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Safety and short-term outcomes of a modified tubular esophagogastrostomy versus double tract reconstruction after proximal gastrectomy: a propensity score matching analysis

Chaoyang Zhang[1], Kaixing Wang[1], Zhidong Zhang[1*], Xuefeng Zhao[1], Bin Yao[1] and Weishuai Zhang[1]

Abstract

Objective To comparatively evaluate the short-term clinical efficacy and quality of life (QoL) between modified tubular esophagogastrostomy (mTEG) and double tract reconstruction (DTR) following proximal gastrectomy (PG), aiming to establish evidence-based recommendations for reconstruction method selection.

Methods The mTEG technique involved three essential steps: 1) tubular reconstruction of gastric remnant, 2) 3-cm artificial gastric fornix creation, and 3) His angle sharpening with posterior mediastinal fixation. This retrospective study included 288 PG patients (2021–2024). Propensity score matching (1:1, caliper = 0.03) balanced baseline characteristics, and thirty-three matched pairs were analyzed. Outcomes encompassed operative metrics, postoperative complications (Clavien-Dindo ≥ II), nutritional status (prealbumin, albumin, hemoglobin, BMI at 1/3/6 months), and QoL (EORTC QLQ-STO22 at 6 months).

Results The mTEG group demonstrated shorter median operative time (163.7 vs 247.9 min, $p < 0.001$) and postoperative hospitalization (8.3 vs 9.9 days, $p = 0.001$). Intraoperative outcomes including blood loss and lymph node yield were comparable. Early complications (≤ 30 days) occurred exclusively in the DTR group (4 cases: 2 anastomotic leakage, 1chylous leakage and 1 pulmonary related). complication rates showed no statistical difference ($p > 0.05$). Endoscopic findings demonstrated comparable incidence of reflux esophagitis in Los Angeles Grade B or higher (11.1% vs 4.5%, $p = 0.457$). Nutritional parameters and QoL scores remained equivalent between groups at all timepoints ($p > 0.05$).

Conclusion mTEG represents a technically optimized reconstruction method that achieves equivalent nutritional preservation and reflux prevention compared to DTR, while offering distinct advantages in surgical efficiency and postoperative recovery. These findings support mTEG as a viable reconstruction option for PG patients.

Keywords Proximal gastrectomy, Tubular reconstruction, Double tract reconstruction, Quality of life

*Correspondence:
Zhidong Zhang
zhang_zhi_dong@hebmu.edu.cn
[1] The Third Department of Surgery, The Fourth Hospital of Hebei Medical University, No. 12 Jiankang Rd. Changan District, Shijiazhuang 050011, China

Introduction

Gastric carcinoma persists as the fifth most prevalent malignancy globally and ranks fifth in cancer-related mortality, constituting a substantial public health burden worldwide [1]. While epidemiological trends demonstrate an overall incidence decline (attributed to dietary modifications and Helicobacter pylori eradication programs), the proportional increase of upper gastric malignancies (encompassing upper gastric body, fundic, and esophagogastric junction [EGJ] carcinomas) has become particularly pronounced in East Asian populations [2, 3]. Surveillance data from the National Cancer Center Hospital Tokyo reveals a striking temporal progression in EGJ adenocarcinoma incidence, escalating from 2.3% during the 1960 s to 10% in the early 2000 s, with Siewert type II tumors surging from 28.5% to 57.3% of cases [4]. This epidemiological shift is corroborated by a Chinese single-institution, high-volume experience documenting EGJ carcinomas accounting for >35% of gastric cancer diagnoses in the 2010 s [5]. The anatomical complexity of these tumors, straddling thoracic and abdominal surgical domains, continues to fuel ongoing debates regarding optimal therapeutic strategies.

Total gastrectomy (TG) remains the historical benchmark for advanced upper gastric carcinomas, prioritizing maximal surgical radicality [6]. Contemporary evidence from multicenter trials reveals comparatively low metastasis rates in lymph node stations 4d, 5, and 6 for upper gastric malignancies, establishing the oncological validity of proximal gastrectomy [7–9]. PG confers distinct advantages through preservation of distal gastric anatomy, obviating left gastric/gastroepiploic vascular dissection and distal lymphadenectomy, thereby reducing mean operative time versus TG. Clinically significant benefits include superior postoperative weight retention, hemoglobin preservation, and enhanced long-term nutritional parameters, alongside reduced incidence of dumping syndrome and chronic diarrhea [10–13]. The advent of neoadjuvant therapies (including SOX regimen) and molecular-targeted agents (e.g., trastuzumab deruxtecan) has enabled tumor downstaging in advanced cases, thereby expanding PG indications while maintaining R0 resection rates [14, 15].

While esophagogastric anastomosis remains the conventional reconstruction method following proximal gastrectomy [16], its universal association with postoperative reflux complications (reported in up to 100% of cases [17]) significantly compromises quality of life. This clinical challenge has driven the development of various innovative reconstruction techniques, including anti-reflux modifications to the esophagogastric anastomosis and jejunal interposition procedures aimed at establishing a physiologic buffering zone, and reconstructing gastric fundus anatomy and His angle configuration. Tubular esophagogastrostomy has emerged as a pragmatic alternative, demonstrating technical feasibility and reduced reflux incidence through partial gastric reservoir preservation, nonetheless, its anti-reflux efficacy remains suboptimal [18]. Our institutional modification incorporates pseudo-fornix creation (3–5 cm length) with diaphragmatic fixation, establishing an acute His angle while maintaining intragastric pressure gradients.

Double tract reconstruction, first conceptualized in 1988, has evolved through iterative refinements to achieve superior anti-reflux efficacy while maintaining nutritional parameters and quality of life. This retrospective cohort analysis compares short-term outcomes between modified tubular esophagogastrostomy (mTEG) and DTR cohorts, employing propensity score matching balanced baseline characteristics. Our findings aim to elucidate optimal reconstruction strategies for upper gastric malignancies in the era of multimodal therapy.

Materials and methods

Patients

This retrospective analysis enrolled 288 patients (aged 18–75 years) undergoing proximal gastrectomy at the Third Department of Surgery, Fourth Hospital of Hebei Medical University, between January 2021 and May 2024. Inclusion criteria included: (1) histologically confirmed adenocarcinoma of the upper stomach; (2) primary tumor diameter ≤4 cm; (3) adequate cardiopulmonary/renal function for major surgery; (4) R0 resection with D2 lymphadenectomy. Exclusion criteria comprised: (1) pregnancy/lactation; (2) severe psychiatric disorders; (3) emergency surgery for complications (hemorrhage/obstruction/perforation); (4) distant metastasis of gastric cancer; (5) secondary malignancies within 5 years; (6) incomplete clinical data.

After exclusions ($n=53$: tumor size >4 cm [$n=9$], secondary malignancies [$n=5$], missing data [$n=39$]), 235 patients were analyzed. Propensity score matching (1:1, caliper =0.03) balanced baseline characteristics between modified tubular esophagogastrostomy and jejunal interposition cohorts (Fig. 1). Ultimately, thirty-three patients in each group were matched by PSM. Notably, patients excluded for tumor size exceeding criteria underwent neoadjuvant therapy followed by surgical resection.

Surgical techniques

All procedures were performed by a surgical team with >100-case experience in either minimally invasive surgery (including laparoscopic and robotic surgery) or open gastrectomy.

Lithotomy position for minimally invasive cases (5-port technique) vs. supine position for open cases (midline incision). Radical proximal gastrectomy with D2 lymphadenectomy was conducted by the 4th Japanese Gastric Cancer Treatment Guidelines, adhering to the following technical sequence: 1. Harmonic scalpel division of gastrocolic ligament, progressing toward splenic

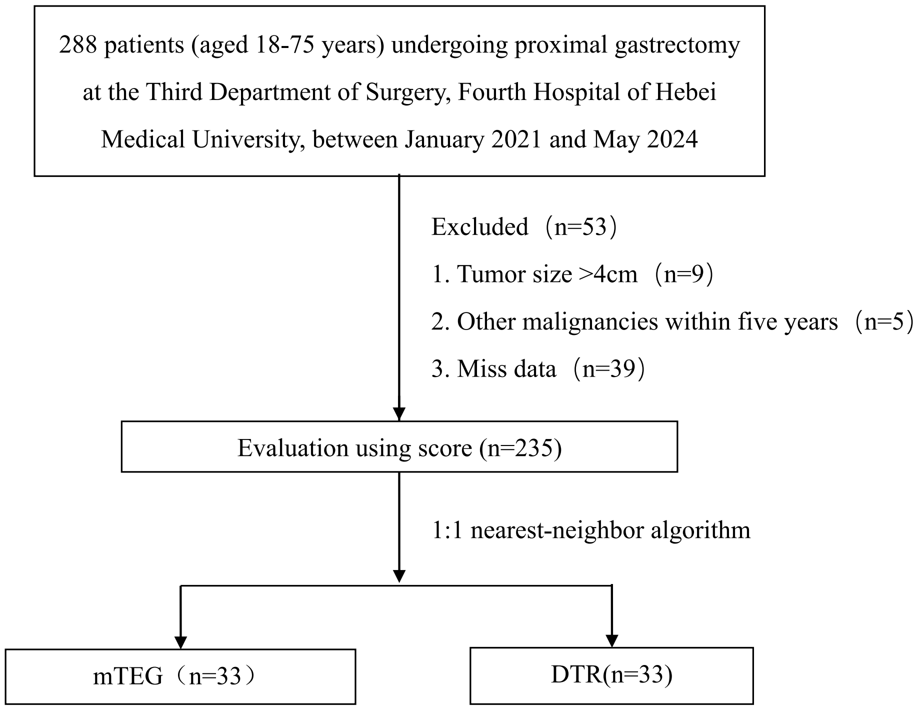

Fig. 1 A flowchart of patients enrolled in present study

hilum with ligation of left gastroepiploic/short gastric vessels (LN stations 4 sa/4 sb; Fig. 2a). 2. Clamping of left gastric artery followed by en bloc resection of LN stations 7/8a/9 (Fig. 2b). 3. Distal splenic artery exposure with LN station 11 clearance. 4. Ligation of posterior gastric vessels, superior mobilization of the posterior gastric wall with resection of LN station 2. 5. LN stations 1/3 clearance with extensive esophageal mobilization to minimize

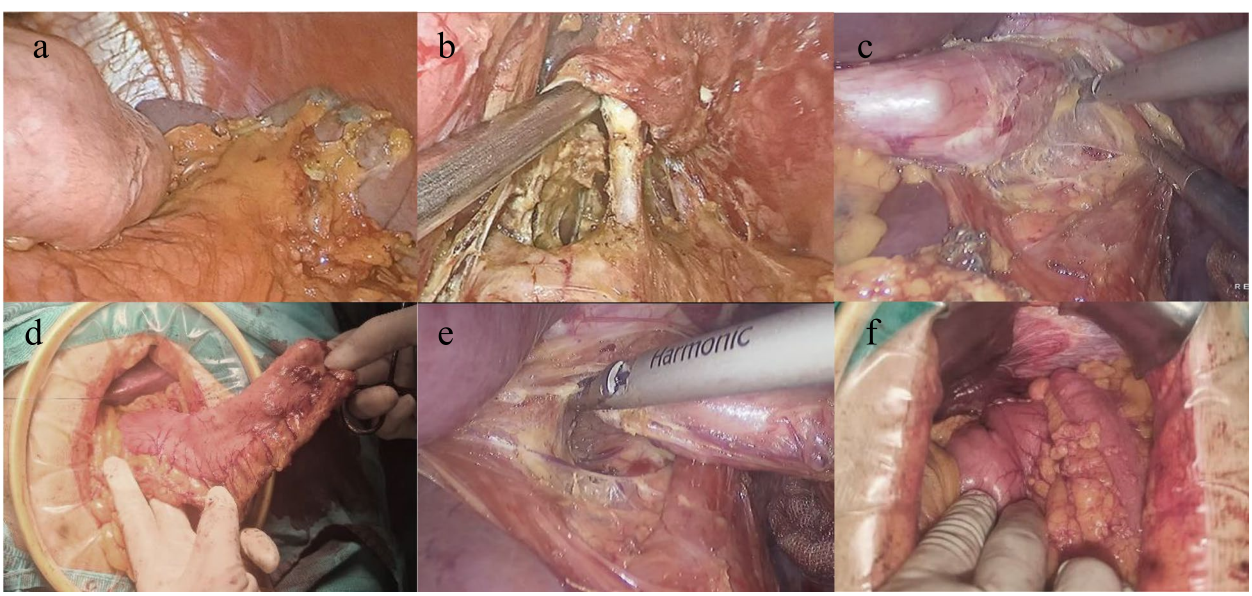

Fig. 2 **a** Division of the right gastroepiploic vessels and dissection of the Group 4 sa and 4 sb lymph nodes. **b** Division of the left gastric vessels with subsequent lymphadenectomy of stations 7, 8a, and 9. **c** Superior mobilization of the abdominal and mediastinal esophagus. **d** Construction of a 4.0-cm-wide tubular gastric measuring approximately 20 cm in length. Panel **e** Comprehensive dissection of the inferior mediastinum. **f** Placement of the constructed gastric conduit into the posterior mediastinum with posterior esophageal positioning and diaphragmatic fixation

anastomotic tension (LN station 19/20/110/111/112), and Routine division of distal esophageal vagal trunks.

Modified tubular esophagogastrostomy

Following standard lymphadenectomy and 5–8 cm mediastinal esophageal mobilization: 1. Purse-string application after distal esophageal division. 2. Creation of 4 cm ×20 cm gastric conduit along greater curvature using endoscopic linear stapler (Fig. 2d). 3. Placement of the circular stapler 4–5 cm proximal to the gastric antrum, End-to-side esophagogastric anastomosis at anterior wall, preserving 3–4 cm"pseudo-fornix"above anastomotic line (Fig. 2e). 4. 3–0 V-Loc suture closure of gastric incision. 5. Fixation of pseudo-fornix to posterior mediastinum and diaphragmatic crura to recreate acute His angle (Fig. 2f). The technical schematic of mTEG procedure is presented in Fig. 3.

Double tract reconstruction

Following proximal gastrectomy: 1. division of 20 cm distal to Treitz ligament with endoscopic linear stapler. 2. Side-to-side jejunojejunostomy 40 cm distal to transection line (common opening closed with V-Loc). Mesenteric defect closure to prevent internal herniation. 3. Functional side-to-side anastomosis using linear stapler. Staple line reinforcement with seromuscular sutures. 4. Antecolic side-to-side anastomosis 15 cm distal to esophagojejunal junction.

Outcome measures

(1) Intraoperative outcomes: Operative duration, estimated blood loss, and total lymph nodes harvested. (2) Postoperative recovery: Time to first postoperative exhaust, first liquid diet, hospital stay duration, and drainage tube/gastric tube removal. (3) Complications: Early (≤ 30 days): Anastomotic leakage, intra-abdominal hemorrhage, pleural effusion, intraabdominal abscess, incision infection, chylous leakage, and gastroparesis. Late (> 30 days): Anastomotic stricture, intestinal obstruction, and reflux esophagitis (graded by Los Angeles classification [LA] via endoscopy at 1 year). (4) Nutritional status: Body mass index (BMI), albumin, prealbumin, and hemoglobin levels at 1-, 3-, and 6-month postoperative intervals. (5) Quality of life (QoL): Assessed using the EORTC QLQ-STO22 questionnaire, with raw scores linearly transformed to 1–100 scales per QLQ-C30 guidelines.

Assessment criteria

Postoperative complications were graded by Clavien-Dindo (C-D) classification [19]: Grade I: Symptomatic management (e.g., analgesics/antiemetics). Grade II: Pharmacological interventions (e.g., transfusions). Grade III: Endoscopic/surgical reintervention. Grade IV: Life-threatening complications (e.g., cerebral hemorrhage). Grade V*: Mortality. Clinically significant complications were defined as C-D classification ≥II. Anastomotic stricture required ≥1 endoscopic balloon dilation. Reflux esophagitis severity was quantified using LA grades (A–D) during 1-year surveillance endoscopy. Gastrointestinal continuity and anastomotic integrity were evaluated via contrast esophagography on postoperative days 5–6, with modified tubular esophagogastrostomy

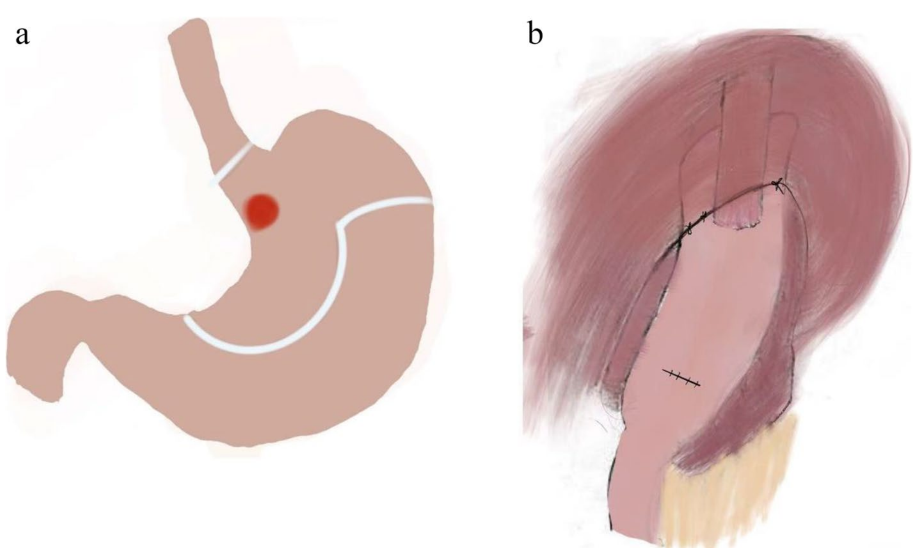

Fig. 3 Schematic illustration of mTEG

(mTEG) cases assessed in 15° Trendelenburg position for reflux.

Follow-up

A dedicated research team collected anthropometric data (height/weight), laboratory parameters, and QoL scores at 1, 3, and 6 months postoperatively through hospital visits and outpatient clinics.

Statistical analysis

Data analysis utilized SPSS 26.0 (IBM Corp.). Propensity score matching (PSM) with 1:1 nearest-neighbor algorithm (caliper =0.03) minimized selection bias between mTEG and DTR cohorts. Matching covariates included age, sex, BMI, tumor size, differentiation grade, TNM stage, adjuvant therapy status, and surgical approach (open vs. minimally invasive). Normality was assessed via Shapiro–Wilk test. Continuous variables were expressed as mean ±SD (normal distribution) or median (IQR) (non-normal), while categorical variables as frequencies (%). Comparative analyses employed: Continuous variables: Independent t-tests for normally distributed data; Wilcoxon rank-sum tests for skewed data. Categorical variables: Chi-square or Fisher's exact tests. Ordinal variables: Wilcoxon rank-sum tests. Statistical significance was set at $P < 0.05$ (two-tailed).

Results

Baseline characteristics

The study flowchart is depicted in Fig. 1. After PSM, 66 patients (mTEG =33, DTR =33) were included. Prematching analysis revealed significant age disparities ($P < 0.05$), which were effectively balanced post-matching (Table 1). Both cohorts demonstrated comparable baseline characteristics for sex, BMI, tumor size, differentiation grade, TNM stage, adjuvant therapy status, and surgical approach (all $P > 0.05$), ensuring minimal confounding and well-balanced distribution.

Comparative analysis of intraoperative and postoperative outcomes

The Modified tubular esophagogastrostomy cohort demonstrated significantly shorter operative duration (163.7 ±39.5 vs. 247.9 ±64.6; $P < 0.001$) and superior postoperative recovery metrics compared to the double tract reconstruction group, including earlier drainage tube removal (7.0 ±1.2 vs. 8.7 ±2.3; $P = 0.001$) and reduced hospitalization length (8.3 ±1.6 vs. 9.8 ±2.0; $P = 0.001$). No significant intergroup differences were observed in

Table 1 Comparison of baseline characteristics between two groups of patients before and after propensity score matching

Before propensity score matching				After propensity score matching		
	mTEG (*n* = 34)	**DTR (*n* = 201)**	***P***	**mTEG (*n* = 33)**	**DTR (*n* = 33)**	***P***
Age	66.5 (58.8, 74.2)	62.6 (54.9, 70.3)	0.006	65.9 (58.8, 73)	64.7 (58, 71.4)	0.456
Sex			0.344			0.592
Male	25 (73.5)	162 (80.6)		24 (72.7)	22 (66.7)	
Female	9 (26.5)	39 (19.4)		9 (27.3)	11 (33.3)	
BMI	24 (20.5, 27.5)	24.8 (21.7, 27.9)	0.196	23.9 (20.4, 27.4)	24.5 (21.8, 27.2)	0.459
Tumor size	2.5 (1.5, 3)	2.6 (1.8, 3)	0.983	2.5 (1.5, 3)	2.5 (2, 3)	0.958
Differentiation			0.245			0.398
Well	2 (5.9)	12 (6)		6 (18.2)	2 (6.1)	
Moderately	15 (44.1)	115 (57.2)		12 (36.4)	16 (48.5)	
Moderately- Poorly	11 (32.4)	43 (21.4)		10 (30.3)	7 (21.2)	
Poorly	6 (17.6)	31 (15.4)		5 (15.1)	8 (24.2)	
TNM			0.796			0.369
I	20 (58.8)	128 (63.7)		20 (60.6)	16 (48.5)	
II	9 (26.5)	41 (20.4)		8 (24.2)	10 (30.3)	
III	5 (14.7)	32 (15.9)		5 (15.2)	7 (21.2)	
Adjuvant therapy			0.115			0.457
Yes	17 (50)	72 (35.8)		17 (51.5)	20 (60.6)	
No	17 (50)	129 (64.2)		16 (48.5)	13 (39.4)	
Surgical approach			0.903			1.000
Open	14 (41.2)	85 (42.3)		13 (39.4)	13 (39.4)	
Minimally invasive	20 (58.8)	116 (57.7)		20 (60.6)	20 (60.6)	

intraoperative blood loss (P= 0.851), lymph node yield (P= 0.369), time to first aerofluxus (P= 0.392), or liquid diet (P= 0.423) (Table 2).

Functional recovery assessment

Contrast gastroenterography performed on postoperative days 6–7 revealed unimpeded contrast passage in upright positioning (Fig. 4a) and absence of reflux in the 15° Trendelenburg position (Fig. 4b) for mTEG patients. Dynamic imaging demonstrated preserved peristalsis within the gastric tube (Fig. 4c–f).

Postoperative complications

Early complications in the DTR group included two anastomotic leaks, one chylous fistula, and one pleural effusion. Late complications comprised one case of intestinal obstruction (conservative management) and one anastomotic stricture requiring endoscopic dilation in each group. All complications were resolved with appropriate interventions (C-D classification ≤III), with no significant intergroup differences in complication rates (P> 0.05) (Table 2).

At 1-year endoscopic follow-up, LA grade B+ reflux esophagitis rates (mTEG: n= 18; DTR: n= 22) were comparable (11.1% vs. 4.5%; P= 0.457), with one mTEG patient developing grade C esophagitis (Table 3). The preserved pseudo-fornix architecture was endoscopically confirmed in mTEG cases (Fig. 4g–h).

Nutritional and quality-of-life outcomes

Both groups exhibited significant postoperative declines in nutritional parameters (Fig. 5). While mTEG demonstrated attenuated reductions in BMI (− 17.2% vs. −19.1%), hemoglobin (− 6.2% vs. −7.2%), and prealbumin (− 15.2% vs. −21.0%) compared to DTR at 6 months, albumin levels favored DTR (− 4.4% vs. −3.9%; all P> 0.05). Nutritional nadirs occurred at 3 months postoperatively, with gradual recovery trajectories observed thereafter. No significant differences emerged in EORTC QLQ-STO22 symptom scales (Table 4).

Discussion

PG has gained traction as a viable alternative to TG for upper gastric malignancies, particularly for cT1 N0M0 tumors per Japanese gastric cancer treatment guidelines [6]. Contemporary evidence supports PG's superiority in mitigating weight loss, maintaining hemoglobin levels, and preserving long-term nutritional homeostasis compared to TG, with equivalent oncological outcomes [11, 12, 20]. Nodal metastasis patterns critically inform resection boundaries. A Japanese prospective trial (n= 363) [21] identified ≥10% metastasis rates in stations 1, 2, 3, 7, 9, and 11p for EGJ cancers, justifying systematic dissection. Conversely, stations 4d, 5, and 6 demonstrated <5% metastasis rates overall, though tumors >6 cm exhibited 10.7% involvement in these groups. Mounting evidence from Yura et al. [9], Kinami et al. [22], and Khalayleh et al. [7] substantiates the low metastatic propensity of distal nodal basins (stations 4d, 5, 6) in proximal gastric cancers, while it pertains to the dimensions and positional attributes of the tumor. This anatomical selectivity is further corroborated by Yuan et al. [23] and Ri et al. [24], whose analyses of locally advanced and neoadjuvant-treated cohorts demonstrated minimal metastasis rates in stations 4d (2.74%), 5 (0.67%), 6 (1.33%), and 12a (1.74%) following total gastrectomy, with equivalent 5-year overall survival rates between proximal gastrectomy (PG, 68.4%) and total gastrectomy (TG, 66.0%; P= 0.881). These findings underscore PG's oncological validity when applied to appropriately staged and sized tumors with adequate margins. The proportion of proximal gastrectomy procedures has seen a substantial increase, concomitant with the advent, clinical application, and ongoing optimization of diverse reconstructive techniques.

The historical reluctance toward PG stemmed from its association with reflux esophagitis due to disruption of

Table 2 Comparison of intraoperative and postoperative recovery outcomes between two groups of patients

	mTEG (n = 33)	DTR (n = 33)	P
Operative duration (min)	163.7 (124.2, 203.2)	247.9 (183.2, 312.5)	0.000
Blood loss (ml)	55.2 (16.2, 94.1)	53.2 (7.7, 98.7)	0.851
Lymph nodes harvested	31 (22, 36)	23 (19, 45)	0.369
First liquid diet (d)	4.1 (2.9, 5.3)	4.4 (3.0, 5.9)	0.395
First postoperative exhaust (d)	3.5 (3, 4)	4 (3, 5)	0.326
Gastric tube removal (d)	4 (2.4, 5.6)	4.5 (2.5, 6.5)	0.324
Drainage tube removal (d)	7 (5.8, 8.2)	8.7 (6.4, 11)	0.001
Hospital stay (d)	8.3 (6.6, 9.9)	9.8 (7.8, 11.7)	0.001

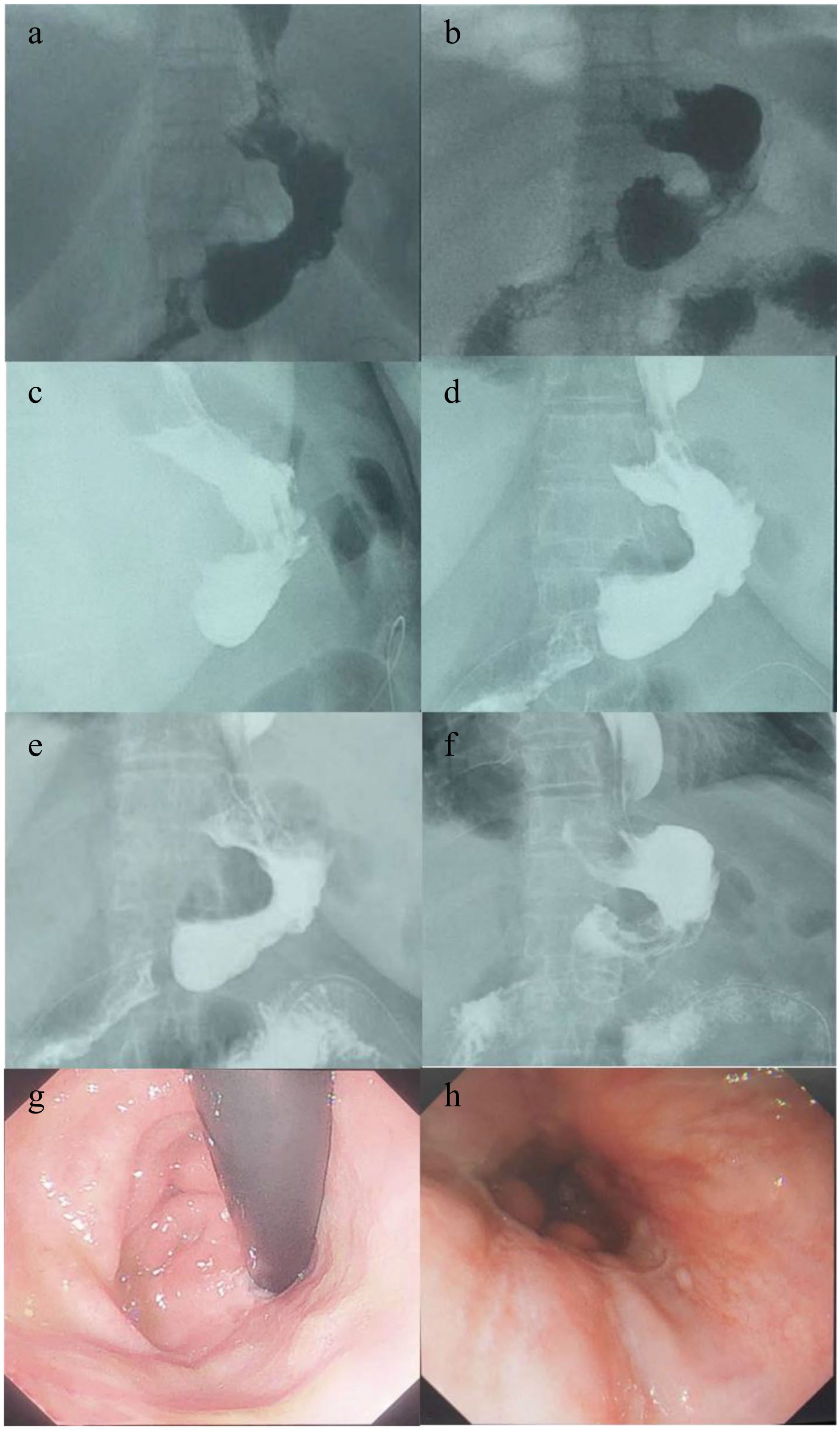

Fig. 4 Postoperative imaging and endoscopic findings, **a** Upright position; **b** Head-down position; **c**-**f** Phasic contractions of modified tubular esophagogastrostomy; **g** Endoscopic pseudo-fornix; **h** Distal esophageal anastomosis

Table 3 Comparison of postoperative complications between the two groups (%)

	mTEG (*n* = 33)	DTR (*n* = 33)	*P*
Early complications[a]	0	4 (12.1)	0.122
Anastomotic leakage	0	2 (6.1)	0.492
intra-abdominal hemorrhage	0	0	-
intraabdominal abscess	0	0	-
pleural effusion	0	1 (3.0)	0.99
Incision infection	0	0	-
chylous leakage	0	1 (3.0)	0.99
gastroparesis	0	0	-
Late complications[a]	6 (18.2)	5 (15.2)	0.99
Anastomotic stricture	1 (3.0)	1 (3.0)	0.99
intestinal obstruction	1 (3.0)	2 (6.1)	0.555
Reflux esophagitis[b]	4 (22.2)	3 (13.6)	0.472
A	2	2	
B	1	0	
C	1	1	
D	0	0	
B/C/D	2 (11.1)	1 (4.5)	0.457

[a] Patients may present with multiple comorbidities

[b] Assessment using the Los Angeles classification (mTEG, *n* = 18; DTR, *n* = 22)

the normal anatomical architecture of the esophagogastric junction and pyloric preservation-induced delayed emptying [25, 26]. However, subgroup analyses reveal these complications are reconstruction-dependent rather than inherent to PG itself [27]. In 1988, Japanese surgeon Aikou et al. pioneered the double tract reconstruction technique [28], which achieved anti-reflux efficacy while resolving food stasis associated with jejunal interposition. Subsequent multicenter investigations, including both retrospective analyses and prospective cohort studies, have demonstrated its superiority in reducing reflux and anastomotic stricture incidence compared to conventional methods [29, 30]. These evidence-based advantages have established DTR as a globally recognized reconstruction approach following proximal gastrectomy. However, the procedure's inherent technical complexity may elevate anastomotic leakage risks and heighten healthcare expenditures.

The evolution of reconstruction techniques for proximal gastrectomy has been marked by iterative refinements to balance anti-reflux efficacy and procedural feasibility. Shiraishi et al.'s pioneering 1998 description of tubular esophagogastrostomy [31] introduced a technically straightforward procedure utilizing pressure gradients to reduce acid reflux, with inherent advantages for laparoscopic adaptation. Subsequent studies by Toyomasu et al. (*n* = 171) and Aihara et al. reported

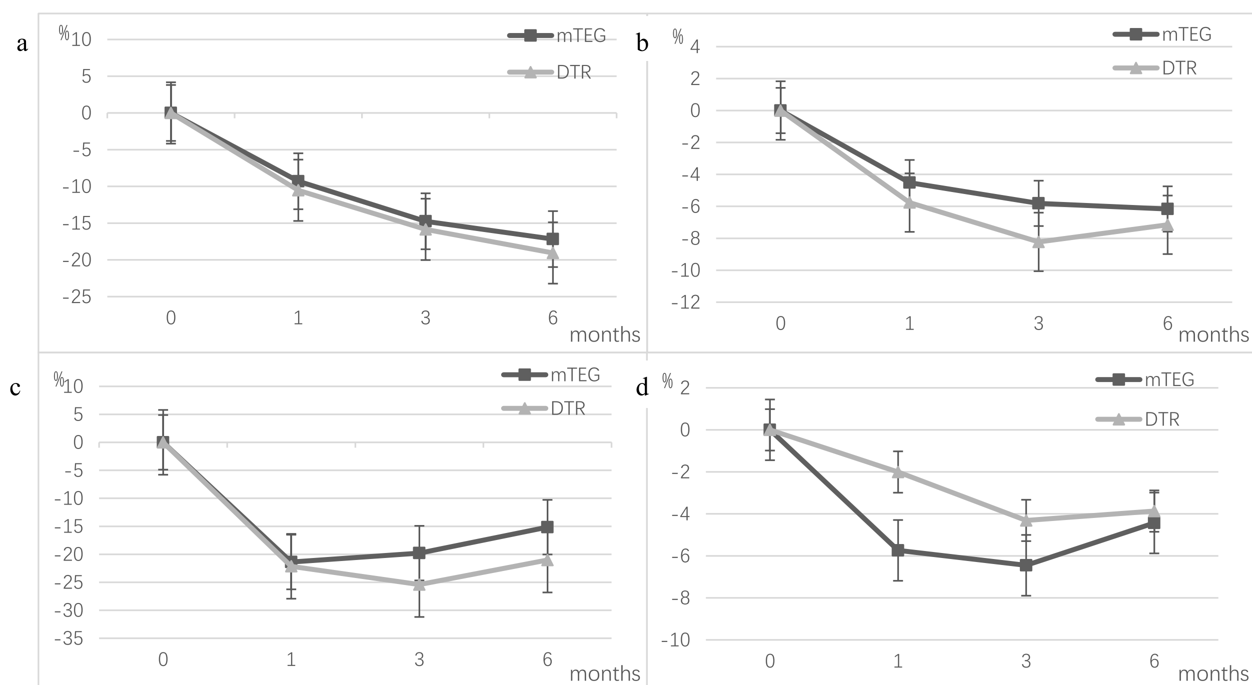

Fig. 5 Comparison of preoperative and postoperative nutritional parameters between the two groups, **a** Body mass index (BMI); **b** Hemoglobin; **c** Prealbumin; **d** Albumin. No statistically significant differences were observed in the four nutritional indicators between the two anastomosis techniques

Table 4 Comparison of 6-month postoperative EORTC QLQ-STO22 scores between the two groups

	mTEG (n = 33)	DTR (n = 33)	P
Dysphagia	16.7 (8.3, 16.7)	16.7 (16.7, 16.7)	0.284
Pain	11.1 (0, 22.2)	11.1 (0, 11.1)	0.619
Reflux	22.2 (11.1, 44.4)	22.2 (11.1, 22.2)	0.134
Eating	16.7 (8.3, 25)	16.7 (8.3, 22.9)	0.322
Anxiety	11.1 (0, 33.3)	0 (0, 33.3)	0.641
Dry mouth	0 (0, 33.3)	0 (0, 33.3)	0.594
Taste	0 (0, 33.3)	16.7 (0, 33.7)	0.727
Body image	33.3 (0, 33.3)	33.3 (0, 33.3)	0.848
Hair loss	0 (0, 16.7)	0 (0, 33.3)	0.350

reflux esophagitis rates of 16.7% and 14%, respectively, though accompanied by concerning anastomotic stricture rates (35%) [32, 33]. Comparative analyses against TG and DTR revealed the suboptimal performance of tubular esophagogastrostomy in reflux mitigation and stricture prevention [34, 35]. The surgical innovation by Yasuda et al. [36], which introduced mediastinal placement of a pseudo-fornix, demonstrated technical simplicity and effective reflux control but lacked comprehensive evaluation of nutritional and QoL outcomes. Our mTEG addresses this gap while incorporating three synergistic anti-reflux mechanisms: 1. Fabrication of a 4.0 ×20 cm gastric conduit reduces residual stomach volume, enhancing gastric emptying. Strategic resection of the lesser curvature and partial antrum decreases acid-secreting parietal cell mass. The elongated reflux pathway increases mechanical resistance to retrograde flow. 2. Anterior wall anastomosis combined with 4 cm pseudo-fornix construction and diaphragmatic fixation to establish a stable His angle. 3. Supine positioning or postprandial gastric distension generates a pressure gradient between the pseudo-fornix and esophageal lumen to mechanically occlude the anastomosis. 3. gastric conduit peristalsis promotes efficient evacuation of gastric contents, reducing stasis-related reflux triggers.

To mitigate confounding factors influencing postoperative complications, nutritional status, and quality of life, propensity score matching was rigorously implemented. The modified tubular esophagogastrostomy cohort demonstrated superior operative efficiency compared to double tract reconstruction, with a mean operative time reduction of 84.2 min ($P < 0.001$), while maintaining comparable intraoperative blood loss and lymph node yield. These findings align with Tian et al. [35] and Chen et al. [37] reported study, confirming the technical simplicity and safety of mTEG. The prolonged operative duration in DTR reflects its inherent multi-anastomotic design—requiring jejunal transection, vascular dissection, and three anastomotic sites—potential learning curves from robotic-assisted procedures within our research center. Extensive or anatomically disruptive operations may compromise overall survival, underscoring the importance of complication profiles as critical metrics for evaluating surgical safety and efficacy [38]. Prior retrospective analyses [35, 39] demonstrated comparable overall complication rates between DTR and tubular esophagogastrostomy despite DTR's multi-anastomotic design. Our findings align with this consensus, yet notably, all early complications requiring prolonged hospitalization (anastomotic leakage, chylothorax, pleural effusion) occurred exclusively in the DTR cohort.

Restoration of the anti-reflux barrier constitutes a pivotal endpoint in proximal gastrectomy reconstruction. While both tubular esophagogastrostomy and DTR demonstrate superior reflux control compared to historical esophagogastric anastomosis, Tian et al.'s endoscopic evaluation at 1-year follow-up revealed significantly lower reflux rates with DTR (9.7% vs. 24.2%; $P = 0.031$) [35]. In contrast, our mTEG cohort exhibited comparable reflux esophagitis incidence to DTR, with only one grade C esophagitis case in mTEG versus none in DTR. This improved performance likely stems from our improvement. Notably, studies are finding that impaired peristalsis in gastric tube has been linked to early reflux events [40]. Gradual recovery of gastroduodenal motility coordination postoperatively enhances emptying efficiency. These findings underscore the need for extended follow-up to evaluate the durability of our modified technique's anti-reflux mechanisms.

Both reconstruction methods theoretically preserve key elements of gastrointestinal continuity, allowing residual stomach to facilitate digestive processes through controlled chyme delivery with proteases and intrinsic factor to the duodenum for optimal nutrient assimilation—a critical determinant of postoperative weight maintenance. While prior studies suggested nutritional and QoL advantages with DTR over conventional tubular gastric anastomosis [40], our mTGA cohort demonstrated comparable nutritional parameters and QoL scores. This equivalence may reflect mTGA's enhanced anti-reflux efficacy, effectively mitigating reflux-induced nutrient malabsorption.

The tubular esophagogastrostomy, following esophageal cancer resection, can fulfill the requirements for cervicothoracic anastomosis, offering a length advantage over total gastroesophageal anastomosis [41]. This represents one of the key advantages of tubular stomach anastomosis. Nevertheless, in cases of upper one-third gastric cancers, where proximal stomach resection is necessary, the length of the tubular stomach is inevitably reduced. Furthermore, this study employed anterior gastric wall anastomosis for the tubular stomach, necessitating a longer esophageal stump. To construct a 4-cm fornix during modified tubular gastric anastomosis, upward elevation is required to create sufficient mediastinal space for optimal fornix placement. Insufficient space may hinder the ideal positioning of the fornix. Additionally, a shorter esophageal stump could elevate the anastomotic site, thereby increasing the complexity of diaphragmatic fixation and potentially impairing the anti-reflux mechanism.

While this study provides a multidimensional evaluation of mTEG versus DTR encompassing operative metrics, complications, nutritional outcomes, and quality-of-life parameters, three methodological constraints warrant consideration: 1. Retrospective design: Despite rigorous matching clinical covariates, unmeasured confounders (e.g., socioeconomic status, dietary compliance) may persist. 2. Short-term follow-up and single-center cohort: While this study offers preliminary comparative insights into the perioperative outcomes and short-term efficacy between the two surgical approaches, the current 6-month follow-up window limits evaluation of longitudinal nutritional profiles and late-phase complications including reflux esophagitis and anastomotic stricture. Extended surveillance is warranted to elucidate these clinically significant endpoints. Notably, vitamin B12 malabsorption exhibited substantial correlation with postgastrectomy status. To address these knowledge gaps, we are initiating a prospective multicenter, large-scale cohort study with a 36-month follow-up framework, which will systematically incorporate comprehensive nutritional indices such as serum vitamin B12.

Conclusion

The Modified tubular esophagogastrostomy—featuring esophageal-conduit sidewall anastomosis, optimized pseudo-fornix dimensions, and diaphragmatically stabilized His angle—demonstrated comparable anti-reflux efficacy and nutritional/QoL outcomes to DTR, while offering technical simplicity. These findings position mTEG as a viable simplified alternative for proximal gastric cancer reconstruction, particularly in minimally invasive approaches.

Abbreviations

mTEG	Modified tubular esophagogastrostomy
DTR	Double tract reconstruction
PG	Proximal gastrectomy
EGJ	Esophagogastric junction
TG	Total gastrectomy
LA	Los Angeles classification
PSM	Propensity score matching

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12885-025-14284-9.

Supplementary Material 1.

Acknowledgements
Not applicable.

Authors' contributions
Chaoyang Zhang\ Kaixing Wang\Zhidong Zhang wrote the paper and conceived and designed the experiments; Xuefeng Zhao, Bin Yao analyzed the data; Weishaui Zhang collected and provided the sample for this study.

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Data availability
Data is provided within the manuscript or supplementary information files.

Declarations

Ethics approval and consent to participate
The Ethics Committee of the Fourth Hospital of Hebei Medical University embraced this retrospective study (protocol number 2023 KS156). Due to the retrospective nature of the current study, the Ethics Committee of the Fourth Hospital of Hebei Medical University waived the need of obtaining informed consent. All study procedures were conducted in accordance with the Helsinki Declaration.

Consent for publication
Consent for publication was obtained from the participants.

Competing interests
The authors declare no competing interests.

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