



Open Surgery for Gastric Cancer: Reconstruction

9

Joong Ho Lee and Woo Jin Hyung

Introduction

Restoring gastrointestinal continuity has remained an issue since the first successful gastrectomy. Although various reconstruction techniques are possible after gastrectomy, researchers and clinicians have yet to decide on an optimal or ideal reconstruction method. When choosing a reconstruction method, surgeons should seek to maintain, in addition to surgical and oncological stability, quality of life by ensuring nutritional intake after surgery.

Possible reconstruction methods after distal gastrectomy include gastroduodenostomy (also known as Billroth I reconstruction), gastrojejunostomy (also known as Billroth II reconstruction) with or without Braun anastomosis, and Roux-en-Y fashion gastrojejunostomy. After total gastrectomy, Roux-en-Y reconstruction is the most widely used procedure, although several modifications thereto have been devised.

J. H. Lee
Department of Surgery, National Health Insurance Service Ilsan Hospital, Goyang, Republic of Korea

W. J. Hyung (✉)
Department of Surgery, Yonsei University College of Medicine, Seoul, Republic of Korea
e-mail: wjhyung@yuhs.ac

Operative Technique

Reconstruction After Distal Gastrectomy

Gastroduodenostomy (Billroth I Reconstruction)

Gastroduodenostomy following distal subtotal gastrectomy is considered a preferred reconstruction method, especially in Asia [1]. Gastroduodenal anastomosis is performed end to end between the remnant stomach and the duodenum. Gastroduodenostomy has physiological advantages by affording duodenal passage preservation, and studies have described enhanced nutrient uptake and iron metabolism therewith, compared to other reconstruction methods, after distal gastrectomy [2, 3]. Anatomical advantages (e.g., single anastomosis) theoretically reduce the possibility of complications, such as anastomosis leakage, and allow for easier access to the biliary system.

Anastomosis can be performed manually or mechanically with a circular stapling device. Gastroduodenostomy with a circular stapler has been performed since the 1970s [4], and various modifications thereto have been reported. The use of a circular stapling device has been found to significantly shorten operation times, with similar incidences of complications, compared to other methods [5, 6].

Surgical Technique

To perform a gastroduodenostomy, a purse-string clamp is applied at the distal resection line of the duodenum. A straight clamp is applied just proximal to the purse-string clamp. The duodenum is then transected between two clamps (Fig. 9.1a). After a purse-string suture is made at the stump of the duodenum, a detachable anvil from a circular stapler with a diameter of 28–31 mm is gently inserted into the duodenal stump. Importantly, after the purse-string suture is tied over the anvil, the anvil should be grasped with the clamp to prevent its slippage down into the duodenal lumen (Fig. 9.1b).

A disposable automatic purse-string device can also be used. Performing a Kocher maneuver at the duodenum may reduce tension on the anastomosis site and readily allows the anvil to be inserted into the duodenum. Before transection of the duodenum, the Kocher maneuver can be more easily implemented.

After dividing the duodenum, anastomosis can be made before resection of the stomach, or gastrectomy can be performed first, followed by anastomosis. To perform the anastomosis before gastrectomy, a 3–4-cm gastrotomy in the distal part of the stomach is made to insert a circular stapler. The incision must avoid the area around the tumor and be opened along the greater curvature of the stomach, if possible (Fig. 9.2a). Through this gastrotomy, a lesion in the stomach can be grossly confirmed, and an adequate proximal resection margin can be determined.

After insertion of the anvil, the proximal cut edge of the gastrotomy is grasped, and the body of the circular stapler is inserted. The central rod of the circular stapler is then moved to penetrate through the posterior wall or the greater curvature of the stomach at the proper place of anastomosis (Fig. 9.2b). Afterward, the circular stapler is rotated toward the duodenum 180 degrees to lock the central rod and the anvil (Fig. 9.2c) to achieve side-to-end anastomosis of the gastroduodenostomy (Fig. 9.2d).

After anastomosis, any bleeding or disruption in the anastomosis is checked under direct vision through the opening of the gastrotomy. The donut ring in the anvil should be inspected carefully to ensure a complete ring is formed in the tissue. Following this procedure, the position of a nasogastric tube can be verified and gastric transection performed using linear staplers. The staple line is made about 1–2 cm from the anastomosis line of the gastroduodenostomy (Fig. 9.3a). Completed anastomosis of the stapled gastroduodenostomy is shown in Fig. 9.3b: the anastomosis was performed along the greater curvature of the remnant stomach, and note that the anastomosis did not cross the linear stapler lines of the gastric closure.

Anastomosis is easier to perform after retrieving the tumor specimen during resection of the stomach. After duodenal transection and completion of lymph node dissection, clamps are applied on the greater curvature of the stomach

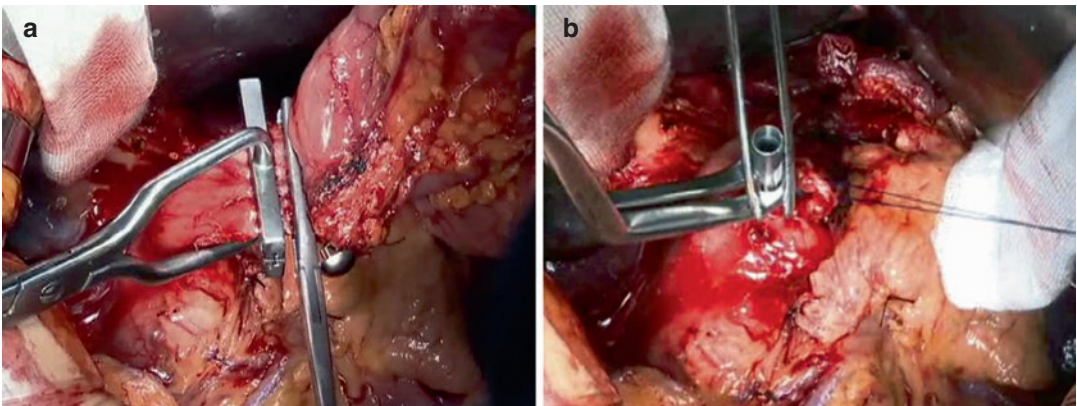


Fig. 9.1 Division of the duodenum for performing gastroduodenostomy. (a) A purse-string clamp is applied at the distal resection line of the duodenum. (b) The duodenum is transected, and the purse-string suture is tied over

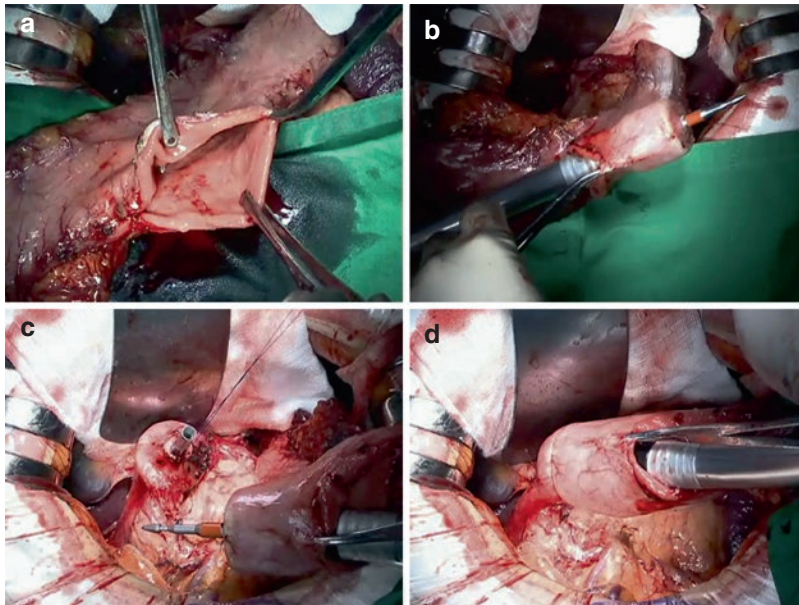


Fig. 9.2 Gastroduodenostomy with a circular stapler. (a) A gastrotomy in the distal part of the stomach is made. (b) Inserting a circular stapler through the gastrotomy, the central rod penetrates through the greater curvature of the

stomach. (c) The stomach and stapler are rotated toward the duodenum. (d) The central rod and anvil are locked to perform side-to-end anastomosis

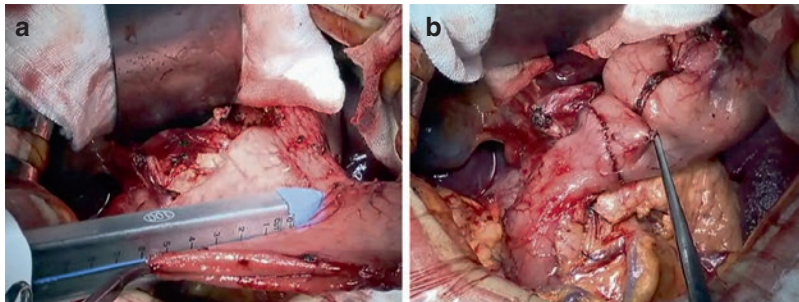


Fig. 9.3 Completed gastroduodenostomy with a circular stapler after distal subtotal gastrectomy. (a) The stomach is transected with linear staplers. (b) The staple line of the

gastroduodenostomy does not cross the linear stapler lines of the gastric resection

along a determined proximal resection line, and then the greater curvature side of the stomach is divided between the clamps (Fig. 9.4a). Gastric resection is then carried out using a linear stapler, and the specimen is retrieved (Fig. 9.4b). For anastomosis, the body of a circular stapler is inserted at the entry hole in the remnant stomach upon removal of the applied clamp. The central rod of the stapler is advanced 1–2 cm away from the resection line to the posterior wall of the

remnant stomach (Fig. 9.4c). After approximation of the central rod and the anvil, side-to-end anastomosis of the gastroduodenostomy is made by firing the stapler. Then, the entry hole of the remnant stomach is closed using a linear stapler (Fig. 9.4d). This method provides anastomosis on the posterior wall of the remnant stomach.

In both techniques, the circular and linear stapler lines do not cross one another, which is thought to lessen the risk of anastomotic leakage

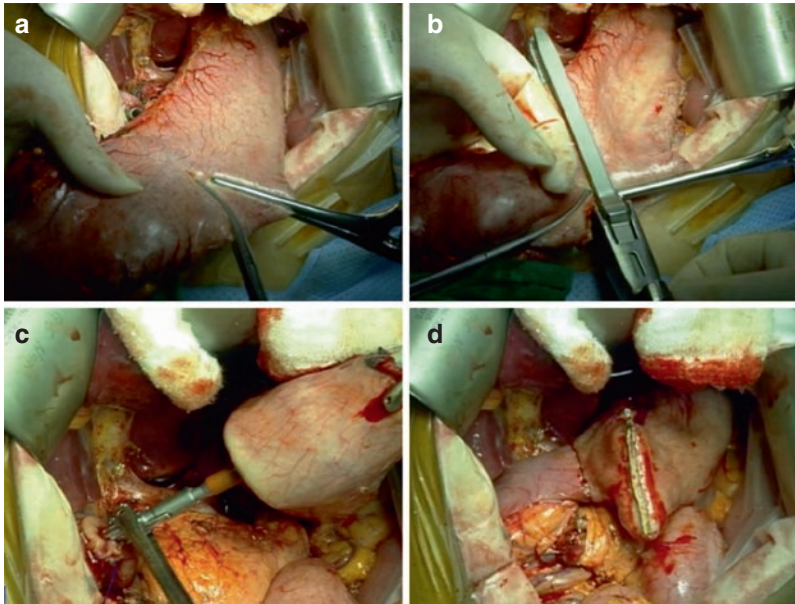


Fig. 9.4 Gastroduodenostomy after resection of the stomach. (a) A Payr's intestinal clamp is applied on the greater curvature side of the stomach. (b) The stomach is transected with linear staplers, and the tumor specimen is retrieved. (c) A circular stapler is inserted through the

remnant stomach such that the central rod penetrates through the posterior wall of the stomach. (d) After finishing side-to-end gastroduodenostomy, the entry hole of the remnant stomach is closed using a linear stapler

[7]. To decrease tension during the gastroduodenostomy, incising the gastrophrenic ligament in the left edge of the fundus of the stomach is helpful, together with performing Kocher's maneuver [8].

Gastrojejunostomy (Billroth II Reconstruction)

Gastrojejunostomy provides anastomosis between the remnant stomach and the proximal loop of the jejunum after distal gastrectomy. A gastrojejunostomy is preferred over a gastroduodenostomy in cases in which only a small amount of remnant stomach is left because a larger portion of the stomach is removed due to a tumor located higher in the stomach. A gastrojejunostomy is also preferred when a tumor lesion is close to the pylorus ring of the stomach or when an ulcer is identified at the duodenal bulb. Unlike gastroduodenostomy reconstruction, gastrojejunostomy is always possible without unwarranted tension after anastomosis. The anastomosis can be performed manually or mechanically with a linear stapling device.

Gastrojejunostomy can be performed at the jejunal loop either behind the transverse colon (retrocolic) or in front of it (antecolic). While antecolic anastomosis is preferred because it is technically easier, both show similar long-term outcomes [9].

After resection of the stomach, gastrojejunostomy can be performed in a manner in which the remnant stomach is anastomosed to the antimesenteric side of the jejunum. Hand-sewn anastomoses are classically performed in an end-to-side fashion at the stump of the remnant stomach. On the other hand, mechanical anastomosis with a linear stapler is performed side to side in the greater curvature of the stomach. As end-to-side anastomosis allows for a greater range of stomach resection than side-to-end anastomosis, end-to-side hand-sewn anastomosis is preferred in cases of a tumor located higher in the stomach and of a small remnant stomach.

Surgical Technique

Here, the basic antecolic mechanical gastrojejunostomy is described. The side-to-side gas-

trojejunostomy can be performed using linear staplers. For mechanical anastomosis, the jejunal loop measuring approximately 10–15 cm from the ligament of Treitz is brought up to the stomach in an antecolic position after resection of the stomach. To create an isoperistaltic anastomosis, the afferent loop in the jejunum is fixed at the proximal part of remnant stomach, with the efferent loop at the stump. Thus, biliopancreatic secretions are emptied to efferent loop in direction because it is a dependent portion.

Anastomosis may be performed first after retrieval of the tumor specimen or before resection of the stomach. To begin, small holes are created at a proper site along the greater curvature of the stomach and the antimesenteric border of the jejunum. A linear stapler is then placed between the remnant stomach and jejunum, approximated, and then fired to achieve anastomosis (Fig. 9.5a). Following this procedure, gastric transection is performed using linear staplers (Fig. 9.5b). To finish, the common entry hole is closed with a single layer of running suture or using a linear stapler.

Roux-en-Y Gastrojejunostomy

Being increasingly performed, Roux-en-Y anastomosis after distal gastrectomy seeks to improve postoperative complications by preventing bile gastritis after vagotomy. Several studies have

shown that this reconstruction method yields better long-term outcomes in terms of clinical symptoms and postoperative endoscopic findings [10, 11]. For these reasons, many surgeons prefer Roux-en-Y gastrojejunostomy for reconstruction after distal subtotal gastrectomy.

Surgical Technique

To begin the Roux-en-Y gastrojejunostomy, the jejunum, at a length 20–30 cm distal to the ligament of Treitz, is prepared as a Roux limb, transected using a linear stapler, and brought to the greater curvature of the remnant stomach via an antecolic route without any tension. A gastrotomy is then created at the distal edge of the greater curvature, and a small incision is made along the antimesenteric side of the jejunum, 6 cm from the stump, for side-to-side anastomosis. The linear stapler is inserted through enterotomies approximated along the edges of the stomach and jejunum, and the posterior wall of the stomach and the antimesenteric side of the jejunum are anastomosed by firing the stapler. The common enterotomy is closed in a single-layer fashion using a running suture or a linear stapler. Side-to-side or end-to-side jejunojunctionostomy can then be performed at a length along the jejunum of approximately 25 cm from the gastrojejunostomy with a hand-sewn technique or stapled anastomosis (Fig. 9.6).

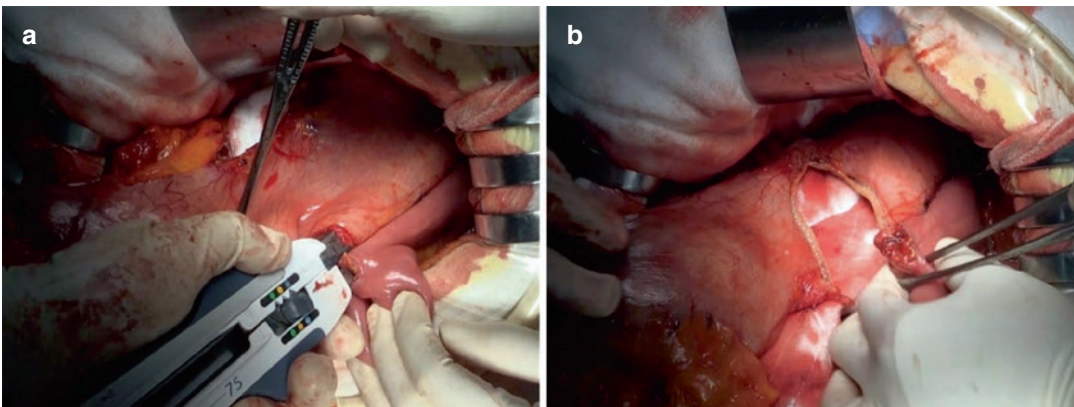


Fig. 9.5 Side-to-side gastrojejunostomy with a linear stapler. (a) A linear stapler is placed between the remnant stomach and jejunum then achieve anastomosis. (b) The stomach is transected with linear staplers, and the common entry hole is closed

Reconstruction After Total Gastrectomy

Roux-en-Y Esophagojejunostomy

Roux-en-Y reconstruction is a simple, well-codified method for achieving anastomosis after total gastrectomy. Recently, more complex constructions have been described, with the goals of preserving duodenal passage, creating a reservoir for ingested meals, and preventing reflux of biliopancreatic secretions [12]. In addition to restoring continuity

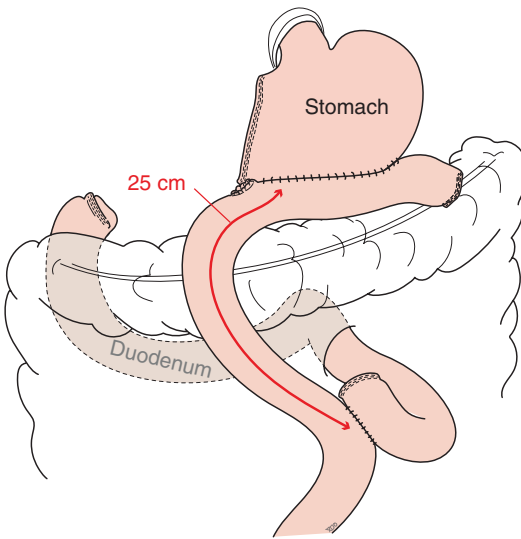


Fig. 9.6 Completed Roux-en-Y reconstruction after distal subtotal gastrectomy

of the digestive tract, these attempts seek to retain the nutritional status and to improve the quality of life of patients after gastrectomy. Notwithstanding, Roux-en-Y reconstruction is easy to perform and the most widely used procedure.

Surgical Technique

After the whole stomach is removed, a purse-string suture is applied at the stump of the esophagus as soon as possible to prevent shrinkage of the distal esophagus. An anvil with a diameter of 25–28 mm is carefully inserted into the esophagus. Following anvil placement at the distal esophagus, the purse-string suture is tied.

To prepare the jejunal loop, an appropriate area of the jejunum is transected distal to the ligament of Treitz while identifying the mesenteric vessel arcade. For esophagojejunostomy, the jejunal loop must be long, mobile, and well vascularized to reach the esophagus without tension.

In general, an esophagojejunostomy is created in an end-to-side fashion, bringing the jejunal loop in front of the transverse colon up to the esophagus. A circular stapler is inserted through the transected end of the jejunum, allowing the central rod to emerge in the antimesenteric wall at about 5 cm from the end of the jejunal loop (Fig. 9.7a). After attaching the anvil to the central rod, the stapler device is fired, and an end-to-side anastomosis is completed. The open end of the jejunal loop is then closed by a linear stapler (Fig. 9.7b).

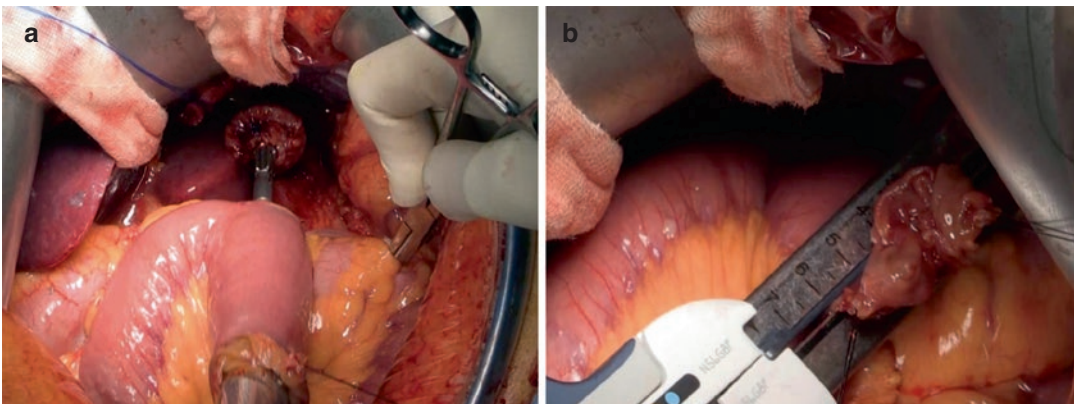


Fig. 9.7 Esophagojejunostomy with a circular stapler. (a) The circular stapler is inserted through the transected jejunal end such that the central rod penetrates the

antimesenteric border of the jejunal loop. (b) The open end of the jejunal loop is closed by a linear stapler

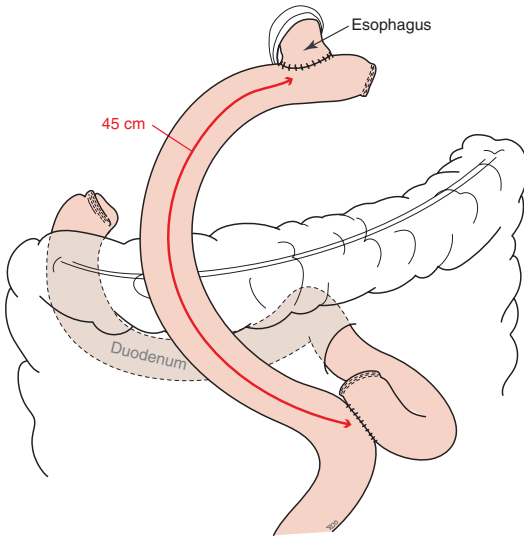


Fig. 9.8 Completed Roux-en-Y reconstruction after total gastrectomy

After the esophagojejunostomy, a jejunojejunostomy is performed to maintain biliopancreatic passage. Anastomosis between the proximal jejunum and the efferent limb is made in an end-to-side fashion at 15–20 cm distal to the ligament of Treitz. The length of the jejunal loop between the esophagojejunostomy and jejunojejunostomy should measure 45 cm to prevent regurgitation. A hand-sewn technique or a stapled anastomosis can be used (Fig. 9.8).

Summary

Gastrointestinal tract reconstruction after gastrectomy has evolved with the development of surgical techniques and stapling devices. A lot of effort has been exerted to make anastomosis safe, feasible, and functionally fit for patients after conventional open gastrectomy. Surgeons should consider surgical and oncological stability and quality of life by ensuring nutritional intake after surgery, although optimal or ideal reconstruction method is not clearly defined.

Disclosures This work was not supported by external or grant funding. None of the authors reports commercial associations or financial involvement that pose a conflict of interest in connection with the submitted article.

References

1. Information Committee of Korean Gastric Cancer A. Korean gastric cancer association nationwide survey on gastric cancer in 2014. *J Gastric Cancer*. 2016;16(3):131–40. <https://doi.org/10.5230/jgc.2016.16.3.131>.
2. Lee JH, Hyung WJ, Kim HI, Kim YM, Son T, Okumura N, Hu Y, Kim CB, Noh SH. Method of reconstruction governs iron metabolism after gastrectomy for patients with gastric cancer. *Ann Surg*. 2013;258(6):964–9. <https://doi.org/10.1097/SLA.0b013e31827eebc1>.
3. Kim BJ, O'Connell T. Gastroduodenostomy after gastric resection for cancer. *Am Surg*. 1999;65(10):905–7.
4. Nance FC. New techniques of gastrointestinal anastomoses with the EEA stapler. *Ann Surg*. 1979;189(5):587–600.
5. Hori S, Ochiai T, Gunji Y, Hayashi H, Suzuki T. A prospective randomized trial of hand-sutured versus mechanically stapled anastomoses for gastroduodenostomy after distal gastrectomy. *Gastric Cancer*. 2004;7(1):24–30. <https://doi.org/10.1007/s10120-003-0263-2>.
6. Takahashi T, Saikawa Y, Yoshida M, Otani Y, Kubota T, Kumai K, Kitajima M. Mechanical-stapled versus hand-sutured anastomoses in billroth-I reconstruction with distal gastrectomy. *Surg Today*. 2007;37(2):122–6. <https://doi.org/10.1007/s00595-006-3361-z>.
7. An JY, Yoon SH, Pak KH, Heo GU, Oh SJ, Hyung WJ, Noh SH. A novel modification of double stapling technique in Billroth I anastomosis. *J Surg Oncol*. 2009;100(6):518–9. <https://doi.org/10.1002/jso.21368>.
8. Kim YN, Aburahmah M, Hyung WJ, Noh SH. A simple method for tension-free Billroth I anastomosis after gastrectomy for gastric cancer. *Transl Gastroenterol Hepatol*. 2017;2:51. <https://doi.org/10.21037/tgh.2017.05.08>.
9. Umasankar A, Kate V, Ananthakrishnan N, Smile SR, Jagdish S, Srinivasan K. Anterior or posterior gastro-jejunostomy with truncal vagotomy for duodenal ulcer—are they functionally different? *Trop Gastroenterol*. 2003;24(4):202–4.
10. Kojima K, Yamada H, Inokuchi M, Kawano T, Sugihara K. A comparison of Roux-en-Y and Billroth-I reconstruction after laparoscopy-assisted distal gastrectomy. *Ann Surg*. 2008;247(6):962–7. <https://doi.org/10.1097/SLA.0b013e31816d9526>.
11. Inokuchi M, Kojima K, Yamada H, Kato K, Hayashi M, Motoyama K, Sugihara K. Long-term outcomes of Roux-en-Y and Billroth-I reconstruction after laparoscopic distal gastrectomy. *Gastric Cancer*. 2013;16(1):67–73. <https://doi.org/10.1007/s10120-012-0154-5>.
12. Chin AC, Epat NJ. Total gastrectomy: options for the restoration of gastrointestinal continuity. *Lancet Oncol*. 2003;4(5):271–6.