11]. In the present study, nutritional status, as measured by the postoperative decline in serum albumin level at 30, 60, and 90 days within the same patient, was equally affected by RY reconstruction or B2 reconstruction. This observation held true on separate subset analyses for distal and subtotal gastrectomy patients. Similarly, in a prospective

randomized study of 159 gastrectomy patients who underwent B1, B2, or RY reconstruction, Lee et al. [4] found a comparable impact of the three reconstruction methods on nutritional parameters (albumin level, protein level, total lymphocyte count, transferrin level, body weight, and body mass index) measured at 3, 6, 12, and 24 months postoperatively. In another randomized trial, Csendes et al. [5] found that there were no differences in the rates of postgastrectomy diarrhea (9.1 % vs. 9.7 %), dumping syndrome (6 % vs. 3.2 %), and weight gain (78.8 % vs. 90.3 %) between patients who underwent either B2 reconstruction or RY reconstruction. Although our retrospective registry did not include information specifically on delayed gastric emptying, dumping syndrome, diarrhea, body weight, or relevant quality-of-life parameters, we used the length of hospital stay, discharge destination, readmission, and dependency on jejunostomy tube feeding on discharge to indirectly evaluate patients for potential postoperative gastrointestinal dysfunction. We found all of the aforementioned parameters to be similar in our study irrespective of the reconstruction method used.

The comparison of RY reconstruction versus B2 reconstruction has previously been addressed in two studies evaluating restoration of gastrointestinal continuity after pancreaticoduodenectomy. A retrospective study from Memorial Sloan Kettering Cancer Center comparing 122 patients who underwent RY reconstruction with 588 patients who underwent classic B2 reconstruction after pancreaticoduodenectomy found no difference in

Table 3 Postoperative outcomes of the entire cohort

	Billroth II (<i>n</i> = 190)	Roux-en-Y (<i>n</i> = 257)	<i>p</i>
Any complication	68 (40.7 %)	89 (39.2 %)	0.762
Clavien score ≥ 3 (<i>n</i> = 394)	23 (13.8 %)	30 (13.2 %)	0.873
Surgical site infection (<i>n</i> = 374)	11 (6.8 %)	14 (6.8 %)	0.921
Intra-abdominal infection (<i>n</i> = 377)	4 (2.5 %)	12 (5.6 %)	0.197
Myocardial infarction (<i>n</i> = 373)	3 (1.9 %)	3 (1.4 %)	0.733
Re-intubation (<i>n</i> = 377)	9 (5.5 %)	16 (7.5 %)	0.450
Pneumonia (<i>n</i> = 377)	9 (5.6 %)	15 (7 %)	0.576
Pulmonary embolism (<i>n</i> = 375)	3 (1.8 %)	2 (0.9 %)	0.656
Deep vein thrombosis (<i>n</i> = 374)	2 (1.2 %)	3 (1.4 %)	0.880
Renal failure requiring dialysis (<i>n</i> = 372)	3 (1.9 %)	2 (0.9 %)	0.656
GI bleeding (<i>n</i> = 372)	6 (3.7 %)	5 (2.4 %)	0.444
Anastomotic leak (<i>n</i> = 375)	4 (2.5 %)	8 (3.7 %)	0.566
Jejunostomy tube feeding at discharge (<i>n</i> = 67)	24 (13 %)	31 (12 %)	0.109
Reoperation (<i>n</i> = 375)	10 (6.2 %)	11 (5.2 %)	0.674
Readmission (<i>n</i> = 442)	34 (18.3 %)	44 (17.2 %)	0.766
Adjuvant therapy (<i>n</i> = 421)	97 (53.3 %)	120 (50.2 %)	0.530
Median length of stay (days)	7 (6–11 ^a)	8 (6–10 ^a)	0.946
Discharge destination			
Home	177 (93.7 %)	225 (87.5 %)	0.077
SNF	9 (4.8 %)	27 (10.5 %)	
In-hospital death	3 (1.6 %)	5 (1.9 %)	
30-day deaths	5 (2.6 %)	7 (2.7 %)	0.952
90-day deaths	9 (4.7 %)	13 (5.1 %)	0.877
Mean decrease in albumin level from preoperative value to lowest postoperative value within 90 days (same patient) (mg/dl)	0.39 (0.68 ^b)	0.43 (0.65 ^b)	0.687
Mean decrease in albumin level from preoperative value to postoperative value (same patient) (mg/dl)			
At 30 days	0.22 (0.67 ^b)	0.38 (0.63 ^b)	0.143
At 60 days	0.12 (0.60 ^b)	0.22 (0.75 ^b)	0.414
At 90 days	0.17 (0.65 ^b)	0.20 (0.57 ^b)	0.738

GI gastrointestinal, SNF skilled nursing facility

^a Interquartile range

^b Standard deviation

the rates of delayed gastric emptying (10.1 % vs. 10.3 %), reoperation (9.1 % vs. 6.9 %), and interventional radiology procedures (9.8 % vs. 6.8 %), length of hospital stay (11 days vs. 10 days), or mortality (0.9 % vs. 2.6 %) between the two groups [12]. In fact, in a prospective randomized trial of 101 patients who underwent pancreaticoduodenectomy, Shimoda et al. [13] actually found higher rates of delayed gastric emptying after RY reconstruction than after B2 reconstruction (20.4 % vs. 5.7 %), and concluded that B2 reconstruction may be a better reconstructive option. These studies do not support the routine use of RY reconstruction after pancreaticoduodenectomy and reinforce our findings that RY reconstruction may not be superior to B2 reconstruction after gastrectomy, at least in the short term.

Bile reflux gastritis associated with B2 reconstruction after distal gastrectomy has been strongly correlated with carcinogenesis in the gastric remnant, as well as in the setting of Barrett's esophagus. [5] Our retrospective study did not specifically examine this issue, but given the long latency period (sometimes decades) before the development of gastric remnant cancer, it is reasonable to advocate RY reconstruction in younger patients with early gastric cancer who have a long life expectancy, thereby being at risk of metachronous gastric remnant cancer.

There are several limitations to this retrospective study. It is difficult to identify intraoperative factors that may have influenced the decision to proceed with RY versus B2 reconstruction, introducing significant selection bias. Second, given the multi-institutional nature of our study,

Table 4 Postoperative outcomes of type of reconstruction based on extent of gastrectomy

	Distal gastrectomy			Subtotal gastrectomy		
	Billroth II (n = 77)	Roux-en-Y (n = 55)	P	Billroth II (n = 113)	Roux-en-Y (n = 202)	p
Any complication	24 (37.5 %)	20 (42.6 %)	0.591	44 (42.7 %)	69 (38.3 %)	0.469
Clavien score ≥ 3	11 (17.2 %)	6 (12.8 %)	0.601	12 (11.7 %)	24 (13.3 %)	0.716
Surgical site infection	4 (6.6 %)	3 (7 %)	0.933	7 (7 %)	11 (6.5 %)	0.866
Intra-abdominal infection	2 (3.2 %)	2 (4.7 %)	0.708	2 (2 %)	10 (5.8 %)	0.140
Myocardial infarction	0 (0 %)	1 (2.1 %)	0.413	3 (3 %)	2 (1.2 %)	0.364
Re-intubation	5 (8.1 %)	4 (9.3 %)	0.824	4 (4 %)	12 (7 %)	0.426
Pneumonia	2 (3.3 %)	4 (9.3 %)	0.228	7 (6.9 %)	11 (6.4 %)	0.863
Pulmonary embolism	2 (3.2 %)	0 (0 %)	0.514	1 (1 %)	2 (1.2 %)	1.000
Deep vein thrombosis	1 (1.6 %)	0 (0 %)	0.404	1 (1 %)	3 (1.8 %)	1.000
Renal failure requiring dialysis	2 (3.3 %)	1 (2.3 %)	0.775	1 (1 %)	1 (0.6 %)	1.000
GI bleeding	1 (1.6 %)	2 (4.8 %)	0.565	5 (5 %)	3 (1.8 %)	0.132
Anastomotic leak	3 (3.3 %)	2 (4.7 %)	0.720	2 (2 %)	6 (3.5 %)	0.714
Reoperation	5 (8.1 %)	3 (7 %)	0.836	5 (5 %)	8 (4.7 %)	0.913
Readmission	15 (20 %)	7 (12.7 %)	0.275	19 (17.1 %)	37 (18.4 %)	0.776
Adjuvant therapy	42 (56 %)	23 (42.6 %)	0.133	55 (51.4 %)	97 (52.4 %)	0.865
Median length of stay (days)	8 (6–11 ^a)	7 (6–11 ^a)	0.289	7 (6–9 ^a)	8 (6–10 ^a)	0.566
Discharge destination						
Home	71 (92.2 %)	44 (80 %)	0.018	106 (94.6 %)	181 (89.6 %)	0.214
SNF	3 (3.9 %)	10 (18.2 %)		6 (5.4 %)	17 (8.4 %)	
In-hospital death	3 (3.9 %)	1 (1.8 %)		0 (0 %)	4 (2 %)	
30-day deaths	4 (5.2 %)	2 (3.6 %)		1 (0.9 %)	5 (2.5 %)	0.426
90-day deaths	6 (7.8 %)	5 (9.1 %)	0.790	3 (2.7 %)	8 (4 %)	0.752
Mean decrease in albumin level from preoperative value to lowest postoperative value within 90 days (same patient) (mg/dl)	0.412 (0.674 ^b)	0.383 (0.810 ^b)	0.876	0.447 (0.639 ^b)	0.404 (0.638 ^b)	0.701

GI gastrointestinal, SNF skilled nursing facility

^a Interquartile range

^b Standard deviation

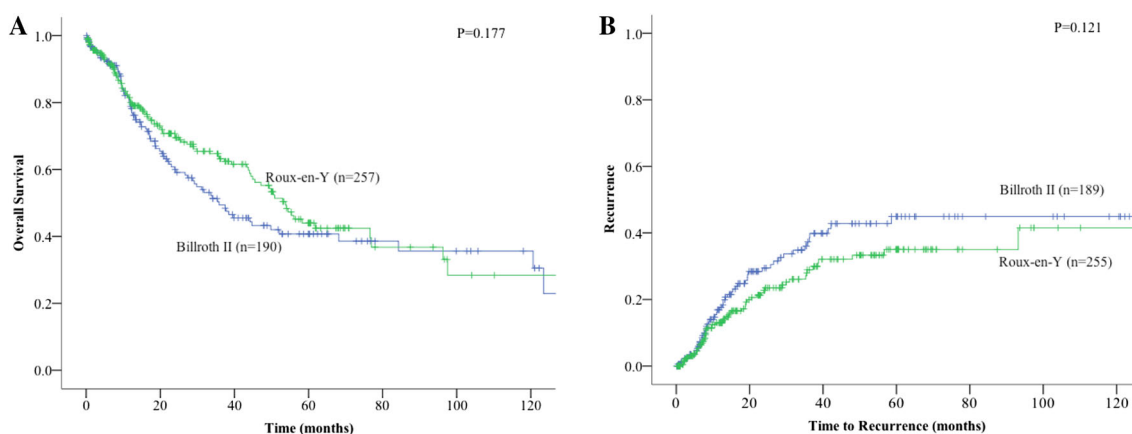


Fig. 1 Comparison of **a** overall survival and **b** time to recurrence between Roux-en-Y reconstruction and Billroth II reconstruction after gastrectomy

important technical aspects employed during reconstruction, including stapled versus hand-sewn anastomosis, isoperistaltic versus antiperistaltic anastomosis, the choice of antecolic versus retrocolic routes, the addition of a Braun anastomosis to a B2 reconstruction (which would make it a functional RY reconstruction), the exact percentage of stomach remaining after gastrectomy, and length of the Roux limb, may have differed by institution and surgeon, but were not available for analysis. Similarly, it was not feasible to collect long-term quality-of-life measures, although we acknowledge that such information would have been extremely helpful for the purposes of this study. Furthermore, it is difficult to discern retrospectively whether specific complications were directly related to the type of reconstruction performed; however, one of our main findings was that the rate of any morbidity or a serious morbidity was comparable between the two groups. Lastly, the exact findings of postoperative endoscopic surveillance (specifically in regard to alkaline gastritis) and perhaps the incidence of aspiration pneumonia secondary to bile reflux were also not recorded, but could have shed light on the differing incidence of this phenomenon after various types of postgastrectomy reconstruction as reported by others.

Conclusion

Despite the presumed theoretical advantage of RY gastrojejunostomy over B2 gastrojejunostomy with regard to bile reflux gastritis, and its potential disadvantage because of the need for an additional anastomosis, this multi-institutional study did not reveal any differences based on the type of reconstruction after partial gastrectomy in the rate and distribution of postoperative complications, postoperative mortality, length of stay, dependency on enteral feeding, discharge destination, readmission, and decline in albumin level. In regard to short-term perioperative outcomes, RY and B2 reconstruction can be considered as equally acceptable restorative options following partial gastrectomy for gastric cancer.

Compliance and ethical standards All participating institutions obtained institutional review board approval for this retrospective study. The research was performed in accordance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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