Chapter 1

Reconstructive Procedures after Total Gastrectomy for Gastric Cancer

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Abstract

Till this day, there are more than 60 described surgical procedures of the intestinal reconstructions after a total gastrectomy. In 1897, Schlatter reconstructed the digestive tract by creating a termino-lateral esophagojejunostomies that was the first successful total gastrectomy. Many of the total gastrectomy pioneers did the reconstruction by esophagoduodenostomy or by forming a loop esophagojejunostomy. The main reconstruction modalities after a total gastrectomy are a restitution of the intestinal continuity, without a preservation of the duodenal food passage (esophagojejunostomy with a Roux-en-Y configuration) and a restitution of the intestinal continuity with a preservation of the duodenal passage (esophagojejunostomy with Roux-en-Y configuration and forming of the lateral-terminal jejunoduodenal anastomosis double tract and jejunal interposition by Longmire). The surgeries in these categories can be combined with forming of an enteral pouch or a stomach reservoir which would simulate a reservoir of a normal intact stomach. The ideal reconstruction procedure after total gastrectomy should replace all lost functions of the stomach. Preservation of duodenal transit with replacement of the jejunal segment, the so-called physiological route, is now believed to be preferential for postoperative nutritional condition, prevents persistent postgastrectomy syndrome, and improves the quality of life. Reconstructive procedures which allow duodenal passage should be regarded as a key to physiological reconstruction.

Keywords: gastric cancer, total gastrectomy, reconstructive procedures, nutritive status, quality of life

1. Introduction

1.1. Background and history

The development of stomach surgery is one of the most fascinating chapters in the history of surgery. The era of surgical treatment of gastric cancer (GC) began with the first successfully performed distal subtotal gastrectomy in 1881 by Theodor Billroth. The first total gastrectomy (TG) was probably carried out by Conner in 1887 in Cincinnati, but the patient died [1]. The first successful TG due to GC was performed by Carl Schlatter in Switzerland in 1897 [2]. The patient was a 56-year-old woman who lived less than 14 months and died from secondary metastatic deposits in the liver. Krönlein first introduced the term TG in 1898. Charles Brigham of San Francisco in the same year performed the first successful TG in the United States to create an esophagoduodenal anastomosis, using the Murphy button [3]. The high postoperative mortality in TG performed in the 1940s, was reduced by the introduction of antibiotics, the use of blood transfusions, and the improvement of anesthetics and surgical techniques. During this period TG was proposed as a routine surgical treatment for all resectable GC. This approach was later abandoned due to inability to improve the survival rate, high operative mortality, and increased incidence of undesirable postoperative effects after TG [4]. By 1980, TG was rarely performed and was only applied in highly selective cases [5]. The contribution of these and many other authors during the nineteenth century provided a basis for modern surgical treatment of patients with GC. From the beginning of the 1940s, radical resection, including regional lymphadenectomy for all GC, was recommended [6]. Operations of such extensions, at that time, were burdened with unacceptable morbidity and mortality. To date, efforts have been made to define the optimal extent of resection, lymphadenectomy, and reconstruction.

Digestive tract reconstruction after TG was mostly performed initially by creating a direct anastomosis of the esophagus with a duodenum or with a jejunum loop. The inevitable problem of billiard regurgitation was solved in 1909 by adopting the creation of the Roux-en-Y (RY) type of esophagojejunostomy configuration [7]. A large number of surgeons continued to perform jejunum loop reconstruction until 1947, when Orr promoted the concept of end-to-end anastomosis using the RY-type configuration of esophagojejunostomy, which is now a standard procedure for reconstruction after TG [8].

2. Reconstructive procedures after total gastrectomy

2.1. Concept of reconstructive procedures after total gastrectomy

During the first successful TG in 1897, Schlatter reconstructed the digestive tract by creating end-to-side esophagojejunostomy [2]. Many of the pioneers of TG performed reconstruction with esophagoduodenostomy or formed loop esophagojejunostomy [7, 9]. High operational risk and frequent malnutrition observed during the postoperative period gave TG an unfavorable reputation. The loop esophagojejunostomy technique was modified by Hoffman in 1922.

He added a small side-to-side jejunojejunostomy between two ends of the jejunum loop [10]. This provided partial bypass to the duodenal content and reduced the frequency of alkaline reflux esophagitis. The major immediate postoperative problem after TG concerned the integrity of anastomosis on the esophagus. Later postoperative problems were associated with reconstruction and nutritional status and quality of life that is more affected by the aspects of reconstruction than the anastomosis on the esophagus itself.

To date, more than 60 different reconstructive procedures (RP) of intestinal reconstructions have been described after TG which were, and are now, in use in surgical institutions [11, 12]. The main modalities of reconstruction after TG are restoration of intestinal continuity, without preserving duodenal passage (DP) of food (esophagojejunostomy with RY configuration) and restoration of intestinal continuity with the preservation of DP (esophagojejunostomy with RY configuration and formation of side-to-end jejunoduodenostomy double tract (DT) and Longmire's longitudinal interposition). Operations in these categories can be combined with the formation of an enteral pouch or a gastric reservoir that simulates the function of the reservoir of the normal intact stomach. The RP with pouch and neo-stomach formation have been developed to provide food tanks, with the goal of preserving duodenal transit and providing the anatomy and physiology of the digestive tract. Advantages and disadvantages of these RP continue to be the subject of discussion due to the existence of contradictory results from various studies.

2.2. Reconstructive procedures without duodenal passage preservation after total gastrectomy

2.2.1. Esophagojejunostomy Roux-en-Y configuration

The RY configuration of esophagojejunostomy has become the most widely used method of reconstructing intestinal continuity around the world [13, 14]. This precious intestinal configuration is now used in reconstruction and drainage of the stomach, esophagus, and pancreatic-biliary tree, as well as in bariatric surgery [15].

The procedure was inaugurated by César Roux (1857–1934), a Swiss surgeon and professor, in 1893 [16]. Initially, after TG, the jejunum loop was placed in a retrocolonic fashion. RY configuration of esophagojejunostomy immediately became objectionable due to a recurrent complication, that is, the potential formation of ulceration on the jejunal anastomosis [7]. The idea of using the RY configuration for reconstruction after TG was introduced early, in 1909 [9]. Despite Reid's 1925 report on the use of this RP, most of the surgeons of that time continued to prefer loop esophagojejunostomy with an anastomosis between two jejunum loops, thereby preventing the alkaline reflux of duodenal content and consecutive esophagitis [17]. In 1940, several papers again drew attention to the Roux-en-Y intestinal configuration, and in 1947, Orr reintroduces end-to-side esophagojejunostomy in creating a RY configuration (**Figures 1–3**) [8].

The primary factor in creating RY is the preservation of adequate vascularization. Jejunum vascularization comes from superior mesenteric artery, aorte abdominalis' branch. Superior mesenteric artery branches for vascularization of the intestinum are formed on its left side, and their number is variable 13–21, for vascularization of jejunum 3–7 (average 5) and 8–17 (average 11) for the ileum. Intestinal arteries branch in the mesenterium, and through the

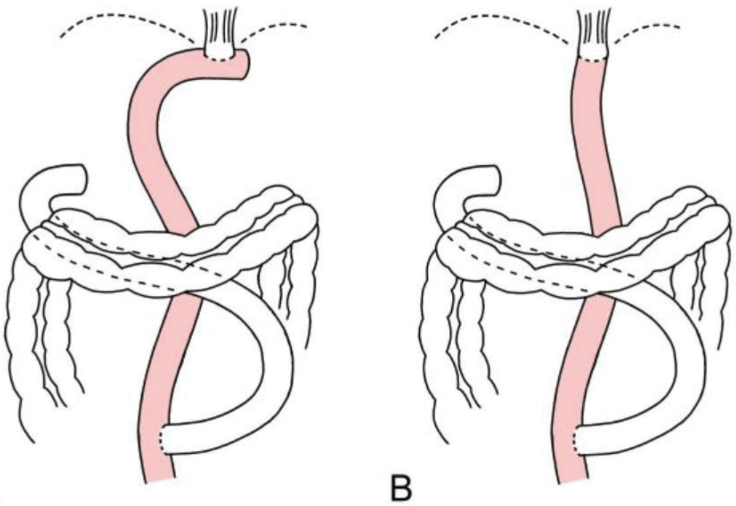

Figure 1. Schematic representation of reconstruction after TG without DP with a standard RY configuration with the creation of (A) end-to-side or (B) end-to-end esophagojejunostomy.

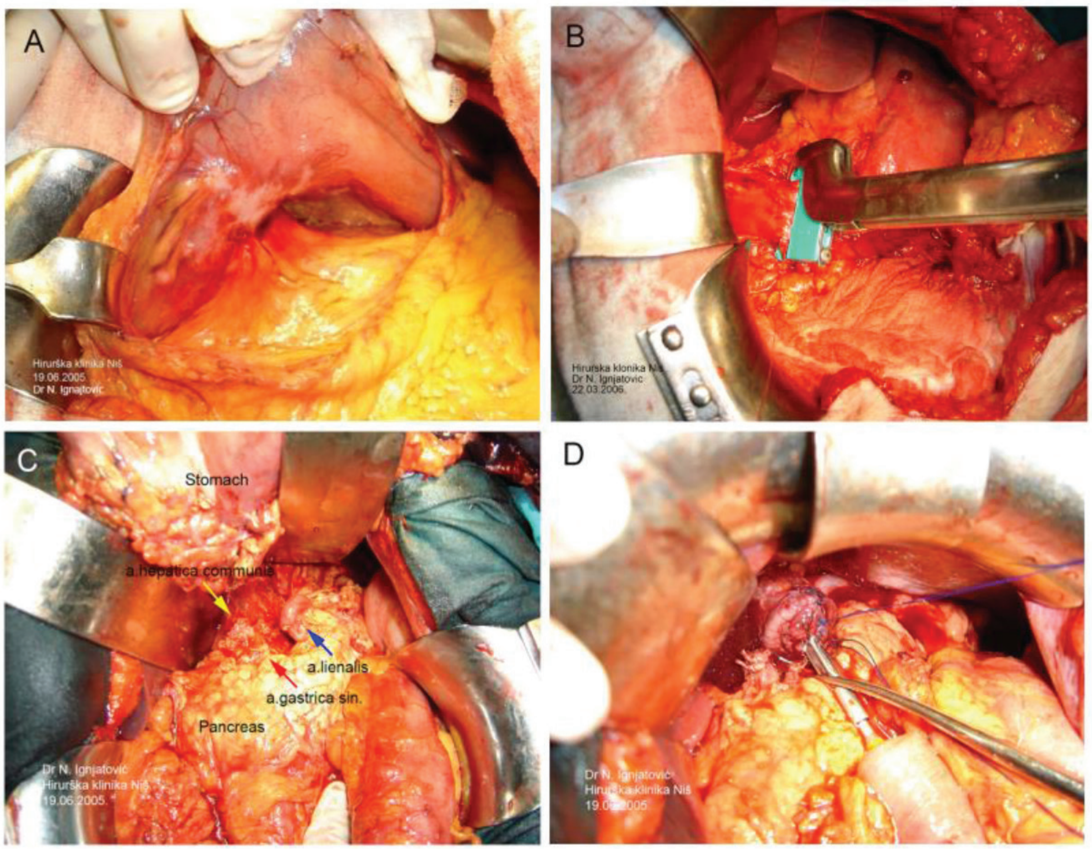

Figure 2. A representation of the operative reconstructive technique after TG without the preservation of DP by the RY configuration on the material of the author of this chapter: (A) diffuse GC of the antropyloric region of the stomach; (B) closure of the duodenal residue using a linear stapler TA 30; (C) lymphovascular dissection of the plexus coeliacus, a.hepaticae communis (yellow arrow), a.gastricae sin. (red arrow), and a.lienalis (blue arrow); (D) bringing the jejunum loop to the approximation with distal esophagus and forming end-to-end esophagojejunostomy with circular stapler CEEA Ø25 mm.

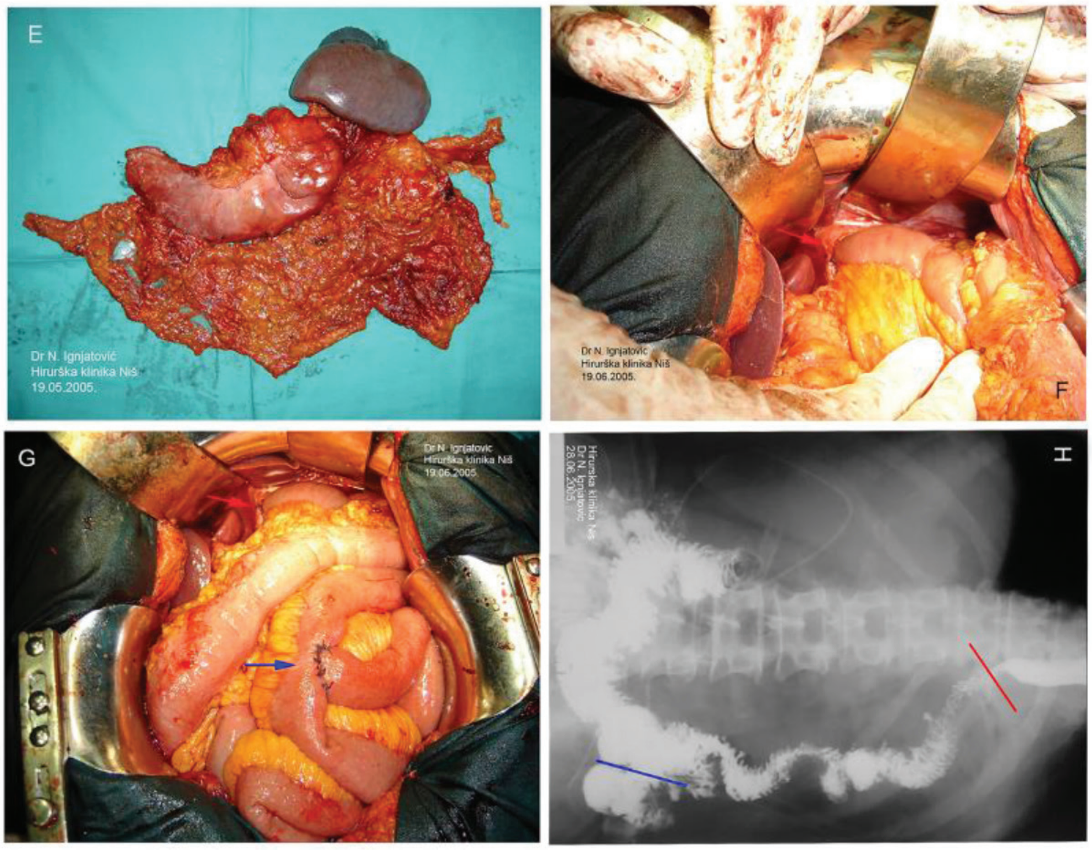

Figure 3. A representation of the operative reconstructive technique after TG without the preservation of DP by the RY configuration on the material of the author of this chapter: (E) specimen of the stomach, spleen, and large omentum, (F) formed end-to-end esophagojejunostomy (red arrow), (G) formed end-to-side jejunojejunostomy with Roux Y anastomosis (blue arrow), (H) contrast radiography: sufficient anastomosis of esophagojejunostomy (red line) and end-to-side jejunojejunostomy with Roux-en-Y anastomosis (blue line).

vascular arcades of the I–IV orders, they connect to one another before the separation of terminal vasa recta entering the small intestine on the mesenteric edge. Arcades are more developed in the proximal part of the intestinum. They are arranged in three rows, so that arcades allow good vascularization and formation of isolated segments. Vasa recta are terminal type, and each such blood vessel vascularizes about 0.5 cm of the intestinal wall [18]. There are long and short arteriolae rectae. The long arteriole recta are divided into two branches, anterior and posterior. Entering the jejunum wall, each of those branches vascularizes specific area of the jejunum wall and they anastomose on the antimesenteric edge. The antimesenteric edge has the weakest vascularization and therefore is susceptible to the occurrence of dehiscence after the creation of anastomosis. Short arteriolae rectae, which can directly originate from the paraintestinal arterial arcades, or from other arterioles, are intended for the vascularization of the mesenteric intestine [19]. The regularly firmed distal end of the RY jejunum loop was mobilized by dividing two vasa recta [7].

The main goal in choosing the reconstruction of the esophago-intestinal continuity RY configuration after TG without preserving DP is to prevent the formation of biliary reflux into the esophagus. Biliary contents can cause damage to the esophagus mucous membranes, or alkaline esophagitis [20]. In 1924, the proposed RY loop length was only 7.5 cm, but it increased steadily and significantly over time. Wells proposed in 1956 a length of 20–25 cm. The smallest length of the RY loop of 35 cm proved to be capable of preventing the formation of alkaline biliary reflux [21]. The vast majority of experienced surgeons today use RY loop length of 40–60 cm. The wide application of the RP RY configuration is attributed to its simplicity because it uses a minimum number of anastomosis.

In order to adequately replace the stomach and increase the reservoir of the jejunal substituent, the RP RY configuration was modified by Hunt and later by Lawrence by creating a jejunal pouch [22, 23]. Several modalities of the reconstruction of the jejunal pouch include forming formations J-pouch, Ω-pouch, S-pouch, and an aboral pouch [22–25].

Forming the Hunt-Lawrence pouch, the jejunum in length is brought up posterior to the transverse colon. The distal portion of the divided afferent limb, with approximate length of 15–20 cm, is placed posterior to the transverse colon, plicated to the proximal efferent limb and retained by traction sutures. A small stab wound is formed at the midportion of each limb of plicated loops, and a linear stapler is introduced through it, while side-to-side anastomoses are created upward and down along the antimesenteric borders. Following the inspection of the anastomotic lines for complete hemostasis, a circular stapler (stapler CEEA) is introduced through the central hole of the pouch for the esophagojejunostomy.

The hole is closed transversely with a running suture following the withdrawal of the circular stapler. Intestinal continuity is then reestablished by hand in RY fashion, about 20–30 cm below the pouch (**Figures 4** and **5**) [26–28].

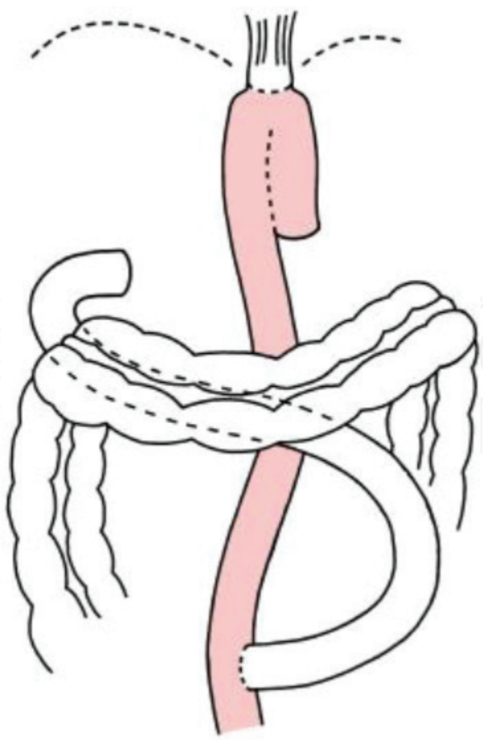

Figure 4. Schematic representation of reconstruction after TG without DP with a the Hunt-Lawrence pouch.

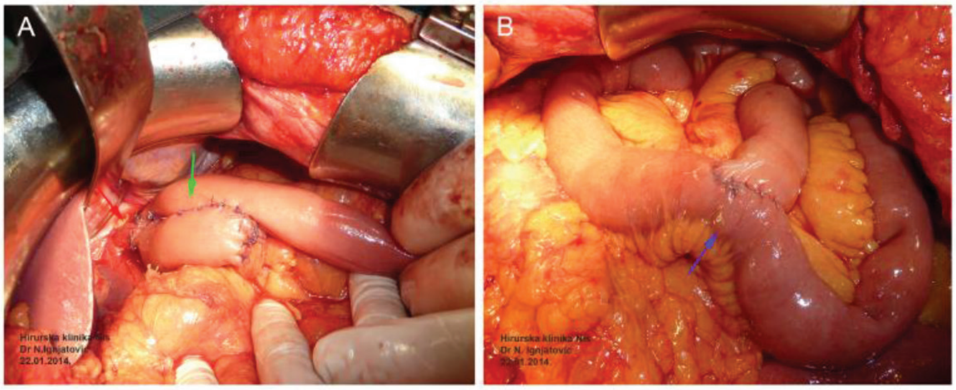

Figure 5. A representation of operative reconstructive technique after TG without DP preservation by the pouch configuration on the material of the author of this chapter: (A) end-to-side esophagojejunostomy is formed (red arrow) and longitudinal side-to-side jejunojejunostomy (green arrow); (B) end-to-side jejunojejunostomy is created with Roux-en-Y anastomosis (blue arrow).

The use of pouch reconstruction provides a reduction in the occurrence of dumping syndrome, postoperative weight development, regurgitation of bile, and insufficient size of indigested meals [27].

2.3. Reconstructive procedure with duodenal passage preservation after total gastrectomy

2.3.1. Esophagojejunostomy Roux-en-Y double tract configuration

The RP using the jejunum after TG with the preservation of DP is the esophagus RY configuration of the DT in the establishment of esophagoduodenal continuity. The description of operational technique was first provided in 1965 by Japanese authors Kajitani and Sato [29]. In this RP after TG, the duodenum in the first act remains open, and after the creation of an esophagojejunal anastomosis according to the principles of the operational technique of carrying RY configurations with a duodenum duct, an additional distal end-to-side jejunoduodenal anastomosis is established at about 20 cm distal from created esophagojejunal anastomosis [30]. Today's modification of the originally described technique is the creation of end-to-end duodenal anastomosis at 35–40 cm distal from esophagojejunal anastomosis [31]. Creation of distal termino-lateral jejunojejunal anastomosis is performed according to the principles of the original RY configuration of esophagojejunostomy at about 60 cm from end-to-side or end-to-end esophagojejunal anastomosis (**Figure 6**). Creation of esophagojejunal anastomosis is performed by a manual two-layer suture technique or the use of the CEEA circular surgical stapler, while the creation of jejunoduodenal and jejunojejunal anastomosis is performed by a manual two-layer suture technique (**Figure 7**) [31, 32]. The RY configuration of the DT is now applied in some institutions in Japan.

2.3.2. Esophagojejunostomy with the interposition of the jejunal segment by Longmire

RP using the jejunum after TG with the preservation of DP is the interposition to isoperistaltics free jejunal segment according to the Longmire method in establishing esophagoduodenal

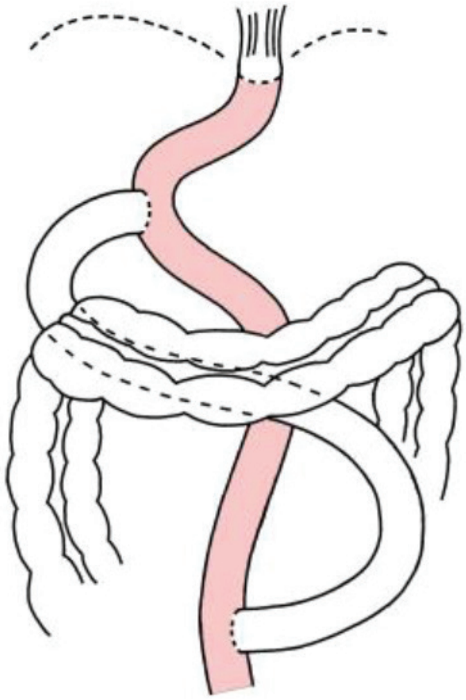

Figure 6. Schematic representation of reconstruction after TG with DP with a RY configuration of DT with the creation of end-to-end esophagojejunostomy and side-to-end jejunoduodenostomy.

continuity. After Seo's first attempt in 1941, the inauguration of this RP after TG was performed by Longmire in 1951, even though the idea was proposed 3 years earlier by Saccharow [33–36].

Hays interposed a triple jejunal pouch between the esophagus and duodenum in 1953 [37]. Gütgemann recommended the interposition of a very long jejunum loop of at least 30 cm in length to increase the reservoir function of the inserted jejunal pouch [38]. Poth in 1966 favored the interposition of an antiperistaltic jejunal pouch in various combinations [39]. In 1972, Schrader and Koslowski interposed an additional 10 cm shorter antiperistaltic jejuna segment, which anastomosed distally from Longmire's reconstruction [40]. They favored the view that a short anisoperistaltic interposition of the neuromuscular segment could slow down the gastric emptying and simulate neopylorus [40, 41]. In 1982, Cuschieri created a large jejunum pouch interposed between the esophagus and the duodenum [42]. Nakane and Schwarz recommended Hunt-Lawrence Shaped pouch in 1990, interposed between the esophagus and duodenum [27, 43]. The reconstruction of the ileocecal interposition described by Lee and Hunnicutt is also in use with the basic idea of replacing the ileocecal valve as a substitute for the cardiac sphincter [44, 45]. This reconstruction provides anatomic barrier between the neo-stomach and the esophagus to prevent biliopancreatic reflux.

The original RP after TG by Longmire implies the establishment of an esophagoduodenal continuity using a previously fully mobilized intestinal segment on a free vascular sponge ante- or in a retrocolonic fashion by using an isolated first jejunal segment of 15 cm in length (**Figure 8**) [34].

This type of reconstruction is also known as the Beal-Longmire operation. Today, after the mobilization of the first segment of the jejunum in the length of at least 25–35 cm and with a longer

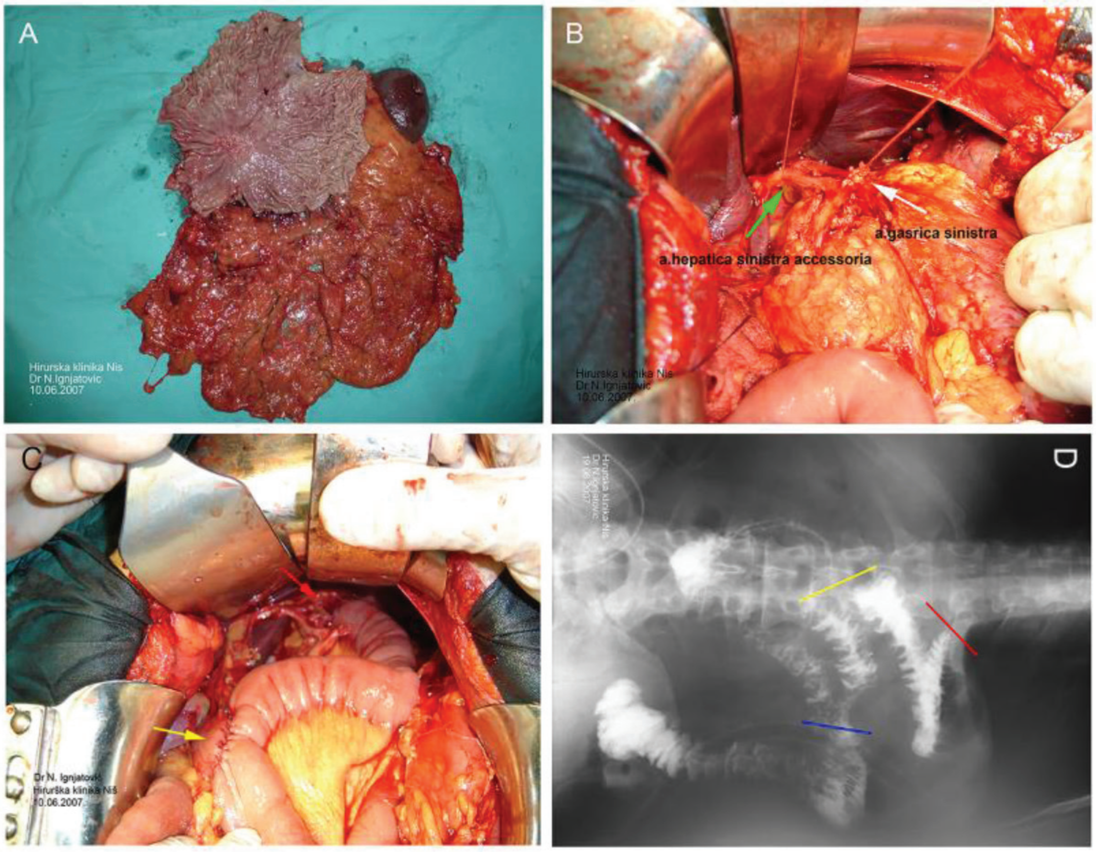

Figure 7. A representation of the operative reconstructive technique after TG with the preservation of DP by the RY configuration on the material of the author of this chapter: (A) specimen of the stomach (stomach open by large curvature), spleen, and large omentum, (B) arterial variation of branching a.hepaticae sinistrae accessoriae (yellow arrow) from a.gastricae sinistrae (white arrow), (C) formed end-to-end esophagojejunostomy (red arrow) and side-to-end jejunoduodenostomy (yellow arrow), (D) contrast radiography: sufficient anastomosis of esophagojejunostomy (red line), jejunoduodenostomy (yellow line), and jejunojejunostomy with Roux-en-Y anastomosis (blue line).

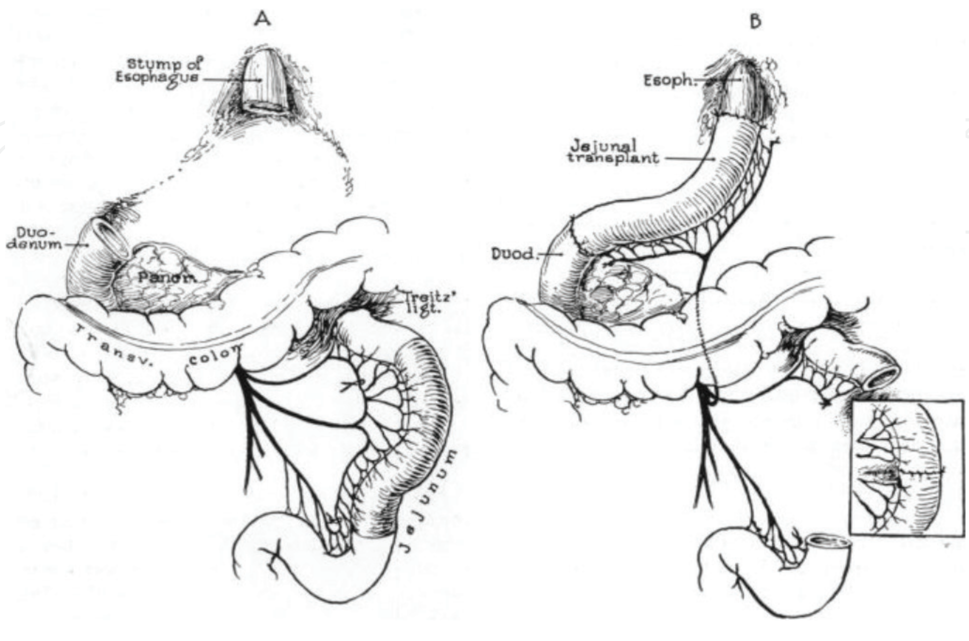

Figure 8. Original schematic representation of reconstruction after TG with DP by Longmire [34].

mesentery, both of these structures have retrocolonic transmesocolic position and they make anastomosis with the esophagus and duodenum in the isoperistaltic position. Modification by Schreiber and Gütgemann uses the jejunum segment in a length of 40 cm [38, 46]. Creating a proximal termino-lateral or end-to-end esophagojejunostomy is performed by a manual dual-layer technique or the use of a circular stapler (stapler CEEA), while a distal end-to-end jejuno-duodenostomy is performed by a manual two-layer mint technique. It is very important that the torsion and tension of the mesenterium be avoided in creating an isolated jejunum segment. The continuity of the resected proximal end of the first segment and the second segment of the jejunum with the application of a two-layer manual knot tying technique is established with end-to-end jejunojejunostomy (**Figures 9** and **10**).

In 1952, Longmire and Beal stated that all patients with reconstructed isolated jejunal segment after 4 months of follow-up were able to restore regular nutrition and preoperative body weight. In all patients, there was no early onset of pyrosis and epigastric pain [34]. Longmire also states that after adequate mobilization of the duodenum and avoidance of tension on the esophageal and jejunoduodenal anastomosis itself and the normalization of food passage through the duodenal segment, the benefits of interposition with the jejunal segment have been achieved: increasing the capacity of the isolated jejunal segment with the dilatation of the intestinal wall itself and the smaller regurgitation of biliary and intestinal contents [34]. Longmire points out that with this RP, there was no significant increase in operative risk during the performance of total gastrectomy, that is, the risks of vascular ischemia that are present in the transposition of the ileum and ascendant colon were eliminated. The reconstruction

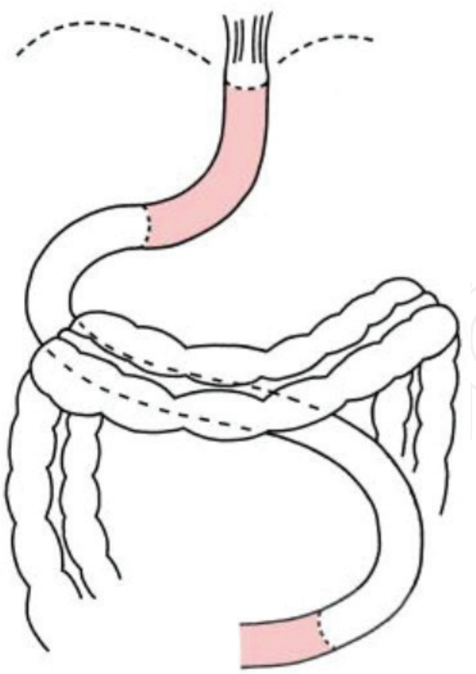

Figure 9. Schematic representation of reconstruction after TG with DP by Longmire, by interposition of jejunal segment with the creation of end-to-end esophagojejunostomy and end-to-end jejunoduodenostomy.

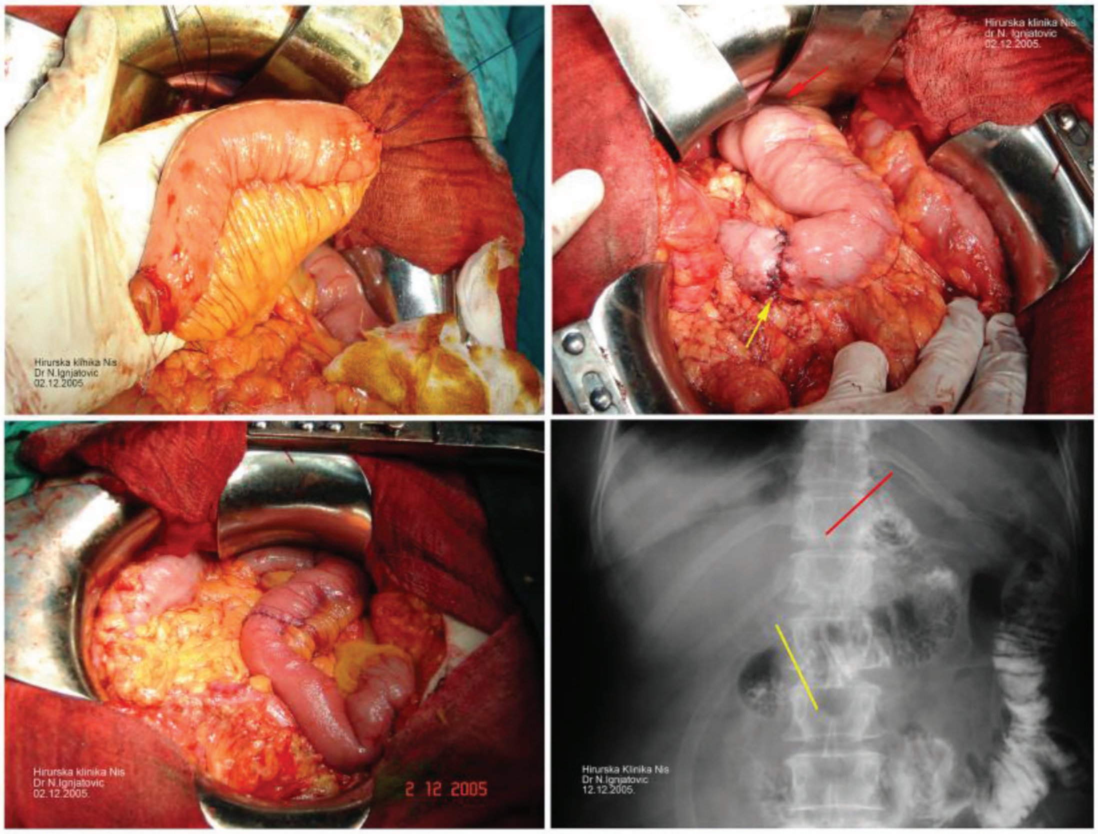

Figure 10. A representation of the operative reconstructive technique after TG with the preservation of DP by Longmire on the material of the author of this chapter: (A) isolated free jejunal segment on the vascular retina placed in a retrocolonic fashion, (B) formed end-to-end esophagojejunostomy (red arrow) and end-to-end jejunoduodenostomy (yellow arrow), (C) formed end-to-end jejunojejunostomy, (D) contrast radiography: sufficient anastomosis of esophagojejunostomy (red line) and jejunoduodenal anastomosis (yellow line).

of the intestinal continuity with the Longmire's jejunal interposition provides theoretical advantages over the reconstruction of the RY configuration [31].

3. Advantages of reconstructive procedures with preservation duodenal passage after total gastrectomy

The survival rate after TG in GC has been improved thanks to early diagnostics and advanced operating techniques. Many reconstructive techniques after TG have been developed in efforts to prevent postgastrectomy syndrome and preserve the physiological nutritional status of patients and rapid return to normal daily preoperative activities [47]. At the same time, the procedure for gastric reconstruction should be technically easily performed with minimal postoperative complications. RP that meet these requirements are those with the preservation of DP RY configuration of DT, Longmire procedure for the esophagus interposition of the jejunal segment, as well as the procedure of interposition with the jejunal pouch (e.g., Hunt-Lawrence pouch) [31].

Following a RP, the RY configuration of DT, food on the intestinal digestive pathway passes the duodenum and makes the intestinal wall distension by stimulating the ganglion cells of the myenteric and submucosal plexus, thereby leading to an adequate regulation of intestinal motility. This physical contact with the intestinal mucosa stimulates a large number of cells to produce peptides with hormonal, paracrine, and neurocrine effects. Chymus entering the duodenum primarily stimulates secretion: secretin, cholecystokinin, cholecystokinin-pancreozymin, enteroglucagon, vasoesthetic peptide, motilin, somatostatin, gastric inhibitory peptide, intestinal gastrin, serotonin, insulin, insulin glucagon, P substance, neurotensin, and enkephalin. These numerous polypeptides have a complex initial and stimulating regulatory role in the food digestion phase: bile release, gallbladder contact stimulation, Oddi sphincter relaxation, pancreatic juice secretion, vasodilation of the blood vessels of the mesentery of the intestinum and portal vein, intestinal secretion and peristalsis, absorption of food, secretion of insulin, and inhibitory effects in the interdigestive phase [48]. Kelly and authors suggest an explanation of the cause of the secondary deficiency of pancreatic secretion, inadequate stimulation, insufficient microvasculus of the heme and pancreatic enzymes, and weakened dietary fat assimilation in the new conditions of the absence of DP after TG [49]. Some non-randomized, retrospective studies have demonstrated the superiority of the performance of the jejunal interposition on the RY configuration of esophagojejunostomy when it comes to nutrition and the ability of postoperative rehabilitation [50–52]. However, due to a terminal vascular stem, the interposition of the jejunal segment as a free intestinal transplant between the esophagus and the duodenum is considered a high-risk procedure compared to other RP [53].

The nutritional status of patients after TG is changed. In many patients, calorie intake is inadequate, thus making it impossible to regain preoperative body weight. The causes of nutritional status disorders are the lack of appetite or problems caused by abnormal food passage. In order to maintain an ideal nutritional status, i.e., to preserve the integrity of the tissue and the function of the cells of the organism, nutrition requires essential nutrients and energy materials, regularity of food intake, regularity of passage and digestion, adequate resorption, and utilization of nutrients. Loss of body weight after TG is temporary and represents a significant postoperative problem in asthenic patients with GC. The mechanism of body weight loss includes malabsorption, malnutrition, and the consumption of material elements due to tissue restitution. It is known that the state of nutrition of the patient correlates with morbidity and mortality. Malnutrition usually manifests itself as a weight loss (15–24% of preoperative weight), which many authors cite in their studies in patients after TG [54]. If ingested food does not pass through the duodenum, an adequate mixture of the chymus with gallbladder and pancreatic enzymes is not formed. Therefore, the mixing of chymus and gallbladder and pancreatic contents is delayed beyond the time required for proper digestion in the distal parts of the jejunal Roux loop beneath the anastomosis with a jejunum in reconstruction without DP. Relative pancreatic insufficiency may also lead to malabsorption of patients in whom reconstruction excludes the passage of food through the duodenum [54]. Studies have shown that patients with TG who have undergone DP prevention have less loss of body weight and body mass index and have fewer symptoms as consequences of RP [55–58]. Fat and protein malabsorption occurs in over 50% of patients after total gastrectomy. In most patients, malabsorption of fat after TG is of doubtful clinical significance. The cause of steatorrhea after gastrectomy is most likely multifactorial: loss of digestive enzymes of the stomach, reduced stimulation of pancreatic and bile secretions, inappropriate or inadequate mixing of food with bile and pancreatic juice, increased bowel motility, and excessive bacterial colonization of the small intestine. Carbohydrate absorption can be reduced by excessive bacterial colonization and the use of nonmalignant carbohydrates [57].

Postgastrectomy sideropenia anemia is caused by iron-induced malabsorption that occurs after reconstruction with the circumvention of the duodenal segment in which its resorption normally occurs. The iron resorption disorder in patients following TG is due to gastric acid deficiencies that allow the passage of nonabsorptive Fe^{2+} into the absorbent Fe^{3+} form and the removal of the duodenum as the main site of absorption of iron from the passage of the chymus [55].

In a study by Bae and authors, there were very serious deficiencies of vitamin B_{12} in patients after TG. This indicates that parenteral substitution of vitamin B_{12} in gastrectomized patients is necessary due to inadequate absorption in the intestines. The serum level of vitamin B_{12} was significantly reduced after TG and is believed to be due to its deficiency in absorption. Bae also pointed out that anemia due to deficiency of vitamin B_{12} is a process that develops within a few years [54].

The term postgastrectomy bone disease describes bone disease after TG. It can occur as an osteomalacia or osteoporosis that is more pronounced than in normal physiological aging. Postgastrectomy bone disease is probably due to RP after TG in which the duodenum and proximal jejunum from food passage are excluded, since they are the major sites for the absorption of calcium in physiological conditions [59]. Calcium absorption is primarily performed in the duodenum and jejunum and depends on the level of vitamin D [60]. Accelerated transit of food through the intestinum also reduces calcium absorption time, while the presence of steatorrhea leads to the formation of insoluble calcium soaps that can contribute to calcium malabsorption [59].

Liedman reported in his study that a significant increase in alkaline phosphatase levels in patients after 3–10 years after TG, in a group of patients with a RY RP [61]. Heiskanen and authors have reported that the serum level of alkaline phosphatase has been used to detect postgastrectomic osteomalacia. In other prospective studies after partial gastrectomy and TG, normal and elevated serum levels of alkaline phosphatase were observed [62]. In a group of patients with reconstructed RY configurations in the study of Iivonen and authors, serum alkaline phosphatase activity increased significantly over the course of 3 postoperative years with a tendency to be higher than the group of patients with DP preservation [63].

Bassotti and authors were probably the first to examine the intestinal motility of the Roux loop after a complete gastrectomy by manometric route and concluded that patients with reconstruction of the Roux-en-Y configuration had significant motor abnormality in the Roux loop [64]. Sun and authors in their study claimed that the continuity of the gastrointestinal tract plays a key role in the coordination of intestinal motility [65]. Studies have shown that surgical manipulation of the gastrointestinal tract, in the form of resection followed by reanastomosis, results in intestinal motility disturbance [47, 64]. In support of this assertion, several studies suggest that the interruption of motility due to gastrointestinal resection is actually due to damage to the pacemaker for the gastrointestinal tract, i.e., interstitial cell of Cajal (ICC). The ICC is responsible for the creation and propagation of slow electrical waves that coordinate the stages of contraction of the intestine [65]. The entire problem of postgastrectomy symptoms may be attributed to accelerated intestinal transit. Fast transit results in accelerated glucose uptake, which causes increased insulin secretion. Accelerated transport of peptides and lipids gives an unusually large incentive to the secretion of cholecystokinin and stimulation of feedback regulation. In the end, there are abnormally high levels of gastrointestinal hormones and increased production of somatostatin. Excreted somatostatin has an inhibitory effect on GUT hormones, but this further reduces bowel motility and digestive juice production. This entire phenomenon becomes less significant in time due to the adaptation of the intestine [66].

Several studies have shown that the presence of postprandial hyperglycemia following TG reconstruction can indicate an abnormal glucose metabolism, possibly representing intolerance to glucose or diabetes at an early stage [43]. In relation to the type of RP, Schwarz and authors have found significantly higher levels of glucose in a patient with RY reconstruction, when there was no DP preservation in patients with pouch, as opposed to patients undergoing a RP in which DP was preserved. There was no development of pathological glucose tolerance in patients with established DP prevention [43]. Kalmár and authors have published significantly higher levels of postprandial glucose in patients with exclusion of DP RY reconstruction than the control group, thus supporting the hypothesis that the exclusion of DP disrupts homeostasis of glucose more than reconstruction with the preservation of DP [66]. Observing duodenal preservation, the glucose homeostasis disorder was significantly higher in patients with RY procedure [65].

With the standardization of TG performance due to GC, the survival period of operative patients has significantly increased and hence the possibility of postgastrectomy syndrome. The causes of the postgastrectomy syndrome can be hypocaloric food intake, exclusion of duodenal passage, loss of absorption surface, lack of peptic digestion, excessive bacterial colonization, and the occurrence of exocrine and endocrine pancreatic insufficiency [57]. Symptoms related to food intake due to abnormal transit reported in several studies relate to the onset of early and late dumping syndrome, alkaline reflux, pyrosis, loss of appetite, feeling of satiety and fullness, epigastric pain, meteorism, dysphagia, and diarrhea [67]. Schwarz and authors, as well as Zherlov and authors, have shown in their studies that reconstruction in which DP is preserved has a lower incidence of postgastrectomy symptoms [43, 68]. Persistent postprandial discomfort and fullness may be to some extent due to poor receptive adaptation of the proximal part of the small intestine. In addition to poor receptive adaptation of the proximal part of the small intestine, the distal end of the Roux loop can also act as a functional obstruction, which leads to Roux-stasis syndrome, which is characterized by epigastric pain, nausea, and vomiting, and is most likely due to the lack of motor function in the distal region Roux loop [57, 69].

The lack of gastric acid after TG and altered intestinal motility in reconstruction with RY configuration with or without pouch seems to lead to bacterial colonization, which may be one of the main causes of malnutrition after TG. Excessive bacterial growth leads to the formation of damage to the mycelium and decongestion of bile salts. Several mechanisms blame for malabsorption of fat: loss of gastric emulsification of triglycerides, rapid food passage, and pancreatic stimulation disorder [63].

The overall impact of many symptoms after a RP can be summarized in the health quality of life. The quality of life is a multidimensional approach that consists of functional, emotional, physical, and social aspects, as well as from subjective disease symptoms and adverse effects of therapy. Controlling gastrointestinal symptoms seems important in an attempt to reduce damage to quality of life [70]. In their study, Hoksch and authors confirmed that reconstruction with the preservation of DP is the most optimal procedure in improving the quality of life of patients after TG [58].

4. Conclusion

TG is widely used as a major surgical treatment for GC. TG results in risk of postgastrectomy syndrome, such as weight loss, dumping syndrome, biliary reflux esophagitis, and a reduction in the quality of life [3, 4]. The ideal RP after TG should replace all lost functions of the stomach, provide an optimal enough reservoir that can accommodate to the size of the meal, prevent reflux, ensure strong propulsion of equal-sized boluses of chyme entering the duodenum, and respond properly to the changing levels of gastrointestinal hormones and neural information [7]. The choice of RP should ensure good digestive function to prevent persistent postgastrectomy syndrome. Preservation of duodenal transit with replacement of the jejunal segment, the so-called physiological route, is now believed to be preferential for postoperative nutritional condition. RP which allow DP should be regarded as a key to physiological reconstruction.

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Conflict of interest

The authors declare no conflict of interest.

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