ORIGINAL ARTICLE

Comparative study of outcomes of Roux-en-Y reconstruction and Billroth I reconstruction performed after radical distal gastrectomy

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Summary *Background:* Billroth I (B—I) reconstruction and Roux-en-Y (R—Y) reconstruction are both commonly performed after distal gastrectomy (DG). We conducted a retrospective study to evaluate which is the better option.
Methods: Included in our study were 162 patients who, between April 2011 and October 2015, underwent DG followed by B—I reconstruction (n = 93) or R—Y reconstruction (n = 69). All patients were followed up for at least 1 year. We compared perioperative outcomes, postoperative complications, gastrointestinal (GI) symptoms, endoscopic findings, and nutritional status between the 2 groups of patients.
Results: Patient characteristics did not differ between the 2 groups, with the exception of the incidence of gastric body tumors, which was significantly higher in the R—Y group (73.9% vs. 19.4%; $p < 0.001$). Operation time was significantly longer in the R—Y reconstruction group ($p < 0.001$). There was no significant between-group difference in the grades of GI dysfunction ($p = 0.122$). The endoscopically determined RGB (*R*esidual food, *G*astritis, *B*ile reflux)scores were significantly better in the R—Y reconstruction group than in the BI reconstruction group ($p = 0.027$, $p < 0.001$, $p < 0.001$, respectively).There was also no significant between-group difference in the change (1-year postoperative value/preoperative value) in body weight, body mass index, serum albumin concentration, or total cholesterol concentration ($p = 0.484$, $p = 0.613$, $p = 0.760$, $p = 0.890$, respectively).

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Conclusions: R—Y reconstruction appears not to be advantageous over B—I reconstruction in terms of GI function or nutritional status 1 year after surgery. R—Y reconstruction does appear to be superior in terms of preventing bile reflux but takes more operation time.

1. Introduction

Radical resection remains the most effective treatment for potentially curable gastric cancer and is the treatment option that provides the only chance of long-term survival.[1] With early diagnosis having significantly improved survival of patients with gastric cancer, surgeons have begun to pay close attention to patients' postoperative quality of life and to curability by improving surgical techniques and choosing the appropriate gastrointestinal (GI) reconstruction method. The best GI reconstruction method after distal gastrectomy (DG) will maintain continuity of the duodenal pathway and prevent bile reflux.

Both B—I and R—Y reconstruction are commonly used after DG in Eastern countries.[1, 2] B-I reconstructions widely performed after DG for gastric cancer, and this is because of its technical simplicity, the physiological passage of food, and the ease of postoperative duodenal endoscopy.[3] However, high rates of remnant gastritis as well as a high risk of cancer in the gastric remnant have been reported in patients who have undergone B—I reconstruction.[4,5] R—Y reconstruction has been nearly universally recognized as a better method in terms of preventing bile reflux and cancer in the gastric remnant.[6,7] However, R—Y reconstructions are reported to be related to the possible development of stomal ulcer, an increased probability of cholelithiasis and the possibility of Roux stasis syndrome.[8,9]

Although Billroth I (B—I) and Roux-en-Y (R—Y) anastomoses are all recommended for reconstruction after DG, which method is best is an open question.[1, 2] We evaluated which is the better reconstruction method by conducting this study in which we compared outcomes of the procedures, especially 1-year outcomes, between patients who underwent DG with B—I reconstruction and patients who underwent DG with RY reconstruction.

2. Methods

2.1. Patients

The study group comprised 162 patients who underwent radical DG with B—I (n = 69) or R—Y (n = 93) reconstruction at our institution between April 2011 and October 2015 and were followed up postsurgically for at least 1 year. Patients who underwent palliative resection and those who underwent gastric wedge were not included.

Between the 2 groups, we compared the following: patients' clinical characteristics, perioperative outcomes, postoperative complications, postoperative GI symptoms, endoscopic findings and nutritional status at a year

postoperatively. The modified Clavien-Dindo classification was used to assess surgical complications.[10] Epigastric pain, nausea, postprandial bloating, bilious vomiting, and heartburn were assessed at a year after surgery as measures of postoperative GI dysfunction, each of these 5 symptoms was scored on a scale of 0—5 points, and GI dysfunction was then graded on the basis of the total 5 scores as follows. (Grade 0: 0 points; Grade 1: 1—5 points; Grade 2: 6—10 points; Grade 3: 11—15 points; Grade 4:16—25 points) (again, the higher the score the more severe the symptoms).[11] The remnant stomach was evaluated endoscopically at 1 year after surgery according to the RGB (*R*esidual food, *G*astritis, *B*ile reflux)scoring system (the higher the score the more severe the symptoms).[4] Body weight, body mass index (BMI), the serum albumin concentration, and the serum total cholesterol concentration were taken as indicators of nutritional status, and the change (1-year postoperative value/preoperative value) in nutritional status was calculated. The questionnaire information about conditions 1 year after surgery were issued for all 162 patients on the case report form for data collection.

2.2. Surgical technique

All the patients underwent distal gastrectomy with lymphadenectomy, usually,a one-third stomach was reserved, according to the Japanese gastric cancer treatment guideline.[12] The stomach was divided with a 75 mm long linear stapler (Ethicon, Linear Cutter) from the greater curvature to the lesser curvature. The site of entry near the lesser curvature for the circular stapler was opened. All the end-to-end gastroduodenal anastomosis and end-to-end gastrojejunostomy anastomoses were completed by using 25 mm circular staplers (Ethicon, CDH25) and reinforced by interrupted full-thickness sutures (Ethicon Vicryl ™ Plus 3-0). Briefly, the end-to-end gastroduodenostomy was made by a 25 mm circular stapler between the duodenal stump and the distal corner of greater curvature in the B—I group. And the site of entry for circular stapler was closed by a 75 mm long linear stapler (Ethicon, Linear Cutter). In the R—Y group, the duodenum was divided and closed by a 55 mm long linear stapler (Ethicon, Linear Cutter) 3 cm distal to the pylorus. Then, the duodenal stump was reinforced by interrupted full-thickness sutures and interrupted seromuscular sutures (Ethicon Vicryl ™ Plus 3-0). For reconstruction, the proximal jejunum was identified and divided 15—20 cm distant from the Treitz ligament firstly. Next, the gastrojejunostomy was performed between the distal corner of greater curvature and the end of the distal jejunums with a 25 mm circular stapler in a end-to-end

fashion, and the site of entry for circular stapler was closed by a 75 mm linear stapler (Ethicon, Linear Cutter). Then, an end-to-side jejunojejunostomy was fashioned 30 cm distal to the gastrojejunostomy using a interrupted hand-sewn suture (Ethicon Vicryl ™ Plus 4-0). The mesenteric defect was closed with interrupted sutures (Ethicon Vicryl ™ Plus 4-0).

In the patients who received laparoscopic surgery, we performed laparoscopic assisted distal gastrectomy. A 10 mm trocar was inserted through the umbilical region, and then carbon dioxide pneumoperitoneum established. The additional four trocars were placed, including two 12 mm trocars in the right and left lower abdomen and two 5 mm trocars in the right and left upper abdomen. After the mobilization of the stomach and lymph nodes dissection by using laparoscopy, a mini-incision at length of 6—8 cm was made above the umbilicus. Then specimen was removed and GI reconstruction was performed through the incision. The procedures for GI reconstruction and staplers used in the operation were as same as the open cases.

2.3. Statistical analysis

Differences in study variables between patients in whom B-I reconstruction was performed and those in whom R-Y reconstruction was performed were analyzed by χ^2 test, Student's t-test, or Mann—Whitney U test, as appropriate. Change from the preoperative to postoperative serum albumin concentration, serum total cholesterol concentration, body weight, and BMI were calculated and compared between groups by Wilcoxon rank sum test. Between-group differences in grades of post-surgical GI dysfunction were analyzed by Mann—Whitney U test. All statistical analyses were performed using SPSSv18.0 for Windows software (SPSS, Chicago, IL), and a p value of <0.05 was considered statistically significant.

3. Results

Clinical characteristics (including treatment details) are shown per B—I group and R—Y group in Table 1. The only statistically significant between-group difference in clinical characteristics was the greater percentage of patients with a gastric body tumor in the R—Y reconstruction group (73.9% vs. 19.4%, respectively; $p < 0.001$).

Surgical outcomes and postoperative complications are shown per group in Table 2. Operation time was significantly longer in the R—Y reconstruction group than in the B—I reconstruction group (200.75 $\pm$ 15.60 min vs. 155.77 $\pm$ 15.97 min, respectively; $p < 0.001$).However, there was no significant between-group difference in blood loss volume ($p = 0.687$), time to the start of a soft diet ($p = 0.678$), postoperative length of stay ($p = 0.576$), anastomotic leakage ($p = 0.835$), anastomotic bleeding ($p = 1.000$), or Clavien-Dindo classification ($p = 0.883$). None of patients was re-operated or readmitted because of postoperative complications. Postoperative questionnaires filled out by all 162 patients 1 year after the surgery showed that 11 patients in the B—I group and 4 patients in the R—Y group experienced dumping symptoms, two patients in the B—I group and 5 patients in the R—Y group experienced

Table 1 Clinical characteristics of patients per study group.

Characteristic	Billroth I (n = 93)	Roux-en-Y (n = 69)	p Value
Male Sex	63 (67.7%)	46 (66.7%)	0.885
Age	63.7 ± 8.8	63.4 ± 10.7	0.833
Body mass index (kg/m^2)	22.0 ± 1.6	21.8 ± 1.2	0.290
Location of tumor			
Body	18 (19.4%)	51 (73.9%)	<0.001
Antrum	75 (80.6%)	18 (26.1%)	
Surgical approach			
Open	85 (91.4%)	63 (91.3%)	0.983
Laparoscopic	8 (8.6%)	6 (8.7%)	
Lymphadenectomy			
D1$^+$	20 (21.5%)	11 (15.9%)	0.373
D2	73 (78.5%)	58 (84.1%)	
Number of lymph nodes harvested	28.9 ± 4.1	29.6 ± 4.0	0.276
Pathological stage			
I	18 (19.4%)	9 (13.0%)	0.562
II	48 (51.6%)	39 (56.5%)	
III	27 (29.0%)	21 (30.4%)	
Adjuvant chemotherapy	73 (78.5%)	58 (84.1%)	0.373

delayed gastric emptying, but the incidences of dumping symptom and delayed gastric emptying did not differ significantly between the 2 groups ($p = 0.190$ and $p = 0.056$, respectively) (Table 3).

There was no significant between-group difference in the grade of GI dysfunction ($p = 0.122$), but the incidences of heartburn and bilious vomiting were significantly lower in the R—Y reconstruction group than in the B—I reconstruction group ($p = 0.021$ and $p = 0.036$, respectively) (Fig. 1).

The endoscopically determined RGB scores for residual food, gastritis, and bile reflux 1 year after surgery were significantly lower in the R-Y reconstruction group than in the B-I reconstruction group ($p = 0.002$, $p < 0.001$, and $p < 0.001$, respectively) (Table 4).

There was no significant between-group difference in the change (1-year postoperative value/preoperative value) in weight or BMI ($p = 0.484$, $p = 0.613$, respectively). The 1-year postoperative/preoperative serum albumin and total cholesterol ratios were also similar between the 2 groups ($p = 0.760$, $p = 0.890$, respectively) (Table 5).

4. Discussion

The ideal reconstruction method should fit the patient's physical condition, reduce the risk of postoperative complications, and improve the patient's quality of life. The reconstruction method applied in patients is often a matter of the surgeon's preference.[1] We choose the reconstruction method on the basis of the tumor location, with concern mainly for good anastomotic blood supply and absence of tension, which explains why the greater percentage of our patients with a gastric body tumor were

Table 2 Surgical outcomes per reconstruction method.

Variable	Billroth I (n = 93)	Roux-en-Y (n = 69)	p value
Operation time (min)	155.8 ± 16.0	200.8 ± 15.6	<0.001
Blood loss (mL)	226.5 ± 19.0	227.9 ± 24.0	0.687
Time to soft diet (days)	4.1 ± 0.3	4.1 ± 0.3	0.678
Postoperative hospital stay (days)	9.5 ± 1.8	9.4 ± 1.5	0.576
Postoperative complication			
Anastomotic leakage	3 (3.2%)	1 (1.4%)	0.835
Anastomotic bleeding	1 (1.1%)	0 (0%)	1.000
Wound infection	3 (3.2%)	1 (1.4%)	0.835
Pneumonia	4 (2.2%)	2 (1.4%)	0.963
Modified Clavien-Dindo classification			
No complication	60	46	0.883
I	17	9	
II	13	12	
III	2	1	
IV	1	1	
V	0	0	

in our R−Y group, and it matches a distribution pattern reported previously.[2]

R−Y reconstruction is advantageous over B−I reconstruction because there is no anastomotic tension and the blood supply is good.[13,14] Moreover, R−Y reconstruction has been thought to reduce the incidence of bile reflux that is associated with B−I reconstruction. However, delayed gastric emptying, known as Roux stasis syndrome, occurs in some patients. This is a major drawback of R−Y reconstruction and related to functional obstruction of the Roux limb after R−Y reconstruction.[9,15] Length of the alimentary limb is an important consideration in R−Y reconstruction. Gustavsson et al[16] reported association between a limb longer than 40 cm and the occurrence of Roux stasis syndrome. Lee et al,[17] however, reported that the frequencies of Roux stasis syndrome were not related to limb length. The discrepant findings may be a result of multiple other factors related to Roux stasis syndrome, such as dissection of the vagus nerve branches, a large residual stomach and separation of the limb from the natural pacemaker in the duodenum.[8,16,18] In our B−I group, the limb was normalized to 30 cm, and the delayed gastric emptying rate was low and similar to a rate recently reported.[9] Operation time was clearly longer in our R−Y group than in our B−I group. This was not unexpected and can be explained by the relatively complex R−Y procedure and the additional

Table 3 Postoperative complications per reconstruction method.

Variable	Billroth I (n = 93)	Roux-en-Y (n = 69)	p value
Readmission	0	0	
Reoperation	0	0	
Dumping syndrome	11 (11.8%)	4 (5.8%)	0.190
Delayed gastric emptying	2 (2.2%)	5 (7.2%)	0.056

anastomosis. B−I reconstruction is considered preferable to the patients with severe co-morbidities who are unable to tolerate longer operation time. Compared with R−Y reconstruction, B−I reconstruction has the physiological advantage of allowing food to pass through the duodenum, which has a better effect on the digestion and absorption of food. It was expected that the natural passage would improve nutritional status and long-term quality of life.- However, the duodenal passage may not be an important determinant of nutritional status after DG[19]. Compared with R−Y reconstruction, B−I reconstruction was associated with higher long-term incidences of both bile reflux into the gastric remnant and remnant gastritis[19,20] and a greater possibility of experiencing symptoms of either early or late dumping after DG[21], which may explain why B−I reconstruction has a more physiological approach but does not show a better nutritional status than that of R−Y reconstruction.[19]

We used the postoperative length of stay and the modified Clavien-Dindo classification to directly assess the early outcome of the 2 reconstruction methods. We found no difference between the 2 methods in terms of the early outcome.

Investigators[7,19,22] have reported significantly lower incidences of endoscopically identified bile reflux, residual food, remnant gastritis, and gastroesophageal reflux among patients in whom R−Y reconstruction was performed in comparison to incidences among patients in whom B−I reconstruction was performed. In addition, biliary reflux, according to 24-h bilirubin monitoring, biliary scintigraphy, and hepatobiliary imaging, has been shown to be significantly less severe after R−Y reconstruction in comparison to that after B−I reconstruction.[6,7,23] Our endoscopic findings at 1 year after surgery are very much in keeping with these reported findings. Bile reflux is regarded as a main factor affecting patients' postoperative quality of life.[24] We advocate R−Y reconstruction for relatively young patients with early-stage cancer and for whom life expectancy is long.

Some reports[17,23,25] suggested that it was difficult to correlate endoscopic findings with clinical symptoms in bile reflux after DG. Although we observed no significant difference between B−I reconstruction and R−Y reconstruction with respect to GI dysfunction, the incidences of heartburn and bilious vomiting were significantly lower after R−Y reconstruction. Heartburn is a typical symptom of gastroesophageal reflux disease.[26] Some authors[13,19,21] reported a lower incidence of heartburn after R−Y reconstruction than that after B−I reconstruction at 1 year and 5 years after surgery. Based on these reports and our data, we speculate that heartburn can be used as an independent index for postoperatively clinical symptoms in bile reflux.

Bile reflux is an important factor affecting food intake after DG. Kojima et al[13] found the 1-year postoperative/ preoperative food intake ratio to be significantly lower in their B−I group than that in their R−Y group, but the final measures of nutritional status did not differ between the groups. Moreover, other investigators[17,19,23] found no correlation between endoscopically determined bile reflux and nutritional status at 1 year or at 5 years. Nakamura M et al reported that the choice between B−I reconstruction
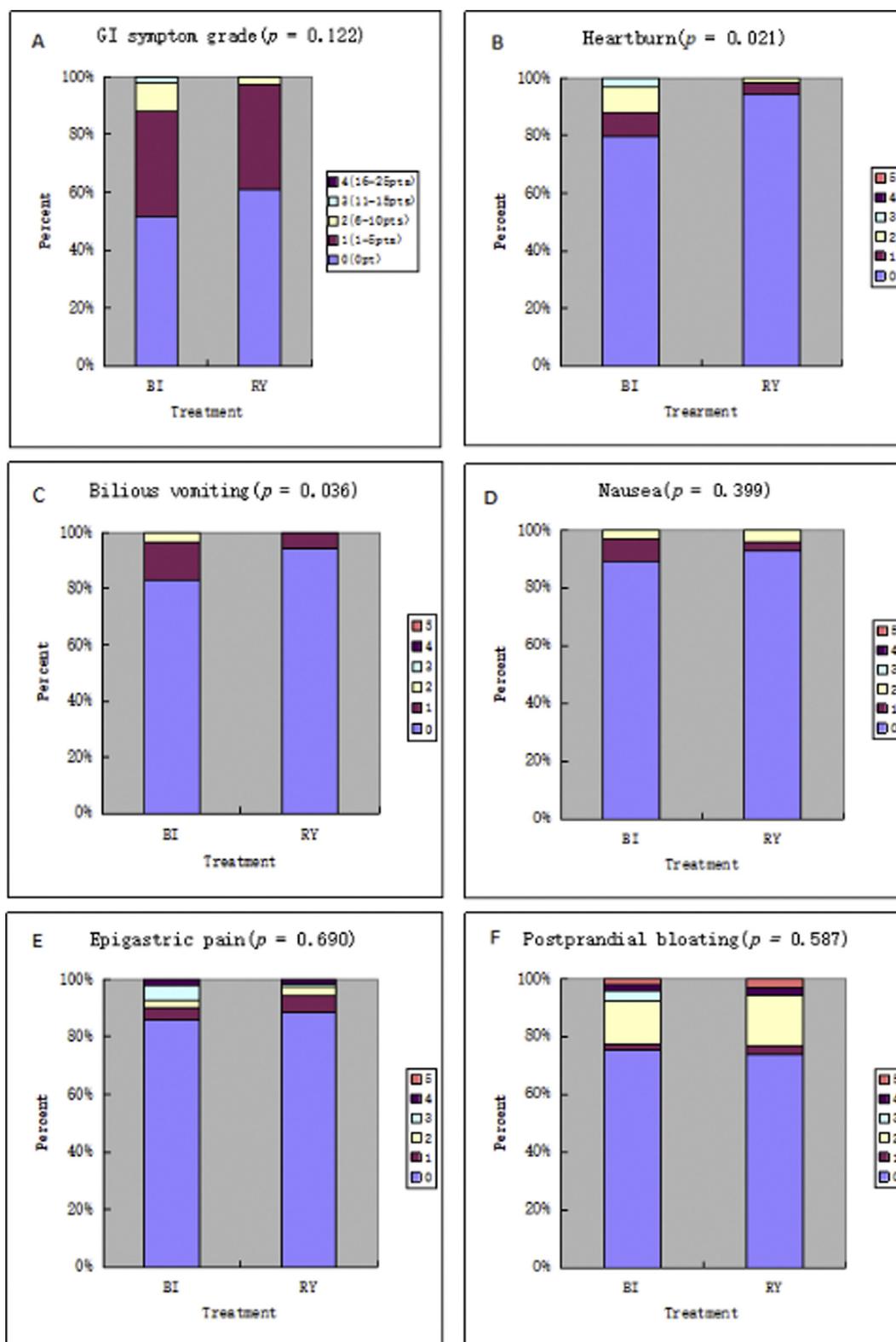
Fig. 1   Assessment of GI dysfunction based on symptoms scores in the 2 study groups. A: Total GI symptoms scores between the 2 groups. B ∼ F: Individual symptom scores between the 2 groups.

and R—Y reconstruction for patients with gastric cancer resulted in no difference in long-term quality of life, however, the rate of weight loss in the third year was lower in their B—I group than that in their R—Y group.[20]

Evidence supporting a direct relation between bile reflux and postoperative nutritional status seems to be lacking. It has been reported that a relatively large gastric remnant may result in relatively good functional outcomes, for

Table 4 RGB scores 1 year after surgery per study group.

Variable	Billroth I (n = 93)	Roux-en-Y (n = 69)	p value
Residual food			
0	47	49	0.027
1	17	11	
2	7	4	
3	22	5	
4	0	0	
Gastritis			
0	7	44	<0.001
1	33	22	
2	34	3	
3	19	0	
Bile reflux			
No	42 (48.4%)	57 (82.6%)	<0.001
Yes	51 (51.6%)	12 (17.4%)	

Number or number of patients is shown unless otherwise indicated.

Table 5 Changes in nutritional indicators (postoperative 1 year value/preoperative value).

Variable	Billroth I (n = 93)	Roux-en-Y (n = 69)	p value
Change in body mass index	-0.15 ± 0.56	-0.11 ± 0.49	0.613
Change in body weight	-0.42 ± 1.52	-0.26 ± 1.31	0.484
Change in serum albumin	0.14 ± 3.04	0.30 ± 3.62	0.760
Change in total cholesterol	0.06 ± 0.44	0.04 ± 0.41	0.890

Values are mean $\pm$ SD unless otherwise indicated.

example, greater food intake, preservation of the postoperative body weight, and fewer complaints of postprandial symptoms at 1 year.[21] Resection of at least two thirds of the stomach is defined, according to the Japanese Guidelines for the Treatment of Gastric Cancer, as standard DG for advanced gastric cancer.[12] When an early-stage tumor is located high in the gastric body or the tension of the anastomosis needs to be considered, more of the stomach can be preserved in some patients undergoing B—I reconstruction, and this could be a factor affecting postoperative nutritional status. Like other investigators,[7,17] we found no statistically significant differences between B—I and R—Y in terms of the changes (postoperative 1-year value/preoperative value) in BMI, body weight, serum albumin, and total cholesterol in our patients.

In conclusion, our data indicate that R—Y reconstruction is not superior to B—I reconstruction in terms of GI function and nutritional status 1 year after surgery. R—Y reconstruction is superior to B—I reconstruction in terms of preventing bile reflux but that takes more operation time. The 2 methods of reconstruction should be equally selective following DG for gastric cancer.

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