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Intracorporeal Esophagojejunostomy Using a Circular or a Linear Stapler in Totally Laparoscopic Total Gastrectomy: a Propensity-Matched Analysis

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ABSTRACT

Purpose: There is no consensus on the optimal method for intracorporeal esophagojejunostomy (EJ) in laparoscopic total gastrectomy (LTG). This study aims to compare 2 established methods of EJ anastomosis in LTG.
Materials and Methods: A total of 314 patients diagnosed with gastric cancer that underwent LTG in the period from January 2013 to October 2016 were enrolled in the study. In 254 patients, the circular stapler with purse-string "Lap-Jack" method was used, and in the other 60 patients the linear stapling method was used for EJ anastomosis. After propensity score matching, 58 were matched 1:1, and retrospective data for patient characteristics, surgical outcome, and post-operative complications was reviewed.
Results: The 2 groups showed no significant difference in age, body mass index, or other clinicopathological characteristics. After propensity score matching analysis, the linear group had shorter operating time than the circular group (200.3±62.0 vs. 244.0±65.5, P≤0.001). Early postoperative complications in the circular and linear groups occurred in 12 (20.7%) and 15 (25.9%, P=0.660) patients, respectively. EJ leakage occurred in 3 (5.2%) patients from each group, with 1 patient from each group needing intervention of Clavien-Dindo grade III or more. Late complications were observed in 3 (5.1%) patients from the linear group only, including 1 EJ anastomosis stricture, but there was no statistical significance.
Conclusions: Both circular and linear stapling techniques are feasible and safe in performing intracorporeal EJ anastomosis during LTG. The linear group had shorter operative time, but there was no difference in anastomosis complications.

Keywords: Stomach neoplasm; Laparoscopy; Gastrectomy; Surgical anastomosis

INTRODUCTION

Despite the increasing acceptance of totally laparoscopic distal gastrectomy for gastric cancer treatment [1], there still are debates on the safety and effectiveness of laparoscopic total gastrectomy (LTG) [2,3]. There are 2 main technical concerns regarding LTG: one is esophagojejunostomy (EJ), and the other is spleen hilar node dissection. Of these,

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Conflict of Interest
No potential conflict of interest relevant to this article was reported.

laparoscopic intracorporeal EJ is a technically demanding procedure, and a standard EJ procedure has not been established yet. Hence, some surgeons still prefer laparoscopy-assisted total gastrectomy over LTG [4], as the complications of EJ can lead to severe patient morbidity [4-6].

Whether it was performed extra- or intracorporeally, several methods of EJ have been suggested and reported in literature [7-9]; yet, none of them is considered the standard method for use in LTG. Some of them include: the use of transorally inserted anvil (OrVil™; Covidien, Mansfield, MA, USA) [10], the hemi-double stapling technique (insertion of the anvil using a 2-0 monofilament suture) [11], and side-to-side EJ using the semi-loop or the overlap method [12]. These techniques can be largely divided into 2 major groups—the circular stapler and the linear stapler EJ. The main concern regarding the use of the circular stapler is the insertion and fixation of the anvil into the distal esophagus. Previously, we reported [13] the use of a laparoscopic purse-string suture instrument (Lap-Jack, Eterne, Seongnam, Korea) which can be used to insert a purse-string suture as it would have been done in open total gastrectomy without the need for trocar site extension. In this report, LTG showed short-term feasibility and safety, with no cases of EJ anastomosis leakage or stenosis among the 50 patients.

This study compares the 2 methods of intracorporeal EJ—circular stapling technique with the use of a laparoscopic purse-string suture device (Lap-Jack) and linear stapling technique—in LTG.

MATERIALS AND METHODS

Study design

Data of patients above the age of 18, diagnosed with gastric cancer, who underwent LTG in the period from January 2013 to October 2016, were retrospectively analyzed. Exclusion criteria were conversion to open procedure, involvement of the esophagogastric junction (EGJ), EJ using other methods than the Lap-Jack or the linear stapler, and resection of other organs. Patients were divided into 2 groups, the circular and the linear group, according to the type of EJ anastomosis, and short-term and long-term results were compared. The primary endpoint was the incidence of anastomotic complications, and secondary endpoints included operative and postoperative results, and other short-term and long-term complications (Clavien-Dindo grade II or more). This study was performed in accordance with the ethical standards of the Institutional Review Board (IRB) on human experimentation (IRB No. B-1809-493-105), and in line with the declaration of Helsinki. All the operations were performed in a single center with the same surgical team.

Anastomosis technique

For the circular stapler anastomosis, the EJ was made using the laparoscopic purse-string suture device (Lap-Jack) [12,13] and a single-stapling technique (SST) was performed as an end-to-side anastomosis. The Lap-Jack is introduced to the peritoneal cavity through a 12 mm port on the left lower quadrant. Once inside the abdomen, the proximal and distal jaws of the clamp are deployed, similar to a jack-knife, through a button on the hand-grip. It is then secured at the esophagus, and 2-0 polypropylene straight needle suture is passed through 2 holes in the clamp to create the purse-string suture. The esophagus is then manually transected distal to the Lap-Jack, and the anvil can be inserted into the esophagus and be fixed. Reinforcement of the purse-string suture is performed using an additional

2-0 prolene suture or the Endoloop (Ethicon Endosurgery Inc., Cincinnati, OH, USA). After the removal of the stomach specimen with a 3 cm extension through the left lower port, the circular stapler body is placed into the jejunum and EJ is performed intracorporeally. The entry hole of the jejunum is closed with a linear stapler.

For the linear stapler anastomosis, after mobilization from the right and left crus of the diaphragm, the esophagus is transected using a linear stapler. The semi-loop method or the overlap method was then used for linear EJ anastomosis. To perform linear stapled EJ using the semi-loop method, an entry hole was made on the end of the Roux limb, on the antimesenteric side, and at the left side of the esophageal stump. A stay suture was made at the esophageal entry hole for traction and better manipulation. After anastomosis using a 45 mm laparoscopic stapler, the entry hole was closed by hand-sewing, using a barbed suture [14,15]. For the overlap method, the entry hole of the jejunal limb was not made at the end, but 5–7 cm distal to it, creating a V-shaped anastomotic staple line using the same 45 mm stapler. The entry hole was closed in the same fashion through intracorporeal hand-sewing technique [9,12].

Statistical analysis

The student's t-test, Mann-Whitney test, χ^2 test, and Fisher's exact test were used for comparison of the continuous and categorical variables, and a P-value of <0.05 was considered statistically significant. Propensity score matching of 1:1 was performed with age, sex, body mass index (BMI), tumor location (circular/longitudinal), radicality, and tumor stage as covariates using the nearest method (caliper=0.2). SPSS Version 22 (IBM Corp., Armonk, NY, USA) was used for statistical analysis with the help of the Seoul National University Bundang Hospital Medical Research Collaborating Center.

RESULTS

A total of 550 patients diagnosed with gastric cancer underwent LTG in the period from January 2013 to October 2016. Of those, 236 patients were excluded due to involvement of the EGJ, conversion to open procedure, use of other circular stapling device (OrVil™), or resection of other organs. Finally, data of 314 patients were analyzed with 254 patients in the circular stapler group and 60 patients in the linear group. Among the latter, the semi-loop method was used in 54 patients, while in 6 the overlap method was used. Median follow-up was 39.4 (5.8–67.4) months in the circular group and 36.4 (2.8–68.8) months in the linear group. Both groups had their initial case on January 2013, and their last case on October 2016. Propensity score matching was performed with 6 covariates (age, sex, BMI, tumor location, radicality, and stage) and 58 patients from each group were matched 1:1.

Mean age of the circular group was 61.5±11.9 years, and of the linear group was 61.9±12.7 years (**Table 1**). The average BMI (kg/m^2) was also very similar, 23.3±3.1 and 23.6±2.9 for the circular and linear group, respectively. In both groups, most of the tumors were in the upper body and on the lesser curvature of the stomach. Eighteen patients with a previous history of gastrectomy received remnant total gastrectomy when gastric adenocarcinoma was found in the remaining stomach. Nearly half of the patients in both groups proceeded with adjuvant chemotherapy after the operation according to the Japanese Gastric Cancer Treatment Guidelines [16]. R0 resection for curative surgery was performed in 94.5% of patients of the circular group, and in 95.0% of patients of the linear group.

Table 1. Patient and tumor characteristics

Stapler type	Total population			Propensity matched population		
	Circular (n=254)	Linear (n=60)	P-value	Circular (n=58)	Linear (n=58)	P-value
Sex			0.062			0.278
Male	174 (68.5)	49 (81.7)		41 (70.7)	47 (81.0)	
Female	80 (31.5)	11 (18.3)		17 (29.3)	11 (19.0)	
Age (yr)	61.5±11.9	61.9±12.7	0.815	61.6±11.5	61.8±12.7	0.933
BMI (kg/m^2)	23.3±3.1	23.6±2.9	0.495	23.4±2.8	23.5±2.9	0.873
Circular tumor location			0.120			0.991
Lesser curvature	99 (39.0)	26 (43.3)		24 (41.4)	24 (41.4)	
Greater curvature	25 (9.8)	11 (18.3)		12 (20.7)	11 (19.0)	
Anterior wall	34 (13.4)	4 (6.7)		5 (8.6)	4 (6.9)	
Posterior wall	75 (29.5)	12 (20.0)		11 (19.0)	12 (20.7)	
Circular	21 (8.3)	7 (11.7)		6 (10.3)	7 (12.1)	
Tubular tumor location			0.147			0.936
Upper body	165 (65.0)	33 (55.0)		36 (62.1)	33 (56.9)	
Middle body	57 (22.4)	17 (28.3)		14 (24.1)	17 (29.3)	
Lower body	16 (6.3)	8 (13.3)		6 (10.3)	6 (10.3)	
Remnant stomach	16 (6.3)	2 (3.3)		2 (3.4)	2 (3.4)	
Stage			0.502			0.992
IA	76 (29.9)	17 (28.3)		17 (29.3)	16 (27.6)	
IB	27 (10.6)	2 (3.3)		1 (1.7)	2 (3.4)	
IIA	26 (10.2)	7 (11.7)		5 (8.6)	7 (12.1)	
IIB	16 (6.3)	4 (6.7)		3 (5.2)	4 (6.9)	
IIIA	26 (10.2)	6 (10.0)		8 (13.8)	6 (10.3)	
IIIB	34 (13.4)	9 (15.0)		9 (15.5)	9 (15.5)	
IIIC	29 (11.4)	12 (20.0)		12 (20.7)	11 (19.0)	
IV	20 (7.9)	3 (5.0)		3 (5.2)	3 (5.2)	
Adjuvant chemotherapy			0.310			0.813
Yes	130 (51.2)	25 (41.7)		26 (44.8)	24 (41.4)	
No	124 (48.8)	35 (58.3)		32 (55.2)	34 (58.6)	
Radicality			0.946			0.717
R0	240 (94.5)	57 (95.0)		55 (94.8)	55 (94.8)	
R1	6 (2.4)	1 (1.7)		2 (3.4)	1 (1.7)	
R2	8 (3.1)	2 (3.3)		1 (1.7)	2 (3.4)	

Data are shown as mean±standard deviation or number (%).
BMI = body mass index.

In the circular stapler group, 7 (2.8%) patients had EJ leakage compared to 3 (5.0%) patients in the linear group (P=0.630); however, there was no statistical significance. After 1:1 propensity score matching, both groups equally had 3 (5.2%) cases of EJ leakage. In the matched patient list, one from the circular group underwent reoperation after anastomosis leakage, and one from the linear group had percutaneous drain insertion (Clavien-Dindo grade IIIb and IIIa, respectively). The other patients were conservatively managed. There was one bleeding from the EJ site in the circular group, and EJ stricture was observed in 1 patient from each group (n=1, 1.7%). There was no statistical difference before and after propensity score matching regarding anastomotic complications (**Table 2**).

Table 2. Anastomosis complications

Stapler type	Total population			Propensity matched population		
	Circular (n=254)	Linear (n=60)	P-value	Circular (n=58)	Linear (n=58)	P-value
Anastomosis leakage	7 (2.8)	3 (5.0)	0.630	3 (5.2)	3 (5.2)	1.000
Anastomosis bleeding	1 (0.4)	0 (0.0)	1.000	1 (1.7)	0 (0.0)	1.000
Anastomosis stricture	1 (0.4)	1 (1.7)	0.832	0 (0.0)	1 (1.7)	1.000

Values are presented as number (%).

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Operative time was shorter in the linear group than in the circular group (199.2±61.5 vs. 246.1±63.2, respectively; P<0.001), and this remained significant after propensity matching (200.3±62.0 vs. 244.0±65.5, respectively; P<0.001). Although there was a significantly longer proximal margin in the linear group compared to that in the circular group (5.0±3.0 vs. 3.8±2.6, respectively; P=0.003), it showed no difference in the matched comparison (4.9±3.0 vs. 4.2±3.1, respectively; P=0.258). In both groups, the median hospital stay was 7.0 days (P=0.546), and the days until first flatus was 4.0 (2.0–8.0) days in both groups (P=0.193). Operative outcomes are summarized in **Table 3**.

The early and late complications with Clavien-Dindo grade II or more are summarized in **Table 4**. After propensity score matching, early complications, defined as complications within 30 days of the operation, occurred in 12 (20.7%) patients from the circular group and 15 (25.9%) patients from the linear group (P=0.660). Pulmonary complications accounted for most of the complications with fluid collection, with EJ leakage and bowel motility disorder next in order. Other, not classified, complications included catheter-related infections, portal vein thrombosis, splenic infarction, and arrhythmia; these were all controlled through medical treatments. Comparing the matched groups, late complication occurred only in 3 (5.1%) patients from the linear group—EJ stricture, reflux esophagitis, and Y limb obstruction (which is classified as "other complications" in **Table 4**). However, there was no statistical difference in complications between the 2 groups. There was no postoperative mortality in either group.

DISCUSSION

Performing the EJ anastomosis is still considered one of the most technically challenging aspects of LTG. With the advancement of surgical devices, several methods of EJ—whether end-to-end, end-to-side, or side-to-side—have been suggested. There are debates regarding the safest and most effective type of EJ anastomosis, and, to the present, there is no consensus on which is the standard EJ method for LTG. This study used propensity score matching to compare the use of the circular stapler through the Lap-Jack purse-string device and the use of the linear stapler in performing EJ. There was no difference in anastomotic and other relevant complications, but the linear stapler group had shorter operative time.

EJ leakage after LTG is reported from 0.7% up to 9.5% [17]; however, the sample sizes in these studies are small, with most of them being less than 100 cases [2]. The largest study reported by Gong et al. [18] describes 421 patients who underwent the linear stapling EJ, and

Table 3. Operative and postoperative outcomes

Stapler type	Total population			Propensity matched population		
	Circular (n=254)	Linear (n=60)	P-value	Circular (n=58)	Linear (n=58)	P-value
Operative time (min)	246.1±63.2	199.2±61.5	<0.001	244.0±65.5	200.3±62.0	<0.001
Estimated blood loss (mL)	101.5±98.4	149.5±284.6	0.202	120.0±121.3	152.4±288.9	0.434
Proximal resection margin (cm)	3.8±2.6	5.0±3.0	0.003	4.2±3.1	4.9±3.0	0.258
Distal resection margin (cm)	11.4±5.1	10.5±4.9	0.236	11.2±5.3	10.7±4.9	0.608
Retrieved lymph nodes	72.0±31.4	70.9±31.7	0.803	76.9±34.4	70.9±32.3	0.211
Hospital stay (days)	7.0 (5.0–74.0)	7.0 (5.0–45.0)	0.195	7.0 (5.0–34.0)	7.0 (5.0–45.0)	0.546
First SFD (days)	4.0 (2.0–18.0)	4.0 (2.0–23.0)	0.872	4.0 (3.0–18.0)	4.0 (2.0–23.0)	0.928
Time until first flatus (days)	4.0 (2.0–8.0)	4.0 (2.0–8.0)	0.272	4.0 (2.0–8.0)	4.0 (2.0–8.0)	0.193

All values are shown as mean±standard deviation, or median (range). The P<0.05 was considered significant.
SFD = semi-fluid diet.

Table 4. Postoperative complications

Stapler type	Total population			Propensity matched population		
	Circular (n=254)	Linear (n=60)	P-value	Circular (n=58)	Linear (n=58)	P-value
Early complications (≤30 postoperative days)*	38 (15.0)	15 (25.0)	0.094	12 (20.7)	15 (25.9)	0.660
Lung morbidity	17 (6.7)	6 (10.0)	0.156	4 (6.9)	6 (10.3)	0.741
Intra-abdominal abscess	13 (5.1)	2 (3.3)	0.805	2 (3.4)	2 (3.4)	1.000
Anastomosis leakage	7 (2.8)	3 (5.0)	0.630	3 (5.2)	3 (5.2)	1.000
Intestinal obstructive morbidity	3 (1.2)	3 (5.0)	0.156	2 (3.4)	3 (5.2)	1.000
Stump leakage	2 (0.8)	3 (5.0)	0.077	1 (1.7)	3 (5.2)	0.611
Urinary morbidity	3 (1.2)	0 (0.0)	0.914	0 (0.0)	0 (0.0)	-
Wound morbidity	1 (0.4)	0 (0.0)	1.000	0 (0.0)	0 (0.0)	-
Anastomosis bleeding	1 (0.4)	0 (0.0)	1.000	1 (1.7)	0 (0.0)	1.000
Other bleeding	0 (0.0)	1 (1.7)	0.431	0 (0.0)	1 (1.7)	1.000
Loop obstruction	1 (0.4)	0 (0.0)	1.000	1 (1.7)	0 (0.0)	1.000
Pancreatic fistula	0 (0.0)	0 (0.0)	-	0 (0.0)	0 (0.0)	-
Postoperative pancreatitis	0 (0.0)	0 (0.0)	-	0 (0.0)	0 (0.0)	-
Other early complications†	3 (1.2)	2 (3.3)	0.194	2 (3.4)	4 (6.9)	0.675
Early complications ≥Clavien-Dindo grade III	22 (8.7)	8 (13.3)	0.388	7 (12.1)	8 (13.8)	1.000
Late complications (>30 postoperative days)	16 (6.3)	4 (6.7)	1.000	0 (0.0)	3 (5.1)	0.127
Internal hernia	10 (3.9)	0 (0.0)	0.249	0 (0.0)	0 (0.0)	-
Adhesive ileus	7 (2.8)	0 (0.0)	0.415	0 (0.0)	0 (0.0)	-
Anastomosis stricture	1 (0.4)	1 (1.7)	0.832	0 (0.0)	1 (1.7)	1.000
Reflux esophagitis	0 (0.0)	1 (1.7)	0.431	0 (0.0)	1 (1.7)	1.000
Dumping syndrome	0 (0.0)	0 (0.0)	-	0 (0.0)	0 (0.0)	-
Other late complications	2 (0.8)	2 (3.3)	0.346	0 (0.0)	1 (1.7)‡	0.476
Late complications ≥Clavien-Dindo grade III	16 (6.3)	3 (5.0)	0.937	0 (0.0)	3 (5.1)	0.127
Mortality	0 (0.0)	0 (0.0)	-	0 (0.0)	0 (0.0)	-

Values are presented as number (%).
*Patients with multiple complications were counted as one with the highest Clavien-Dindo grade; †Includes catheter-related infections, portal vein thrombosis, splenic infarction, and postoperative arrhythmia; ‡Y limb obstruction.

showed an anastomosis leakage of 3.6%. So far, the current study holds the largest number of reported intracorporeal EJ anastomoses using a circular stapler with 254 patients, reporting a leakage rate of 2.8%—which is an acceptable number considering the previous studies mentioned above. This is due to the use of the intracorporeal purse-string device "Lap-Jack", which allows the operator to effectively place a purse-string suture as it would have been placed in an extracorporeal EJ. For the use of a circular stapler, the most challenging part is the fixation of the anvil in the esophageal stump, and by using the Lap-Jack, the procedure is performed with less effort.

There are several comparative studies that compare anastomosis leakage between the circular stapler and linear stapler methods. Kawamura et al. [6] compared the use of the OrVil™ circular stapler with that of the linear stapler, and showed a significantly higher number of leakage when using the OrVil™. A systematic review [2] analyzed 25 articles regarding LTG, and compared the rate of EJ leakage in the circular and linear stapler methods. Their analysis showed that the linear stapler had a lower rate of EJ leakage (1.1%) compared to the rate of the circular stapler (4.7%, P<0.001). However, among the types of circular EJ, this study used a SST [19,20] using an internally developed laparoscopic purse-string suture device. This study showed that there was no statistical difference between anastomosis leakage rate in the circular and linear stapler methods despite the adequate number of sample size. The rate became even more statistically similar after propensity score matching.

Compared to anastomosis leakage, EJ bleeding is relatively uncommon, but the rate of stenosis of the EJ may be reported as high as 33% [7,17]. Current studies analyzing linear and circular EJ mostly report higher incidence of anastomotic stenosis when the circular

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stapler is used [2,6], occurring in 2.4%–10.0% of circular stapled EJ. This is because when a linear stapler is used, a wider diameter of anastomosis can be secured since the stapler must be inserted longitudinally. The hemi-double-stapling technique (HDST) through the circular stapler is performed by using a linear stapler to create the esophageal stump after the insertion of the anvil [11]. This procedure does not need a purse-string suture to secure the anvil head, but the overlap of the stapler line after the circular stapler is fired may increase the risk of stenosis by causing ischemia through compression leading to fibrosis [19,21]. Several studies have found that the SST causes significantly lower rates of EJ stenosis [20,21] compared to the HDST. In this study, only SST was used for the circular stapler anastomosis and there was no significant difference in EJ stenosis compared to the linear stapler group.

After propensity score matching, the only difference in outcome between the circular stapler group and linear stapler group was operative time, which was roughly 45 minutes longer in the circular stapler group. The comparison may have been more accurate if the anastomosis time was compared; however, since this is a retrospective study and there was no available description of anastomosis time, total operative time was used as a surrogate parameter. One possible explanation for the discrepancy in operative time is that there was more involvement of fellow trainees during the operation for the circular stapler group, while the operations in the linear group were performed by a single expert surgeon for the whole procedure. Shim et al. [7] compared 4 types of EJ anastomosis, and the overlap method using the linear stapler took significantly less time (34.3±6.4 minutes) than the other 3 circular stapler methods ($P=0.041$). In a study by Gong et al. [18], EJ anastomosis time with the linear stapler was shorter than that with the circular stapler by 21 minutes ($P<0.001$). Other comparative studies, however, show that there is no difference in anastomotic time [6,22].

The decision whether to use a circular stapler or a linear stapler for EJ is mostly dependent on the operator's preference, but can also be influenced by other factors. Initially, the proximal margin was longer in the linear group, but after propensity score matching, there was no statistical difference, which may imply that the choice of stapler used was influenced by tumor location. Another study also suggests that the type of stapler used should depend on tumor location, with circular staplers preferred for tumors located higher than the middle cardia [23].

The major limitation of this study was its retrospective design, despite using the propensity score matching to adjust for confounders. Anastomosis time was not recorded, and thus, the total operative time was used as a surrogate marker. In addition, both the semi-loop and the overlap methods were classified into 1 group (linear stapler) because the number of overlap cases was too small compared to that of semi-loop cases. In this study, we only used the “Lap-Jack” purse-string clamp for the circular stapler. As there are several methods of using the circular stapler for EJ, this may not be representative of the use of circular staplers. Furthermore, all patients with involvement of the EGJ were excluded. As the dissection goes higher into the thoracic cabinet, the operating window becomes narrower [10], and there is risk for more tension after EJ anastomosis [7]. This, however, reduced the sample size, making it difficult to compare morbidity with strong statistical significance. A larger study is needed to confirm the results of this study. Additionally, although excluding patients with involvement of the EGJ was a good way to avoid additional confounders, analysis of these patients alone may provide a novel perspective.

In conclusion, both circular stapling and linear stapling techniques are feasible and safe in performing intracorporeal EJ anastomosis during totally LTG. The linear group had shorter

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operative time, but there was no difference in anastomosis complications between the 2 groups. With lack of evidence, currently the choice of EJ anastomosis is made by the operator considering the tumor characteristics. Further well-designed prospective studies are needed to sort out and determine the optimal EJ for LTG.

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