Uncut Roux-en-Y gastrojejunostomy after totally laparoscopic distal gastrectomy: Learning curve and surgical outcomes

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Purpose: Totally laparoscopic distal gastrectomy (TLDG) is now widely used for early gastric cancer patients, but the selection of a reconstruction method after TLDG is still controversial. Roux-en-Y gastrojejunostomy is increasingly used in expectation of less gastritis and alkaline reflux despite its technical difficulty. The uncut Roux-en-Y gastrojejunostomy (uRYGJ) retains the advantages of Roux-en-Y reconstruction but helps prevent Roux stasis syndrome. The present study aims to introduce a single surgeon's experience of TLDG with uRYGJ and analyze the learning curve and surgical outcomes.

Methods: We retrospectively reviewed the medical records of 124 consecutive patients who underwent TLDG with uRYGJ performed by a single surgeon between July 2014 and August 2015 at Asan Medical Center. The baseline characteristics and surgical outcomes were analyzed, and the learning curve was drawn based on the power-law model.

Results: The mean total operative time was 165 minutes, and the average length of hospital stay was 6.6 days. Complications included two cases of duodenal stump leakage, two intra-abdominal bleeding, two intra-abdominal fluid collection, one wound problem, two anastomotic strictures, 14 ileus, and no anastomotic leakage. There were five cases of endoscopically proven reflux gastritis/esophagitis and no Roux stasis syndrome. There were five recurrences and one mortality during the follow-up period. The learning curve leveled at the 15th case.

Conclusion: The results of our study showed the safety and feasibility of uRYGJ, and that the technical difficulty of the procedure can be overcome with a short learning curve for experienced surgeons.

Keywords: Stomach neoplasm, Learning curve, Gastrectomy, Laparoscopy, Roux en Y anastomosis

INTRODUCTION

Radicality and safety are the basis of surgery for malignancies [1]. Over the years, laparoscopic distal gastrectomy (LDG) has proven to be a feasible surgical option, with favorable oncologic and surgi-

cal outcomes [2]. Since its radicality and safety have been established, more concerns are now being raised over the quality of life after surgery.

For reconstruction after LDG, Billroth I (B-I), Billroth II (B-II), and Roux-en-Y gastrojejunostomy (RYGJ) are commonly used. However, the selection of a reconstruction method after LDG still mainly depends on the surgeon's preference [3,4]. According to the Korean Gastric Cancer Association nationwide survey on gastric cancer in 2014 [5], for reconstruction after laparoscopy-assisted and totally laparoscopic distal gastrectomy (TLDG), B-I was most commonly used (51%), followed by B-II (34.3%) and RYGJ (9.3%). B-I reconstruction has the advantage in that it is simpler in procedure, and results in more physiologic passage. However, it is associated with high tendency to alkaline reflux, leading to inflammation of the remnant stomach. B-II reconstruction is rarely done in Japan due to the same issue concerning bile reflux [3,4]. Despite its technical difficulty, RYGJ reconstruction is increasingly used in

Received: Jan 23, 2020 **Revised:** May 13, 2020 **Accepted:** May 27, 2020

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expectation of better quality of life after surgery; less gastritis and alkaline reflux [5,6]. Moreover, it is less dependent on tumor position, whereas there are some occasions B-I cannot be performed because of the expected creation of tension at the anastomosis site.

Unfortunately, Roux stasis syndrome, characterized by symptoms of food stasis in the upper gastrointestinal tract, can be complicated after RYJ reconstruction with incidence of 5% to 37.3% [6-10]. The etiology of Roux stasis syndrome is still unclear, but it is thought to be caused by transection of the jejunum and separation of the Roux limb from the intestinal pacemaker [11,12].

To prevent this complication, a new anastomosis method, the uncut RYJ (uRYJ), was designed by Van Stiegmann et al. in 1988. Zhang et al. [13] revealed advantages of the procedure in myoelectric activity and motility of the Roux limb. Several studies reported a reduced incidence of Roux stasis syndrome as well as the safety and feasibility of the procedure [14,15]. Furthermore, in 2005, Uyama et al. [16] reported a successful early surgical outcome of laparoscopy-assisted LDG with uRYJ.

The present study aimed to introduce a single-surgeon's experience performing TLDG with uRYJ and analyze the surgical outcomes and the learning curve.

METHODS

Patient characteristics

This study is a single-center, retrospective analysis of all consecutive patients who underwent TLDG with uRYJ in our center between July 2014 and August 2015. All operations were performed by a single surgeon who has a previous experience of approximately 1,000 cases of gastrectomy, including 500 laparoscopic cases. The study was approved by the Institutional Review Board of Asan Medical Center (IRB No. 2018-0880). Informed consents from patients for this retrospective study were waived by institutional review board.

Clinical evaluation of surgical outcomes

We reviewed patient electronic medical charts for data collection. Baseline data included age at operation, sex, body mass index (BMI), operative time, length of hospital stay, duration until the first liquid diet, duration until first flatus, tumor size, number of retrieved and metastasized lymph nodes, distal and proximal resection margins, complications including reflux gastritis/esophagitis and Roux stasis syndrome, recurrence, and mortality. Only cases endoscopically proven were included as reflux gastritis/esophagitis.

Operation time was measured from initiation of incision to skin closure. Surgery-related complications that occurred and were detected within 30 postoperative days were defined as early compli-

cations, and those that occurred after 30 days were defined as late complications.

Surgical procedures

The patient was placed in supine reverse Trendelenburg position. The first port was inserted infra-umbilically with the open Hasson technique. The other four ports were inserted with laparoscopic visualization in the upper abdomen. Mobilization of the stomach and duodenum was performed along with en-bloc lymph node dissection including partial omentectomy. The mobilized duodenum and stomach were transected with a laparoscopic linear stapler (iDrive; Covidien, North Haven, CT, USA). After retrieving the specimen, reconstruction was performed. The ligament of Treitz was exposed by retracting the transverse colon, and the jejunum at 20 cm distal to the ligament of Treitz was dragged up towards the stomach. Enterotomy incisions were made in the jejunum and stomach for gastrojejunostomy (GJ) using a 60-mm linear endostapler (Fig. 1A), and the common entry hole was closed with self-retaining sutures (V-Loc; Covidien) (Fig. 1B). At 45 cm from the GJ in the efferent loop, and at 10–15 cm from the ligament of Treitz in the afferent loop, enterotomy incisions were made and Braun anastomosis was performed using a 45-mm linear endostapler (Fig. 2A), and V-loc for the common entry hole (Fig. 2B). At 2 to 3 cm from the GJ, a 45-mm no-knife stapler (ATS45NK: 45 mm ETS Articulating Linear Cutter (No Knife); Ethicon, Cincinnati, OH, USA) is used for the uncut procedure (Fig. 3). Closure of the jejunal mesenteric defect was routinely performed.

Statistical analysis and learning curve evaluation

SPSS 20.0 software (IBM Corp., Armonk, NY, USA) was used to analyze the characteristics and surgical outcomes of the patients. The learning curve was analyzed using Excel 2010 (Microsoft, Redmond, WA, USA) based on the power-law model.

Fig. 1. Construction of gastrojejunostomy. (A) Intracorporeal isoperistaltic side-to-side gastrojejunostomy is made using 60-mm linear stapler and (B) the common entry hole is closed with self-retaining sutures.

Fig. 2. Construction of jejunojejunostomy. (A) Intracorporeal Braun anastomosis is done using 45-mm linear stapler and (B) the common entry hole is closed with self-retaining sutures.

Fig. 3. Uncut procedure. A 45-mm no knife stapler is used on the afferent loop for the uncut procedure.

RESULTS

Patient characteristics and surgical outcomes

A total of 124 patients underwent TLDG with uRYGJ in our center between July 2014 and August 2015. The mean age of the patients was 57.8 ± 11.8 years. There were 72 male patients (58.1%) and 52 female patients (41.9%), and the mean BMI was 24.44 ± 3.13 kg/m². The median follow-up period was 38 months.

The mean total operative time was 165.4 ± 32.5 minutes, with variance from 107 to 285 minutes. The average length of hospital stay was 6.6 ± 2.2 days and liquid diet was initiated after an average of 3.4 ± 1.1 postoperative days. The first passage of flatus was noted after an average of 3.5 ± 0.9 postoperative days (Table 1).

The mean total number of retrieved lymph nodes and metastasized nodes in each surgery was 40.3 ± 16.1 and 0.3 ± 1.1 , respectively. The average tumor size was 2.89 ± 1.42 cm, with a distal resection margin of 5.80 ± 2.83 cm and a proximal resection margin of 4.38 ± 2.60 cm. Under American Joint Committee on Cancer

Table 1. Characteristics and surgical outcomes of patients who underwent TLDG with uRYGJ

Characteristics and operative outcomes	Value (n = 124)
Age (yr)	
Mean	57.8 ± 11.8
Median	56.5 (28–93)
Sex	
Male	72 (58.1)
Female	52 (41.9)
BMI (kg/m ²)	24.4 ± 3.1
Follow-up period (mo)	38 (0–47)
Operative time (min)	165.4 ± 32.5
Operative outcomes (day)	
Length of hospital stays	6.6 ± 2.2
Liquid diet initiation	3.4 ± 1.1
Passage of flatus	3.5 ± 0.9
Reflux gastritis/esophagitis	5 (4.0)
Roux stasis syndrome	0
Recurrence	5 (4.0)

Values are presented as mean $\pm$ standard deviation, median (range), or number (%).

TLDG, totally laparoscopic distal gastrectomy; uRYGJ, uncut Roux-en-Y gastrojejunostomy; BMI, body mass index.

7th edition, there were 101 patients with stage IA gastric cancer, 15 patients with stage IB, four with IIA, and one each with IIB, IIIA, IIIB, and IIIC. There were five recurrences (4%) during the follow-up period, which included one peritoneal dissemination, two liver metastases, and two local recurrences. All patients with recurrence were stage IA at the initial surgery (Table 2).

There was no anastomotic leakage during the follow-up period. Early complications included two cases of duodenal stump leakage, two cases of intra-abdominal bleeding, four cases of ileus that delayed hospital discharge, two cases of intra-abdominal fluid collection and one wound problem. There were 11 cases of medical complications, which occurred within 30 postoperative days. These complications included temporary elevation of bilirubin or liver enzymes, pneumonia, angina, and acute myocardial infarction. Late complications included one case of gastrojejunal stricture, one case of jejunojejunal stricture, and 10 cases of mechanical ileus (Table 3).

The only mortality case resulted from myocardial infarction that occurred on the third postoperative day in a patient who did not have underlying heart disease other than hypertension. Six cases of mechanical ileus, which occurred after 30 postoperative days, resulted in re-operation, and one case of jejunojejunal stricture was managed with balloon dilatation.

There were five cases of endoscopically proven reflux gastritis/

Table 2. Clinicopathologic results of patients who underwent TLDG with uRYGJ

Variable	Early complication
Tumor size (cm)	2.89 ± 1.42
No. of retrieved lymph nodes	40.3 ± 16.1
No. of metastasized lymph nodes	0.3 ± 1.1
Distal resection margin (cm)	5.8 ± 2.8
Proximal resection margin (cm)	4.4 ± 2.6
TNM stage ^{a)}	
IA	101 (81.5)
IB	15 (12.1)
IIA	4 (3.2)
IIB	1 (0.8)
IIIA	1 (0.8)
IIIB	1 (0.8)
IIIC	1 (0.8)

Values are presented as mean ± standard deviation or number (%).

TLDG, totally laparoscopic distal gastrectomy; uRYGJ, uncut Roux-en-Y gastrojejunostomy.

^{a)}TNM stages were based on the American Joint Committee on Cancer Staging Manual 7th edition.

esophagitis; and among them, one patient complained of associated symptom which involved regurgitation. There was no incidence of Roux stasis syndrome during the follow-up period (Table 1).

Learning curve analysis

The power-law model was used to evaluate the association between the number of cumulative cases and the expected operative time. With our data, the curve was best fitted at a learning rate of 95%. Under this logarithmic model, the slope at a certain case number flattens as cumulative case number increases, approaching 0. Lin et al. [17] introduced the learning curve based on the power law method and set the slope of -1 as the point in which the operator reached proficiency. We adopted this concept to identify the point at which the operator reached stability; in our study, this happened at the 15th case.

DISCUSSION

LDG has proven its feasibility, favorable oncologic and surgical outcomes over the years [2]. However, the best reconstruction method after LDG is not yet in consensus and mainly depends on surgeon's preference. B-I, B-II, and RYGJ are commonly used reconstruction methods after LDG. B-I reconstruction is most preferred in Korea because it is technically simple and has physiological advantages [5]. However, B-I reconstruction has been associated with gastroesophageal and duodenogastric reflux.

Table 3. Surgical complication and mortality of patients who underwent TLDG with uRYGJ

Variable	Early complication	Late complication
Complications		
Anastomotic leakage	0	0
Duodenal stump leakage	2	0
Anastomotic stricture	0	2
Pancreatic fistula	0	0
Bleeding	2	0
Mechanical ileus	4	10
Intra-abdominal fluid collection	2	0
Wound problem	1	0
Medical complications	11	0
Mortality	1	0

TLDG, totally laparoscopic distal gastrectomy; uRYGJ, uncut Roux-en-Y gastrojejunostomy.

RYGJ reconstruction is more technically demanding but supplements these disadvantages [5,6,18-20]. Also, it depends less on position of the tumor, and forms a tension-free anastomosis [21]. Some studies have even reported better food intake and nutritional benefit after surgery [20,22].

Unfortunately, despite its advantages, RYGJ reconstruction is associated with Roux stasis syndrome. The etiology of this syndrome is controversial but animal studies suggest that transection of the jejunum with its ectopic pacemaker causes dysfunction of the Roux limb, leading to a slow transit of food material [8,23]. Uyama et al. developed the uRYGJ technique based on this theory and omitted the procedure of jejunal transection in order to avoid Roux stasis syndrome [8,16]. For the uncut procedure, instead of jejunal transection, the afferent loop is blocked with a no-knife stapler. In this way, diversion of the afferent loop is achieved without compromising the jejunal ectopic pacemaker. Performing uRYGJ after gastrectomy has proven to reduce Roux stasis syndrome [8,21].

We performed a modified method of uRYGJ to accomplish a total laparoscopic surgery. A total of 124 patients received TLDG with uRYGJ at our center between July 2014 and August 2015 with a median follow-up period of 38 months. The mean total operative time was 165.4 minutes, which was comparable to other studies [21,24]. Reflux gastritis/esophagitis occurred in only 4.0% of the study group, and there was no incidence of Roux stasis syndrome during the follow-up period. Our results showed the safety and feasibility of uRYGJ, and that the technical difficulty of the procedure can be overcome with a relatively short learning curve for experienced surgeons. The learning curve was no longer than 10 to 29 cases for intracorporeal B-I anastomosis [25-27], which is ac-

cepted as a technically less challenging procedure.

There are several limitations to this study. The study was based on retrospective data collection from a single surgeon, and it is not a comparative study. Another limitation is that we have no data on the recanalization of uncut stapled jejunum during the study period. It is important to evaluate recanalization because the reconstruction turns into a B-II structure when the uncut stapler line of the uRYGJ anastomosis re-opens [16,28-30]. At the time of the study, the endoscopists who performed postoperative follow-up endoscopy were not requested to observe the recanalization after uncut procedure, and there was no description regarding the re-opening on the endoscopic report. A randomized controlled trial with the establishment of a protocol for objective data collection including information on recanalization and detailed description on reflux, nutrition, and quality of life is needed to verify the functional advantage of uRYGJ compared to other anastomotic methods.

In conclusion, laparoscopic uRYGJ is feasible and safe after TLDG. The learning curve was considered to have been reached after 15 cases and this data-based evidence supports our opinion that the technical difficulty of the procedure can be overcome with a short learning curve for experienced surgeons. Therefore, uRYGJ should be considered a viable option after TLDG.

CONFLICT OF INTEREST

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

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