

# Omitting Nasogastric Tube Placement after Gastrectomy Does Not Enhance Postoperative Recovery: A Propensity Score Matched Analysis

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## Research article

**Keywords:** Nasogastric tube, Gastric tumor, Postoperative complications, Length of postoperative hospital stay

**Posted Date:** March 11th, 2020

**DOI:** <https://doi.org/10.21203/rs.3.rs-16585/v1>

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# Abstract

**Background:** Enhanced recovery after surgery (ERAS) program has become the main trend in gastrointestinal surgery. The aim of this study is to investigate factors influencing the decision-making of nasogastric tube (NGT) placement and its safety and efficacy in clinical practice.

**Methods:** We analyzed our prospectively maintained database including 287 patients underwent elective gastrectomy in our department from January 1 to December 31, 2017. All cases were divided into two groups, namely, the non-nasogastric tube group and the nasogastric tube group. Logistic regression was used to analyze the factors that affect the decision of nasogastric tube placement, and propensity score matching (PSM) was later applied to balance those factors for the analysis of the safety outcomes between the groups.

**Results:** Multivariate analysis showed that resection range ( $p = 0.004$ , proximal gastrectomy:  $OR = 4.555$ ,  $95\%CI = 1.392-14.905$ ,  $p = 0.016$ ; total gastrectomy:  $OR = 1.990$ ,  $95\%CI = 1.205-3.287$ ,  $p = 0.009$ ) was the only independent risk factors of nasogastric tube placement. NGT was omitted in the majority (58.8%) of distal gastrectomy, but only in 42.5% and 25% in total and proximal gastrectomy. After PSM, we found no significant differences between patients with or without NGT in postoperative hospital stay, time to first flatus and defecation, time to fluid and semi-fluid diet, rate of reinsertion, or hospitalization expenditure ( $p > 0.05$  respectively). The incidence of postoperative complications in the two groups were 21.7% and 23.5% respectively ( $p = 0.753$ ), and the incidence of major complications were 7.0% and 9.6% ( $p = 0.472$ ).

**Conclusions:** The decision-making of NGT placement is mainly influenced by the resection range. Omitting NGT is a safe approach in all types of gastrectomy but was not able to enhance the recovery in our practice.

## Background

Ever since Kehlet first proposed the concept of Enhanced Recovery After Surgery (ERAS) in 1997, it has been carried out successfully in varied surgical fields. Nowadays, rapid recovery after operations has gradually become clinical routine in gastrointestinal surgery. With the deep understanding of the rapid recovery after gastrectomy, many studies question the necessity of nasogastric tube (NGT) after gastrectomy [1–3]. The international guidelines [4] and domestic expert consensus [5] recommend that there is no need to insert nasogastric tube routinely in patients with gastrectomy, and several randomized controlled trials (RCT) [6–10] and meta-analyses [1, 11] have provided strong evidences against the routine use of nasogastric tube following gastrectomy.

However, nasogastric tube is routinely used in the majority, if not all, gastric cancer patients after gastrectomy in China. With the accumulating evidence against the routine use of nasogastric tube, it is yet unclear that what factors exactly influence the decision making of nasogastric tube placement in China. Moreover, whether omitting nasogastric tube is safe in the setting of Chinese clinical practice also requires more evidence for verification. Since 2017, our department has gradually educated the ERAS

program in gastric cancer patients. Surgeons were also encouraged to avoid the tube placement when consider safe. In this study, we retrospectively analyzed our prospectively maintained database to explore the influence factors of the decision making of nasogastric tube placement, to evaluate whether omitting nasogastric tube accelerate the postoperative recovery of patients after gastrectomy, and last but not least, to assess whether it is safe after gastrectomy without nasogastric tube.

## Methods

### Patient and Clinical data registration

In this study, we included patients underwent elective gastrectomy for gastric tumor in the ward I of gastrointestinal cancer center, Peking University Cancer Hospital & Institute from January 1, 2017 to December 31, 2017. During that time, placing nasogastric tube were no longer restricted as clinical routine and the surgeons might choose not to place the tube when they thought it was safe to do so. We collected the patients' demographic data, clinical pathological characteristics, and perioperative information from a prospectively maintained database [12]. Moreover, since 2017, we prospectively registered the postoperative complication data in accordance to the APPEAL study protocol [13–14] and the severity of complications were scored using the Clavien-Dindo grading system [15] continuously by one set clinical researcher. The postoperative complication data were retrieved from this database to ensure the objectiveness and quality of the data.

### Perioperative managements

The perioperative managements of patients were consistent in accordance with our ERAS protocol. In short, one day prior to the operation, laxative was applied to the patients with no additional mechanical bowel preparation. Patients were fasted from solid food for 12 h, while they were suggested to drink 250 ml 10% glucose in the morning of the operation. Prophylactic antibiotics were administrated for one dose before the operation and 1–2 doses afterwards during perioperative period (in total within 24 h). After surgery, patient-controlled analgesia (PCA) was given to patients for the first three postoperative days, and additional non-steroidal anti-inflammatory drugs or opioids were administrated when acute pain occurred accordingly. In general, patients were recommended to drink water (in small amount) on the first day after surgery, and the total amount of food intake gradually increased daily after surgery based on the patient's feeling and the doctor's judgment. Patients were allowed to take soft food if they have good tolerance of liquid or their bowel function was recovered. We also encouraged them to ambulate at an early stage, usually at the first day after surgery. The patients were discharged when they met the following criteria: satisfied mobility, tolerance of soft food intake for at least one day, not suspicious of complications [5].

### Study endpoints

The major purpose of our study is to determine whether omitting the nasogastric tube accelerates the postoperative recovery in our clinical setting. Therefore we choose the primary endpoint as the length of

postoperative hospital stay, which was defined as the day from the first day after surgery to the day of discharge (including the day of discharge).

To achieve this, we first investigated what are the major factor that influence the decision-making of NGT placement by logistic regression, and then a propensity score matching (PSM) was performed to control the influence of the identified independent risk factor(s) between the groups. In the regression analysis, we included the patient characteristics and intraoperative data into the univariate and multivariate analyses, which were performed by non-conditional logistic regression analysis, and the factors with predictive value in univariate analysis were included in multivariate analysis. The nearest neighbor method was used in the PSM, and caliper width was set to 0.1. The clinical features between the two groups were compared after PSM.

The other recovery outcomes include the time to first flatus and defecation, the time to fluid and semi-fluid diet, and the rate of tube reinsertion. The hospitalization expenses, as one major advantage of the ERAS program, was also measured. In addition to the recovery outcomes, we also measured the safety outcomes (i.e. postoperative complications) between the two corrected groups. The diagnosis and classification of complications was based on Clavien-Dindo classification, and we define those grade III or higher complication as severe complication [15]. The complications included in this study and the diagnostic criteria were referred to the APPEAL study [13–14], and were first recorded by the doctors and double checked by a set researcher. The study design is shown in Fig. 1.

## Statistical analysis

In statistical analysis, the continuous variables such as age, blood loss and postoperative hospital stay were described as the mean  $\pm$  standard deviation if kolmogorov-smirnov test was consistent with a normal distribution. Otherwise, the median were used. For the classified variables such as gender, TNM stage, and tumor location, we described the number of cases and percentage. Differences in variables among groups were tested using student's t test, chi-square test, or Fisher's exact test. However, non-parametric tests (the Krukal–Wallis or Mann–Whitney test) were used for variables with skewed distributions. Bilateral  $p < 0.05$  was considered statistically significant. We used SPSS version 24.0 (IBM SPSS Software) for all statistical analyses.

## Results

### Patient characteristics

After the exclusion of patients who had previous history of gastric surgery, emergency surgery (acute perforation, obstruction, bleeding, etc.), we included 287 patients underwent gastrectomy for gastric tumor in our ward of Peking University Cancer Hospital & Institute from January 1, 2017 to December 31, 2017. These cases were divided into two groups, namely, the no-NGT group (n = 147) and the NGT group

(n = 140). The patients' demographic data (Table 1.1), clinical pathological characteristics (Table 1.2), and perioperative information (Table 1.3) are summarized in Table 1.

Table 1.1  
Demographic data of the patients

	no-NGT (N = 147)	NGT (N = 140)	Total (N = 287)	P value
Gender				0.445
Male	111(75.5)	111(79.3)	222(77.4)	
Female	36(24.5)	29(20.7)	65(22.6)	
Age				0.836
<65	97(66)	94(67.1)	191(66.6)	
≥65	50(34)	46(32.9)	96(33.4)	
City				0.207
Beijing	34(23.1)	24(17.1)	58(20.2)	
Others	113(76.9)	116(82.9)	229(79.8)	
BMI (kg/m <sup>2</sup> )				0.711
< 18.5	5(3.4)	5(3.6)	10(3.5)	
[18.5,25.0)	88(59.9)	92(65.7)	180(62.7)	
[25,30)	47(32.0)	36(25.7)	83(28.9)	
≥30	7(4.8)	7(5.0)	14(4.9)	
Preoperative comorbidity				0.873
No	90(61.2)	87(62.1)	177(61.7)	
Yes	57(38.8)	53(37.9)	110(38.3)	
Abdominal surgery history				0.333
No	114(77.6)	115(82.1)	229(79.8)	
Yes	33(22.4)	25(17.9)	58(20.2)	
Smoke				0.248
No	73(49.7)	60(42.9)	133(46.3)	
Yes	74f(50.3)	80(57.1)	154(53.7)	
Alcohol				0.239
No	95(64.6)	81(57.9)	176(61.3)	

NGT nasogastric tube, BMI body mass index, NRS2002 nutritional risk screening 2002

	no-NGT (N = 147)	NGT (N = 140)	Total (N = 287)	P value
Yes	52(35.4)	59(42.1)	111(38.7)	
NRS2002				0.454
<3 score	127(86.4)	125(89.3)	252(87.8)	
≥ 3 score	20(13.6)	15(10.7)	35(12.2)	
NGT nasogastric tube, BMI body mass index, NRS2002 nutritional risk screening 2002				

Table 1.2  
Clinical pathological characteristics of the patients

Preoperative pathology	no-NGT (N = 147)	NGT (N = 140)	total (N = 287)	P value
Pathological differentiation				0.513
Poorly	64(43.5)	50(35.7)	114(39.7)	
Moderately to poorly	23(15.6)	25(17.9)	48(16.7)	
Moderately	37(25.2)	43(30.7)	80(27.9)	
Well to moderately and well	5(3.4)	8(5.7)	13(4.5)	
Unknown	18(12.2)	14(10.0)	32(11.1)	
Pathological type				0.873 <sup>c</sup>
Adenocarcinoma	129(87.8)	127(90.7)	256(89.2)	
Signet-ring cell carcinoma	8(5.4)	6(4.3)	14(4.9)	
NET	2(1.4)	1(0.7)	3(1.0)	
GIST	8(5.4)	6(4.3)	14(4.9)	
cTNM <sup>a</sup>				0.164
□	36(24.5)	36(25.7)	72(25.1)	
□	32(21.8)	27(19.3)	59(20.6)	
□	62(42.2)	55(39.3)	117(40.8)	
□	7(4.8)	17(12.1)	24(8.4)	
Others <sup>b</sup>	10(6.8)	5(3.6)	15(5.2)	
Tumor location				0.055 <sup>c</sup>
Lower	88(59.9)	67(47.9)	155(54.0)	
Upper	30(20.4)	47(33.6)	77(26.8)	
Middle	26(17.7)	21(15.0)	47(16.4)	
Total	3(2.0)	5(3.6)	8(2.8)	
NGB nasogastric tube, NET neuroendocrine tumor, GIST gastrointestinal stromal tumor				
a Based on the 8th edition of AJCC cancer staging system. b Non-gastric adenocarcinoma patients. c Fisher's exact test was applied.				



Table 1.3  
Perioperative information of the patients

	no-NGT (N = 147)	NGT (N = 140)	Total (N = 287)	P value
Preoperative treatment				0.348
No	78(53.1)	82(58.6)	160(55.7)	
Yes	69(46.9)	58(41.4)	127(44.3)	
Duration of operation (min)				0.235
<240	113(76.9)	99(70.7)	212(73.9)	
≥240	34(23.1)	41(29.3)	75(26.1)	
Operative approach				0.531 <sup>c</sup>
Laparotomy	66(44.9)	72(51.4)	138(48.1)	
Laparoscopic-assisted	15(10.2)	17(12.1)	32(11.1)	
Totally Laparoscopic	63(42.9)	49(35.0)	112(39.0)	
Conversion to laparotomy	3(2.0)	2(1.4)	35(1.7)	
Resection range				0.002 <sup>c</sup>
Distal	87(59.2)	61(43.6)	148(51.6)	
Proximal	4(2.7)	12(8.6)	16(5.6)	
Total	48(32.7)	65(46.4)	113(39.4)	
Local resection	8(5.4)	2(1.4)	10(3.5)	
Multiple organ resection				0.100
No	142(96.6)	129(92.1)	271(94.4)	
Yes	5(3.4)	11(7.9)	16(5.6)	
Lymph node dissection				0.069
D0	9(6.1)	4(2.9)	13(4.5)	
D1+	6(4.1)	14(10.0)	20(7.0)	
D2	132(89.8)	122(87.1)	254(88.5)	
Surgeon				0.253 <sup>c</sup>
NGB nasogastric tube, ICU intensive care unit				
c Fisher's exact test was applied. d Continuity Correction chi-square test was applied.				

	no-NGT (N = 147)	NGT (N = 140)	Total (N = 287)	P value
A	122(83.0)	107(76.4)	229(79.8)	
B	13(8.8)	13(9.3)	26(9.1)	
C	10(6.8)	19(13.6)	29(10.1)	
Others	2(1.4)	1(0.7)	3(1.0)	
The first assistant				0.438
D	50(34.0)	44(31.4)	94(32.8)	
E	41(27.9)	37(26.4)	78(27.2)	
F	40(27.2)	49(35.0)	88(31.0)	
Others	16(10.9)	10(7.1)	26(9.1)	
The degree of adhesion				0.794
No	106(72.1)	102(72.9)	208(72.5)	
Mild	24(16.3)	25(17.9)	49(17.1)	
Moderate-severe	17(11.6)	13(9.3)	30(10.5)	
ICU				0.331 <sup>d</sup>
No	143(97.3)	132(94.3)	275(95.8)	
Yes	4(2.7)	8(5.7)	12(4.2)	
Blood loss (ml)				0.713
Table 1.3(continued)				
	no-NGT (N = 147)	NGT (N = 140)	Total (N = 287)	P value
< 200	115(78.2)	112(80.0)	227(79.1)	
≥200	32(21.8)	28(20.0)	60(20.9)	
NGB nasogastric tube, ICU intensive care unit				
c Fisher's exact test was applied. d Continuity Correction chi-square test was applied.				

## Influence factors of nasogastric tube placement

Univariate analysis (Table 2.1) showed that resection range ( $p = 0.004$ ) and lymph node dissection range ( $p = 0.032$ ) were significantly correlated with nasogastric tube placement. These two, together with the preoperative pathological differentiation, clinical TNM stage, operative approach, multiple organ resection, surgeon and nasogastric tube placement required further exploration ( $0.05 < p < 0.2$ ,

respectively) were included in the multivariate analysis (Table 2.2), and we found that only resection range ( $p = 0.004$ ) was the independent influence factor of nasogastric tube placement. NGT was omitted in the majority (58.8%) of distal gastrectomy, but only in 42.5% and 25% in total and proximal gastrectomy.

Table 2.1  
Univariate analysis of nasogastric tube placement

	no-NGT (N = 147)	NGT (N = 140)	OR (95%CI)	P value
Pathological differentiation				0.517
Poorly	64(43.5)	50(35.7)	Ref	
Moderately to poorly	23(15.6)	25(17.9)	1.391(0.707–2.736)	0.339
Moderately	37(25.2)	43(30.7)	1.488(0.838–2.642)	0.175
Well to moderately and well	5(3.4)	8(5.7)	2.048(0.631–6.645)	0.233
Unknown	18(12.2)	14(10.0)	0.996(0.452–2.194)	0.991
cTNM <sup>a</sup>				0.190
I	36(24.5)	36(25.7)	Ref	
II	32(21.8)	27(19.3)	0.844(0.423–1.682)	0.629
III	62(42.2)	55(39.3)	0.887(0.493–1.596)	0.689
IV	7(4.8)	17(12.1)	2.429(0.899–6.562)	0.080
Others <sup>b</sup>	10(6.8)	5(3.6)	0.500(0.155–1.609)	0.245
Operative approach				0.540
Laparotomy	66(44.9)	72(51.4)	Ref	
Laparoscopic-assisted	15(10.2)	17(12.1)	1.039(0.481–2.245)	0.923
Totally Laparoscopic	63(42.9)	49(35.0)	0.713(0.432–1.177)	0.186
Conversion to laparotomy	3(2.0)	2(1.4)	0.611(0.099–3.772)	0.596
Resection range				0.004
Distal	87(59.2)	61(43.6)	Ref	
Proximal	4(2.7)	12(8.6)	4.279(1.317–13.896)	0.016
Total	48(32.7)	65(46.4)	1.931(1.176–3.172)	0.009
Local resection	8(5.4)	2(1.4)	0.357(0.073–1.737)	0.202
Multiple organ resection				

NGB nasogastric tube

a Based on the 8th edition of AJCC cancer staging system. b Non-gastric adenocarcinoma patients.

	no-NGT (N = 147)	NGT (N = 140)	OR (95%CI)	P value
No	142(96.6)	129(92.1)	Ref	
Yes	5(3.4)	11(7.9)	2.422(0.819–7.157)	0.110
Lymph node dissection				0.081
D2	132(89.8)	122(87.1)	Ref	
D1+	6(4.1)	14(10.0)	5.250(1.151–23.937)	0.032
D0	9(6.1)	4(2.9)	2.080(0.624–6.927)	0.233
Surgeon				
A	122(83.0)	107(76.4)	Ref	
B	13(8.8)	13(9.3)	1.140(0.507–2.567)	0.751
C	10(6.8)	19(13.6)	2.166(0.965–4.863)	0.061
Others	2(1.4)	1(0.7)	0.570(0.051–6.376)	0.648
NGB nasogastric tube				
a Based on the 8th edition of AJCC cancer staging system. b Non-gastric adenocarcinoma patients.				

Table 2.2  
Multivariate analysis of nasogastric tube placement

	OR (95%CI)	P value
Resection range		0.004
Distal	Ref	
Proximal	4.555(1.392–14.905)	0.016
Total	1.990(1.205–3.287)	0.009
Local resection	0.366(0.074–1.797)	0.202

## Postoperative recovery and safety

To further determine the influence of NGT to postoperative recovery, we used PSM to balance the differences between the two groups in resection range. After screened and matched, a total of 230 patients were included, and 115 patients were assigned to the NGT' group and no-NGT' group respectively. The patients characteristics before and after PSM were shown in Table 3.

Table 3  
Clinical characteristics of the patients before and after PSM

	Before		P value	After		P value
	no-NGT (N = 147)	NGT (N = 140)		no-NGT' (N = 115)	NGT' (N = 115)	
Resection range			0.002 <sup>c</sup>			1.000 <sup>c</sup>
Distal	87(59.2)	61(43.6)		61(53.0)	61(53.0)	
Proximal	4(2.7)	12(8.6)		4(3.5)	4(3.5)	
Total	48(32.7)	65(46.4)		48(41.7)	48(41.7)	
Local resection	8(5.4)	2(1.4)		2(1.7)	2(1.7)	
NGB nasogastric tube						
c Fisher's exact test was applied.						

In the analysis of the primary endpoint, no statistical differences were found between the two groups (9 days in no-NGT' group versus 10 days in NGT' group,  $p = 0.344$ , Table 4). Non-parametric tests also showed no statistical differences in the other recovery parameters including time to first flatus and defecation, time to fluid and semi-fluid diet, ( $p > 0.05$  respectively). The rate of reinsertion and hospitalization expenses between no-NGT' group and NGT' group were not significant either ( $p > 0.05$  respectively).

Table 4  
Postoperative recovery and safety parameters

	<b>no-NGT' (N = 115)</b>	<b>NGT' (N = 115)</b>	<b>Total (N = 230)</b>	<b>P value</b>
Total hospital stay (d)	13(5-100)	13(6-75)	13(5-100)	0.407
Postoperative hospital stay (d)	9(4-98)	10(4-71)	10(4-98)	0.344
First time to ambulation (d)	1(0-4)	1(0-4)	1(0-4)	0.160
Time to first flatus (d)	3(1-7)	3(2-32)	3(1-32)	0.903
Time to first defecation (d)	4(2-10)	4(3-13)	4(2-13)	0.761
Time to fluid (d)	2(1-6)	2(1-25)	2(1-25)	0.712
Time to semi-fluid (d)	7(3-96)	8(3-58)	7(3-96)	0.500
Postoperative complications (%)				0.753
No	90(78.3)	88(76.5)	178(77.4)	
Yes	25(21.7)	27(23.5)	52(22.6)	
Severe complications (%)				0.472
No	107(93.0)	104(90.4)	211(91.7)	
Yes	8(7.0)	11(9.6)	19(8.3)	
Infection (%)				0.604
No	108(93.9)	106(92.2)	214(93.0)	
Yes	7(6.1)	9(7.8)	16(7.0)	
Pulmonary complications (%)				0.332 <sup>d</sup>
No	108(93.9)	112(97.4)	220(95.7)	
Yes	7(6.1)	3(2.6)	10(4.3)	
Gastrointestinal obstruction (%)				0.622 <sup>c</sup>
No	114(99.1)	112(97.4)	226(98.3)	
Yes	1(0.9)	3(2.6)	4(1.7)	

NGB nasogastric tube

c Fisher's exact test was applied. d Continuity Correction chi-square test was applied.

Supplementary Data

	no-NGT' (N = 115)	NGT' (N = 115)	Total (N = 230)	P value
Delayed gastric emptying (%)				0.683 <sup>c</sup>
No	113(98.3)	111(96.5)	224(97.4)	
Yes	2(1.7)	4(3.5)	6(2.6)	
Postoperative hemorrhage (%)				0.064 <sup>d</sup>
No	106(92.2)	113(98.3)	219(95.2)	
Yes	9(7.8)	2(1.7)	11(4.8)	
Intra-abdominal hemorrhage (%)				0.622 <sup>c</sup>
No	112(97.4)	114(99.1)	226(98.3)	
Yes	3(2.6)	1(0.9)	4(1.7)	
Gastrointestinal hemorrhage (%)				0.125 <sup>d</sup>
No	109(94.8)	114(99.1)	223(97.0)	
Yes	6(5.2)	1(0.9)	7(3.0)	
Lymphatic leakage (%)				0.443 <sup>d</sup>
No	113(98.3)	110(95.7)	223(97.0)	
Yes	2(1.7)	5(4.3)	7(3.0)	
Anastomotic leakage (%)				1.000 <sup>c</sup>
No	111(96.5)	112(97.4)	223(97.0)	
Yes	4(3.5)	3(2.6)	7(3.0)	
Table 4 (continued)				
	no-NGT' (N = 115)	NGT' (N = 115)	Total (N = 230)	P value
Pancreatic leakage (%)				0.683 <sup>c</sup>
No	113(98.3)	111(96.5)	224(97.4)	

NGB nasogastric tube

c Fisher's exact test was applied. d Continuity Correction chi-square test was applied.

Supplementary Data



	no-NGT' (N = 115)	NGT' (N = 115)	Total (N = 230)	P value
Yes	2(1.7)	4(3.5)	6(2.6)	
Reinsertion of nasogastric tube (%)				0.492
No	103(89.6)	106(92.2)	209(90.9)	
Yes	12(10.4)	9(7.8)	21(9.1)	
Hospitalization expenses(¥)	90528.00 (30396.54- 329739.00)	91026.00 (33583.00- 296043.30)	90919.28 (30396.54- 329739.00)	0.916
NGB nasogastric tube				
c Fisher's exact test was applied. d Continuity Correction chi-square test was applied.				
Supplementary Data				

The overall complication rate was 24.4% and the severe complication rate was 8.0% in the 287 patients before PSM. And those were 22.6% and 8.3% respectively after PSM, with no statistical differences between the groups in overall complication rate (21.7% versus 23.5%,  $p = 0.753$ ) or severe complications (7.0% versus 9.6%,  $p = 0.472$ , Table 4). Comparisons of each respective complication are listed in Table 4.

## Subgroup analysis

As our multivariate analysis showed that resection range was the only independent factor that influenced the tube placement. We conducted the subgroup analysis in patients with distal gastrectomy and in those with proximal or total gastrectomy, aiming for any factor influencing the tube placement in those two subgroups. In the proximal or total gastrectomy group, we did not find any further independent factor determining the tube placement (See supplementary data, Table S1.1 and S1.2), while in the distal group, the pathological differentiation and operative approach (totally laparoscopic, OR = 0.395, 95% CI = 0.187–0.832,  $p = 0.014$ ) were the independent factors that influence the tube placement (See supplementary data, Table S2.1 and S2.2). We also compared the postoperative recovery and safety parameters of the two subgroups, and found no significant differences between patients with or without NGT in neither subgroups (see supplementary data, Table S3, S4.1 and S4.2).

## Discussion

Despite the accumulating data suggesting to omit NGT for gastric cancer surgery, many Chinese centers still routinely apply it when the ERAS guidelines recommend the opposite. Our retrospective analysis of the prospectively maintained database revealed that in our practice, the resection range is the main course of NGT placement. We also found there was not significant difference in postoperative recovery in

patients with or without NGT in our clinical setting. Our data might help surgeons to have new insights into the practice strategy of ERAS program after gastrectomy.

One major finding of our research is that surgeons' choice of placing NGT is mainly influenced by the resection range, i.e. proximal and total gastrectomy. NGT is more often placed when the surgeon estimates a high risk of the surgical approach which might eventually result in anastomotic or other complications after surgery [16]. Importantly, it turned out that those two resection ranges were indeed had higher complication rates when compared to distal gastrectomy (data not shown). In the latter group, NGT was omitted in the majority (58.8%), with satisfactory recovery and safety outcomes. From this point of view, our data demonstrate that the surgeons' decision-making of NGT placement is, at least, reasonable.

However, our data also suggest such effort of NGT placement in high-risk patients did not result in better safety outcomes. In this prospective registry, the complication rates (overall 28%) were comparable to the other studies [17]. For proximal or total gastrectomy, doctors choose to insert the nasogastric tube partly because the decompression effect may prevent leakage into the thoracic cavity, but our results do not indicate additional benefits (i.e. lower complication rate) of such attempt. Similarly, omitting NGT in the distal ones did not increase the complication rate either based on our subgroup analysis. Our data therefore confirmed the safety of omitting NGT in all types of gastrectomy.

As one critical element in the ERAS programs, many studies report the bowel function recovery as main outcomes to investigate whether NGT placement delays its recovery. One commonly used parameter is the time to first flatus. Varied results were reported regarding whether NGT shortens the time to first flatus [18]. Our data, in accordance with the meta-analyses [3, 19] and the prospective randomized controlled trial [10], showed no effect in this regard. However, it is important to notice that actually the time to flatus is not a good indicator of the bowel function recovery [20], let alone its occurrence is quite subjective in clinical practice. In contrast, the study by van Bree [21] indicates that tolerance of solid food and first defecation are better indicator of bowel function recovery instead. Due to a difference in postoperative diet between Chinese and western culture, time to semi-liquid instead of solid food is used to indicate the bowel function in our study. But no difference was found in either time to semi-liquid or time to first defecation in our study. Similar results were also reported by Hu et. al. [22], although many other studies reported earlier defecation in the no-NGT group [23, 24].

On top of bowel function recovery, the ultimate purpose of the ERAS program is to yield a safe and faster recovery after surgery, hence we chose the postoperative stay, instead of the bowel recovery outcomes, as our primary endpoint in this study. Unfortunately, the good safety outcomes in the no-NGT didn't result in shorter hospital stay (e.g. postoperative stay, prolonged hospitalization) in our analysis. This is probably because of the fact that omitting NGT is only one small procedure in the concept of ERAS and itself may not have enough influence to the whole picture, especially when an ERAS protocol had been running routinely in our practice. Of course, our study is also subject to its retrospective nature and limited to a relatively small group size. These limitations may also influence the statistical power of our results.

## Conclusions

In this retrospective analysis of our prospectively maintained database, we found that the decision-making of nasogastric tube placement was mainly influenced by the resection range in gastric cancer surgery. Omitting NGT is a safe approach in all types of gastrectomy but was not able to enhance the recovery in our practice.

## Abbreviations

ERAS

Enhanced Recovery after Surgery

NGT

Nasogastric Tube

RCT

Randomized Controlled Trial

PCA

Patient-controlled Analgesia

PSM

Propensity Score Matching

BMI

Body Mass Index

NRS

Nutritional Risk Screening

NET

Neuroendocrine Tumor

GIST

Gastrointestinal Stromal Tumor

ICU

Intensive Care Unit

pPLOS

prolonged Postoperative Length of Stay

## Declarations

*Ethics approval and consent to participate*

The current study is approved by Peking University Cancer Hospital Ethics Committee (2016YJZ32). This study is a retrospective analysis for our prospectively maintained database. It does not require permission/consent of the participants.

*Consent for publication*

Not applicable.

### *Availability of data and materials*

The datasets generated and/or analysed during the current study are not publicly available because they are derived from the patient database of the center and hence subject to confidentiality but are available from the corresponding author on reasonable request.

### *Competing interests*

The authors declare that they have no competing interests.

### *Funding*

This study is funded by the Beijing Municipal Science & Technology project, Beijing Municipal science & technology commission (D131100005313010), and National Key Technology Research and Development Program of the Ministry of Science and Technology of China (2014BAI09B02). Neither of them was involved in the study design, data collection, analysis and interpretation of the data, or manuscript writing.

### *Authors' contributions*

WZQ and LZY conceived of the study. WZQ and WQ were the major contributors in drafting and revising the manuscript. WQ, SJY and HSY collected patients' data. WQ and ZY provided statistical analysis and interpretation. JJF, LZY, SF and LSX provided necessary administrative support for the study. All authors contributed to refinement of the study protocol and approved the final manuscript.

### *Acknowledgements*

Not applicable.

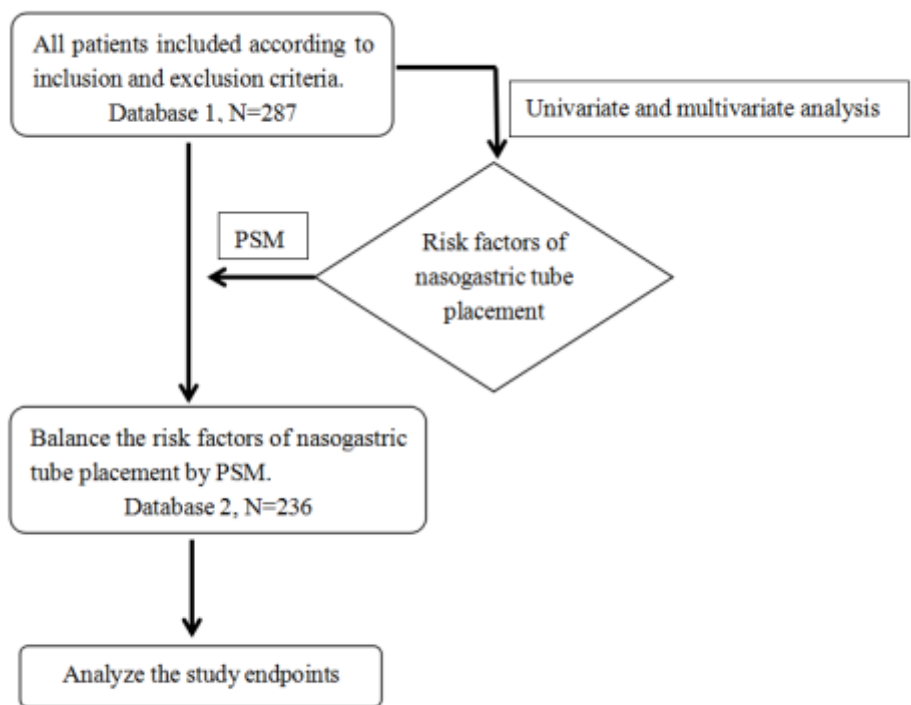
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## Figures



**Fig.1** Flow chart of the study

## Figure 1

Flow chart of the study

## Supplementary Files

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