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Review

A review on double tract reconstruction after proximal gastrectomy for proximal gastric cancer

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ABSTRACT

Gastric cancer remains one of the deadliest malignancies on the planet, accounting for the fourth highest cause of death by cancer worldwide. While trends indicate that its incidence is decreasing globally, it remains a concern, particularly when identified at an advanced stage with a high mortality rate. The best treatment option for early proximal stomach cancer has been identified as surgical resection followed by an acceptable reconstructive procedure.

One such surgical management called Double Tract Reconstruction (DTR), has piqued surgeons' interest. DTR has been found to be a potential reconstructive strategy for reducing esophagogastric reflux or post-gastrectomy gastritis and esophagitis. Not only does this technique ensure adequate vitamin B12 maintenance post surgically, but it is also a safe and effective procedure. According to several researchers, the benefits may be comparable to those of total gastrectomy as it relates to, post-operative recovery time, operation time, intraoperative complications, and early complications. DTR is still being studied, and gastrointestinal surgeons worldwide are looking for new ways to improve this method and increase overall survival of gastric cancer.

1. Introduction

Gastric Cancer (GC) is one of the world's deadliest malignancies. Data from research on cancer incidence and mortality from GOLOCAN 2020 shows stomach cancer as the 4th leading cause of death by cancer worldwide with 10 89103 new cases for the year [1]. Early gastric cancer (EGC) has a 5-year survival rates of over 90% especially if treated early with an adequate surgical procedure [2]. Many treatment protocols have been designed for the surgical management of EGC. They have been designed to improve patients' lives post gastrectomy and to attempt to maintain disease free progression, improving overall survival. Hong bo Wei et al. reported that over seventy (70) surgical procedures currently exist for the management of gastric cancer after total or subtotal gastrectomy [3]. However, the optimal digestive reconstructive method remains a matter of debate. In recent times, the subject of double tract reconstruction (DTR) after proximal gastrectomy (PG) has gained widespread interest among surgeons. Data from a few studies have revealed that it provides excellent benefits and is comparable to total gastrectomy (TG) for the management of proximal gastric cancer [4]. This could possibly, alter certain guidelines for reconstructive gastric surgery in the future for the management of proximal gastric cancer.

Double tract means that two pathways have been formed for the passage of food; one for the entry of food into the stomach and duodenum (where most food is expected to flow into) and the other from the esophagus into the jejunum. DTR after proximal gastrectomy consists of three anastomoses: an esophagojejunostomy (EJ-stomy), a gastrojejunostomy (GJ-stomy) and a jejunostomy- jejunostomy (JD-stomy) [5,6]. DTR has been studied as an alternative reconstruction to TG for proximal gastric cancer (PGC) and, for certain patient populations has also become the choice of reconstruction. It has been compared to many other reconstructive methods (Roux-en y, Bilroth, jejunal interposition, jejunal pouch repositioning etc.) and has additionally, been studied as a reconstructive option after distal gastric gastrectomy [7,8]. However, more research is needed to solidify its position. Several articles have been published on the topic, but there are still unanswered questions and aspects which need further investigation and clarification. The purpose of this paper is to review some of the data currently available on DTR.

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2. Method

This article reviewed the research materials available on DTR after proximal gastrectomy. The review focuses on the type of gastrectomy performed, the comparison of DTR as an alternative to other gastric reconstructions, the intraoperative outcome, post-operative outcomes, and quality of life for patients after proximal gastrectomy. For the revision of data and material PUBMed, Google Scholar, Web Science, Cochrane Library, Scopus, World Journal of Surgery were used to search for articles dated from 1995 to 2021. The Medical Subject Heading (MedsH) terms included: Double tract reconstruction, gastric cancer, proximal gastrectomy, gastric reconstruction. Articles discussing gastrectomy or gastric reconstruction without mentioning DTR were excluded. A total of 22 articles inclusive of metanalysis and systemic reviews were utilized to conduct this review.

3. Surgical procedure/surgical background

There are conflicting reports of who invented the DTR technique, but a study reports that it was first mentioned by Japanese surgeons Kajitani and Sato [9]. DTR is classified as a duodenal preserving reconstructive method because it maintains the passage of food into the duodenum for digestion [10]. In this section the surgical procedure of DTR after PG is briefly explained. The technique may differ across nations and with surgeons as clinicians have developed personal styles and preferences.

3.1. DTR after proximal gastrectomy

Proximal gastrectomy is performed by removal of the cardia and preservation of the pylorus [11].

For DTR the jejunum is divided approximately 15 cm distal from the ligament of Treitz and the distal jejunal limb is brought up to the esophagus to form an end to side EJ-stomy using circular stapler, the jejunal stump (usually 3–5 cm in length) is later closed with linear stapler or hand sewn suture. Then side-to-side gastrojejunostomy (GJ-stomy) is performed with the posterior or anterior region of the greater curvature of the remnant stomach 15–20 cm below the EJ-stomy. The final anastomosis includes an end-to-side JJ-stomy (with linear staplers or hand sewn sutures) 35–40 cm distal to the EJ-stomy [4,11].

4. Effect on postoperative complications

Surgeons have noted that after proximal gastrectomy with esophagogastrostomy (EG) many patients suffered from high rates of esophageal/gastric reflux and esophagitis [12–14]. In some instances, these patients required management with a protein pump inhibitor (PPI) or other medications for symptom relief. Many studies have indicated that proximal gastrectomy with DTR is safe and depending on the case can provide better results when compared to TG [5,13–17].

After gastrectomy, surgical reconstruction aims at maintaining intestinal continuity, decreasing post-operative complications, and preserving good nutritional status. Gastric reconstructive procedures can be designed to either preserve the duodenal passage or without preserving the duodenal passage for food [4,10]. Many researchers have argued over the benefits of maintain the duodenal passage of food. Some argued that in duodenal preserving techniques food allowed to pass through the duodenum results in rapid absorption of nutrients at rates as seen in healthy individuals. Additionally, the passage of food through the duodenum maintains the normal digestive function of food mixing with chyme, leading to the secretion of digestive enzymes, subsequently leading to peristalsis, Oddi sphincter relaxation etc. and the process of the normal digestion [18]. This leads to favorable weight maintenance and nutritional outcomes for these patients [19,20]. Preservation of the duodenal passage in gastric reconstruction procedures may also be beneficial for access to the hepatobiliary system after surgery, in patients requiring Endoscopic Retrograde Cholangiopancreatography (ERCP) for various reasons post surgically [8,21].

Nonetheless, current data is conflicting as to whether it is the maintenance of duodenal passage, possible construction of a pouch or presence of a remnant stomach that results in maintenance good nutritional status and satisfactory QOL in patient with duodenal preserving procedures. Contrastingly, some researchers have reported that the preservation of the duodenal passage provides no added clinical or physiological benefits for the patient [22,23].Various reconstructive methods (jejunal interposition, DTR, jejunal pouch interposition, double flap technique) have been designed to solve the high incidence of esophagitis and gastric reflux with EG Refs. [24,25]. Nonetheless, the most suitable reconstructive method remains controversial.

Aburatani et al. investigated the clinical outcomes of laparoscopic proximal gastrectomy (LPG) followed by DTR at their institution in Japan [26]. In their clinical study of 41 patients, 19 DTR and 22 who underwent esophagogastrostomy were compared. They found that the use of PPIs, the frequencies of reflux symptoms (10.5% vs. 54.5%, $P = 0.003$) and anastomotic strictures (0% vs. 27%, $P = 0.014$) respectively, were significantly lower in the DTR group. However, the study found no difference on the incidence of endoscopic reflux esophagitis between the two procedures,. They concluded that between the two methods, DTR had better clinical outcomes with lower esophageal reflux and anastomosis. Their study, however, requires a longer follow up period and a larger cohort or multiple centers. In addition to observing patients who are not on PPI (for purpose of endoscopic monitoring) to further investigate the results of the results of the endoscopic.

In a study at their institution including 43 patients who underwent LPG with DTR, Anh et al. found that for late complications which included reflux symptoms (4.6%), anastomotic stricture, and post-gastrectomy symptom the rate was 11.6% (5 of 43 patients) [27]. The rate of reflux symptom for this study was even less in comparison to the one of Aburatani et al. mentioned above. Post operative complications which included anastomotic stenosis and chylous ascites, were successfully treated within a short space of time and did not create grave complications for the patients. Three months after the operation endoscopy revealed no reflux esophagitis in these patients. They concluded that LPG-DTR as an acceptable treatment for proximal gastric cancer, it is easy to perform, is a time efficient procedure and prevents reflux esophagitis. Nonetheless, in their study, DTR was not compared to another reconstruction and no comparison was made. The study was also limited in not assessing the quality of life of patients. As one of the early studies on this topic, monitoring the QOL would have added value.

Ji et al. as additional contributors to the topic, compared DTR and esophagogastrostomy. The study comprised of 64 patients diagnosed with proximal gastric adenocarcinoma or esophagogastric junction (EGJ) adenocarcinoma at early stages. Patients were followed up with year one post operation endoscopy and European Organization for Research and Treatment of Cancer Quality of life Questionnaire (EORTC QLQ-C30 ver. 3.0) and EORTC QLQ-STO22 questionnaire. At the end of the study, they showed that reflux esophagitis occurred in twelve patients (30.8%) in the EG group and in two patients (8.0%) in the DTR group, ($P = 0.032$) and patients who suffered from reflux in the DTR group had milder post operative symptoms and better QOL for patients [28]. This study failed to monitor recurrence between the two procedures but is a very important study as esophagogastric junction cancer management poses a difficulty to surgeons.

Xu et al. in their meta-analysis using 9 studies in total, out of which 7 provided data on post-surgery complications of TG and DTR in the management of proximal gastric cancer; showed that DTR had a lower incidence of reflux occurring after the surgery (OR = 0.185; 95% CI 0.083, 0.4146; $P = 0.000$) [6].Other studies have also reported benefits of DTR after PG on reflux symptoms [16,17].

A few hypotheses have been proposed as to why DTR is effective in the prevention of reflux symptoms or reflux esophagitis. It has been suggested that the severity of reflux might be related to the degree of the Angle of His and the distance between EG-stomy and the GJ-stomy, and

an increase in the angle by stretching the stomach or the angle may contribute to increased reflux.

Namiwaka et al. found that when the Angle of His was preserved in procedures like DTR, this resulted in the reduction of reflux symptoms [8]. Additionally, if the distance between the EG and GJ-stomy is between 15 cm and 20 cm, at an optimal length of 15 cm as indicated by some literature then there is a decrease in reflux symptoms [8,17,29,30].

Jung et al. provided insight that the degree of reflux was possibly related to the distance between the anastomoses. In their earlier technique, they placed the GJ-stomy at 10 cm below the EJ-stomy and observed a higher incidence of reflux disease. However, in their more recent study, an alteration of the anastomosis distance from 10 cm to 15 cm below the EJ was made and benefits of no anastomosis-related late complications in any of the patients were reported [17]. Consequently, more research is needed to verify these findings.

Post-operative esophageal reflux and remnant gastritis can affect a patient's life significantly, by causing undesirable symptoms, the need for continuous diagnostic examinations, and long-term medication use. Many studies have indicated that DTR provides favorable results for reflux and remnant gastritis and consequently has become the reconstruction of choice in certain patient populations with PGC.

5. Effect on hematological parameters, nutritional status and weight

An important component of a reconstructive procedures is ensuring that after surgery patients normal or near normal nutritional status is maintained. Some studies have investigated the benefits of DTR and its effect on nutritional status and weight. Studies show that after DTR patients can maintain normal to near normal vitamin B_{12} levels. The effect of DTR on hemoglobin (HGB), proteins (TP), and other serological and nutritional indicators remain controversial as there are conflicting reports. In their meta-analysis comparing DTR with TG for PGC, Li Shengnan et al. found that 4 out of the 7 articles evaluated indicated that LPG-DTR was superior in preventing vitamin B_{12} deficiency, but no benefit was seen for HBG or ferritin [31].

Kim et al. in their retrospective study compared the levels of HGB, serum iron (FE), ferritin, and vitamin B_{12} in 17 patients who underwent DTR and 17 patients who underwent laparoscopic TG, with stage I cancer for up to one year post operatively. They reported that although patients who underwent laparoscopic TG had a greater decrease in iron (4 vs 1 patient) and ferritin (2 vs 0 patient) post operatively, when compared to the DTR group, the values were not significant ($P = 0.194$ & $P = 0.231$ respectively). They were unable to show that DTR had a better effect on albumin (Alb) or TP [32]. Although the values were not statistically significant ($P = 0.027$), no patients who underwent PG-DTR experienced abnormal vitamin B_{12} levels and 5 patients in the TG group experienced abnormal vitamin B_{12} levels post operatively.

Jung D et al. retrospectively observed that DTR is effective in maintaining vitamin B12 levels and in the preventing post-operative anemia; as the decrease in HGB was significantly lower for this group at the follow up periods [17]. The study compared DTR to LTG for stage I PGC management for years one and two post operation. The study failed to show any superior effect of DTR on serum TP, Alb and cholestrol. Only 5.4% of the DTR group required supplementation with vitamin B_{12} in contrast to 88.5% of the patients in the LTG group. They also reported a significantly lesser change in weight in the DTR patients. With the exception of not observing QOL during the time period, this study touched on the major short and long effects of the procedures.

Cho et al.'s research analyzing the hematological benefits, serum Tp, Alb, total cholesterol, and total lymphocyte count in patients (who underwent LPG-DTR versus LTG with REY) found that these parameters did not differ significantly between the two groups, but, the number of patients who required vitamin B_{12} supplementation was smaller in the PG-DTR groupClick or tap here to enter text. The study however found that DTR and LTG has similar nutritional and hematological outcomes. They also concluded that over a year both DTR and TG groups had decreases in BMI by 2.5 kg/m^2. BMI for DTR showed some improvement after18 months but the decreased weight of the TG group remained constant.The values failed to reach statistical significance ($P = 0.938$) [33].

Studies like those of Miyauchi et al. to observe to serum Alb, HGB, skeletal muscle and prognostic nutritional index (PNI) at 6 months and a year post surgery in patients who had PG-DTR ($n = 24$) or EG ($n = 23$); showed that changes to the observed parameters were less in the DTR (the values were not statistically significant). The results also indicated that after a year there was no significant improvement to the parameters. There was no difference in weight at one year post surgery [34].

Sugiyama et al., in evaluating bodyweight and skeletal muscle in patients who underwent PG-DTR and TG-REY for early PGC at 6 months and 1 year post surgery reported that the drop in weight was significantly more in the TG group in contrast to the DTR group (−17.9% vs 9.6%, $p = 0.0042$). In addition, the DTR group had significantly less change to their skeletal muscle index (SMI) than the TG group (9.3% vs 18.3%, respectively; $p = 0.0057$) [35].

Choi et al. used 31 patients who had proximal gastric masses (cancer, leiomyoma or gastrointestinal stromal cancer) to observe the effects of DTR. They reported patients had maximum weight decreases of 10.5% within a year after surgery, but by year 3 their weight was able to increase back to 96.8% of their preoperative weight. In contrast to some of the studies mentioned above Choi et al. were able to show that by year 2 serum HGB returned to values higher than those before surgery [36].

Additional long-term studies are needed to further investigate on the effects of DTR on BMI, skeletal muscle index, and other serological and nutritional parameters. These studies should include meticulous monitoring of the study groups nutritional intakes, daily activities, short or long-term habits which may affect weight change and maintenance. Additionally, other factors which may cause anemia and poor nutritional status should be thoroughly investigated if conditions persist.

6. Effect of DTR operation time and intraoperative complications

As it relates to operation time, intra-operative complications (blood loss, anesthesia complications, conversion to open surgery), length of hospital stay and early complications, many articles reviewed showed no difference between DTR in comparison to other reconstructive procedures [16,26,32,33,35,37]. In contrast, two studies reported that DTR had shorter operation time and less blood loss than TG groups [13,17]. It is worthy to note that these outcomes may be affected by the experience of the surgeon techniques used, surgical complications, patient factors during or after surgery.

7. Possible question or concerns of DTR

As with any surgical procedure, surgeons are always concerned about the possible disadvantages or limitations of the procedure. The goal of every procedure should be to provide more benefit than harm. Based on the articles reviewed, there were some questions on DTR highlighted by different studies and some researchers have attempted to address these limitations.

One of the issues that has been mentioned is the failure of contrast during early assessments and then food to enter the remnant stomach, in addition to, the risk of leak or stenosis at the anastomotic sites. The issue of unsuccessful passage of food into the stomach undermines the fundamental purpose of the double tract technique. It has already been mentioned above that DTR has not been shown to cause increased stenosis or leak.

Tanaka et al. in their "how to do it" article on a new technique for DTR for treating early PGC, stated they previously noticed in some cases after undergoing PG- DTR, dietary intake escaped the remnant stomach and often passed directly into the jejunum [38]. To counteract that

problem, they developed an improved method for DTR using intracorporeal linear staplers by twisting the stomach and jejunum posteriorly; then anastomosing the posterior wall of the remnant stomach and the posterior wall of the jejunum. Post-operative radiology showed a wide opening of the gastric entrance allowing contrast to flow mainly into the remnant stomach.

Fujimoto et al. designed the delta shaped anastomosis of the GJ-stomy with linear staples to facilitate the passage of more food into the remnant stomach [30]. The anastomosis was created between the posterior wall of the remnant stomach and the jejunum. A V-shaped anastomosis was then formed to divert food into the stomach. They explained that this occurred secondary to narrowing of the jejunal exit, shunting food into the stomach. Post procedure the patency of the tract was accessed via contrast agent study. They were able to show that post-operative malnutrition was less in the group for which more contrast agent entered the stomach. Although these studies were done on small populations and would require extensive studies, the benefits noted from the improved techniques contributed to increased interest in understanding the best way to maintain the passage of food into the stomach and possibly improve nutritional outcomes. Some authors have demonstrated that creating the anastomosis with linear staples might help decrease the incidence of in leak and stenosis in comparison to using circular staples [39,40].

Another concern of surgeons was that with DTR, the recurrence rate of cancer might be high, and that proximal gastrectomy might not allow for adequate lymphadenectomy and margin resection. This led some researchers to investigate these issue.

Li Shengnan et al. in their meta-analysis comparing PG-DTR to TG found that at the end of the follow-up, no patients who underwent PG-DTR had recurrence or death, whereas in the TG group, 4 patients had relapse. However, the overall survival rates were similar between the 2 groups, 5-year survival rate was 96.1% and 95.9% for the LPG -DTR and LTG groups respectively [31].

Sato et al. also retrospectively studied 289 patients who underwent PG-DTR($n = 99$) or TG ($n = 190$) for EGJ and PGC. In contrast to the other studies above, they reported higher reflux esophagitis rates in patients who underwent DTR (8% vs. 0%). A 5-year relapse free rate of 92.7% was seen for the DTR group. In the DTR group 1 patient experienced recurrence and two patients with early metachronous gastric cancer were treated with curative methods [16].

Ahn SH et al. mentioned that at the final follow-up, tumor recurrence was found to occur in 1 patient who had undergone PG-DTR (stage IIIb), while the overall survival rate of the study group was 100%. In the study, there was no recurrence in patients with stage I gastric cancer who received LPG-DTR. However, for the LTG group, three patients with stage I gastric cancer had recurrence [13]. To measure cancer recurrence and survival much longer follow up periods are needed. Studies on recurrence rates of PG-DTR and those reviewing the factors affecting overall survival and recurrence in these patients are still lacking.

Reconstructive procedures results in changes to normal anatomy. These changes can pose restrictions on diagnostic assessments and examinations of remaining structures. Kim et al. noted the possible issue of intestinal continuity and digestive function post-operatively in their study [32,41]. They discussed that although surveillance of the remnant stomach is possible it might not be easy to adjust the flexible scope to enter the stomach through the jejunum. Additionally, to access the anastomosis site might pose a problem in some patients. Therefore, gastroenterologists performing assessments should be skillful and experienced.

8. Conclusion

The best methods for treating diseases are early diagnosis and treatment when preventative measures fail. Gastrointestinal reconstruction following gastrectomy is still being extensively studied. The method of gastrointestinal reconstruction is very essential as it should be safe, provide benefits, improves patients' survival, disease free progression, and should effectively maintain a substantial nutritional status.

DTR can be carried out safely via both conventional and laparoscopic methods. In many countries TG is still performed for patients with early PGC. This papers provides some promising results that DTR can be utilized in these patients; as it results in decreased gastroesophageal reflux symptoms, it is applicable, it can be performed in approximately the same time as other reconstructions, can prevent severe anemia and also maintains vitamin B_{12} levels, which is important to the prevention of megaloblastic anemia, the formation of red blood cells, DNA and the health of nerves and cells [42]. Literature have indicated that adequate resection margins are attainable with DTR. The benefit of this procedure in maintaining overall nutrition, weight, serum iron etc. is debatable and more studies are needed to delve into this topic.

This paper is useful to investigating the treatment of patients with EGJ cancers, specifically Siewert types II and III. At present, most research exists on the transthoracic and transhiatal approaches to treating these cancers. However, studies are lacking on abdominal approaches without thoracotomy, as is currently practiced in China. EGJ cancers pose a challenge to surgeons with its rising incidence and DTR can be investigated as an option in the treatment of these entities. Additionally, more research should investigate the benefits of DTR in stage II and III PGC and after distal gastrectomy. The benefits of DTR coupled with systemic therapy should also be considered. Studies to investigate the factors affecting OS and long-term effects of DTR and longer follow up periods QOL are lacking and should be considered. To date, most of the studies conducted on this technique have been in Asia (Korea, Japan, China). Hence, more studies are need in the west to compare findings. Although it has its limitations, DTR is an effective and practical reconstructive procedure worthy of further investigation.

Provenance and peer review

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