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Research Article

Billroth II Reconstruction Method with Foregut Bypass after Gastrectomy as a Possible Cause of Improvement of Type 2 Diabetes

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Abstract

Introduction: Diabetes is a major healthcare disease worldwide and the high remission rate of type 2 diabetes mellitus (T2DM) after bariatric surgery in morbidly obese patients has been reported in various studies. This study reports the T2DM-improving effect of foregut bypass by comparing the outcomes of different post-gastrectomy reconstruction methods in patients with gastric cancer.

Methods: A retrospective study was performed using the data obtained from 469 patients who had been diagnosed with T2DM and underwent gastrectomy for gastric cancer between 2010 and 2020. Medical history, operative methods, pathologic reports and preoperative and postoperative laboratory data for a total of 190 patients were included in the analyses.

Results: All collected factors related to T2DM and hyperlipidaemia improved after gastrectomy, irrespective of the reconstruction method. Glycated haemoglobin (HbA1c), fasting glucose, total cholesterol and triglyceride levels improved after gastric resection and the patients showed weight loss and a reduction in BMI. However, Billroth II (BII) reconstruction showed statistically better outcomes than Billroth I (BI) reconstruction for HbA1c improvement (-1.01 vs. -0.18, p = 0.002).

Conclusion: The BII reconstruction method, which bypasses the duodenum and the upper part of the jejunum after distal gastrectomy in gastric cancer patients with T2DM, yielded a significantly better improvement in diabetes in comparison with BI reconstruction. For gastric cancer patients with T2DM, the BII anastomosis method may be recommended for better glycaemic control.

Keywords: *Diabetes Mellitus; Metabolic Surgery; Gastric Cancer; Billroth Reconstruction*

Abbreviations

T2DM: Type 2 Diabetes Mellitus; DG: Distal Gastrectomy; TG: Total Gastrectomy; BI: Billroth I; BII: Billroth II; RY: Roux-En-Y; BMI: Body Mass Index

Introduction

Diabetes is one of the most concerning diseases worldwide and accounts for more than 10% of global healthcare expenses [1]. Approximately 3 million deaths per year are caused by diabetes and its complications globally, accounting for approximately 5% of deaths

from all causes worldwide [2]. According to the WHO, the prevalence of diabetes is on a steep rise and approximately 366 million people across the world will be affected by the disease by 2030 [3].

The International Diabetes Federation recommends bariatric surgery for the control of type 2 diabetes mellitus (T2DM) presenting with morbid obesity and this approach has been reported to yield a remission rate of approximately 80% in various studies, including meta-analyses [4,5]. Although weight control is a major factor underlying the improvement in T2DM after bariatric surgery [6] some experimental studies with humans have suggested that other mechanisms may also be responsible for the improvement in glycaemic control [7,8]. In those studies, the process of bypassing the foregut, which includes the stomach, duodenum and upper part of the jejunum, was thought to be the main cause of the effect on blood glucose levels.

Billroth I (BI) and Billroth II (BII) reconstruction methods are time-consuming and widely used methods after distal gastrectomy (DG) for gastric cancer [9]. In cases involving gastric resection, the reconstruction method is selected according to the operator's preference and no specific difference has been identified between the two methods in terms of oncologic safety. However, anatomically, the BII procedure results in changes in the food digestion route through the duodenal switch and foregut bypass, while the BI procedure maintains a relatively physiological anatomy of the gastrointestinal tract. Thus, a comparison of the outcomes of these reconstruction methods could be helpful in understanding their effects on metabolic diseases, especially T2DM. In addition, by comparing these methods with Roux-en-Y (RY) reconstruction after total gastrectomy (TG), the effect of massive food intake restriction with foregut bypass on weight loss and blood glucose control can be determined. Therefore, this 10-year single-centre study conducted at the division of gastrointestinal surgery aimed to report whether foregut bypass affects the improvement in type 2 diabetes.

Materials and Methods

Patients

All patients with type 2 diabetes who underwent gastrectomy for gastric cancer at Kosin University Gospel Hospital between January 2010 and December 2020 were included in this study. The study included patients aged 30-85 years with gastric cancer and previously diagnosed type 2 diabetes who were suitable for undergoing major gastrectomy, including total or distal gastrectomy. Patients were excluded from this study if they had undergone gastrectomy previously, if the operation was performed with a palliative intent, or if outpatient follow-up loss was observed.

This was a retrospective study conducted using the data for 469 patients. Information regarding patient sex, age, medical history, body mass index, cancer location and stage, type of gastrectomy and reconstruction method and laboratory data for HbA1c, fasting glucose, total cholesterol and triglyceride levels before and after surgery was collected. Gastric cancer staging was performed according to the American Joint Committee on Cancer staging manual, which was determined on the basis of pathologic results. The need for informed consent was waived because of the retrospective design of this study.

Surgical procedure and postoperative follow-up

Standard distal or total gastrectomy was performed by five experienced upper gastrointestinal surgeons according to the location of the gastric cancer. Distal gastrectomy was performed if the lesion was located in the middle or lower portion of the stomach and TG was performed for lesions located in the upper part of the stomach. On the basis of the preoperative endoscopic report, laparoscopic gastrectomy with D1+ lymph node dissection was mainly performed for early gastric cancer and open abdominal gastrectomy with D2 lymph node dissection was performed for advanced gastric cancer. The reconstruction method was selected according to the surgeon's preference and hand-sutured or stapled techniques were used. None of the patients received neoadjuvant chemotherapy prior to surgery. Postoperative pathologic reports showed that all resection margins were negative and routine outpatient follow-up or adjuvant chemotherapy was performed depending on the postoperative stage.

Patients were scheduled for outpatient visits at least 6 months to 1 year apart for 5 years after surgery and medication review and blood sampling for laboratory tests were performed during the outpatient visits. The results of laboratory tests performed at 1 year or 2 years after surgery were analysed in this study.

Statistical analysis

The patients were divided into BI, BII (DG) and RY (TG) groups according to the reconstruction method and the preoperative laboratory data of each group were evaluated in statistical analyses. The International Business Machines Statistical Package for the Social Sciences (SPSS) version 25 was used for statistical analysis. A Chi-square test, independent sample t-test and one-way analysis of variance (ANOVA) were used for statistical analysis of baseline patient characteristics and pre-and postoperative laboratory tests. Statistical significance was set at $P < 0.05$.

Results

Patient characteristics

A total of 190 patients were included in this study, which included 54 (28.4%), 87 (45.8%) and 49 (25.8%) patients who underwent DG with BI or BII reconstruction and TG, respectively. Basic characteristics, including sex ratio, age, pathologic stage and comorbidities did not show any significant differences among the groups (Table 1). Preoperative HbA1c level was 7.41, 7.80 and 7.53 in the BI, BII and RY(TG) groups, respectively (Table 2). Since the target patients of this study were limited to those who had previously been diagnosed with T2DM, the comorbidity rate, including the rates of hypertension and cardiac or cerebrovascular disease, was high.

	Distal gastrectomy		Total gastrectomy	
Reconstruction method	**Billroth I**	**Billroth II**	**Roux-en-Y**	**p Value**
n	54 (28.4%)	87 (45.8%)	49 (25.8%)	
Sex				
Male	35 (72.2%)	59 (67.8%)	33 (67.3%)	0.826
Female	15 (27.8%)	28 (32.2%)	16 (32.7%)	
Mean age (years; range)	62.28 (46 - 78)	62.26 (40 - 82)	63.63 (44 - 84)	0.685
Endoscopic result				
Early gastric cancer	41 (75.9%)	57 (65.5%)	31 (63.3%)	0.316
Advanced gastric cancer	13 (24.1%)	30 (34.5%)	18 (36.7%)	
Pathologic stage				
I	40 (74.4%)	66 (75.9%)	32 (65.3%)	0.374
II	7 (13.3%)	10 (11.5%)	5 (10.2%)	
III	7 (13.3%)	7 (8.0%)	9 (18.4%)	
IV	0 (0%)	4 (4.6%)	3 (6.1%)	
Comorbidity				
Hypertension	23 (42.6%)	37 (42.5%)	30 (61.2%)	0.079
Cerebrovascular disease	11 (20.4%)	11 (37.9%)	7 (14.3%)	0.452
Cardiovascular disease	3 (5.6%)	5 (5.7%)	2 (4.1%)	0.911
Pulmonary	5 (9.3%)	6 (6.9%)	1 (2.0%)	0.308
Hyperlipidaemia	0 (0%)	3 (3.4%)	1 (2.0%)	0.382
Liver disease	1 (1.9%)	8 (9.2%)	1 (2.0%)	0.083
Chronic kidney disease	2 (3.7%)	2 (2.3%)	0 (0%)	0.419

Table 1: *Patient characteristics.*

Parameter (variables)	Billroth I Pre → Post	Billroth II Pre → Post	p Value	Roux-en-Y (TG) (Pre → Post)	p Value	Total
HbA1c (%A1c)	7.41 → 7.23 (-0.18)	7.80 → 6.79 (-1.01)	0.002	7.53 → 6.63 (-0.90)	0.007	-0.75
Fasting glucose level (mg/dL)	133.84 → 132.36 (-1.48)	149.94 → 145.47 (-4.47)	0.318	147.73 → 133.54 (-14.20)	0.286	-6.15
Total cholesterol level (mg/dL)	159.41 → 156.15 (-3.26)	158.14 → 150.02 (-8.12)	0.512	168.00 → 143.54 (-22.76)	0.078	-10.18
Triglyceride level (mg/dL)	124.05 → 116.74 (-7.31)	136.64 → 123.22 (-13.42)	0.665	147.98 → 105.84 (-43.22)	0.056	-18.89
Weight (kg)	64.91 → 60.05 (-4.86)	68.04 → 61.43 (-6.61)	0.221	68.71 → 59.09 (-9.62)	0.059	-6.82
Body mass index (kg/m^2)	24.62 → 22.86 (-1.76)	25.05 → 22.98 (-2.07)	0.606	25.28 → 21.95 (-3.32)	0.066	-2.29

Table 2: *Preoperative and postoperative laboratory data.*

Preoperative and postoperative laboratory data analysis

All collected factors related to T2DM and hyperlipidaemia improved after gastrectomy, irrespective of the reconstruction method (Figure 1). The mean HbA1c was decreased by 0.18 and 1.01 with BI and BII anastomosis, respectively, while the total cholesterol and triglyceride levels decreased by 3.26 and 7.31, respectively, in the BI group and 8.12 and 13.42, respectively, in the BII group. The RY(TG) group also showed improvements in diabetes and hyperlipidaemia. Weight loss was also significant in all the groups. The mean decrease in body weight was 6.82 kg in all patients and the mean BMI reduction was 2.29 kg/m^2.

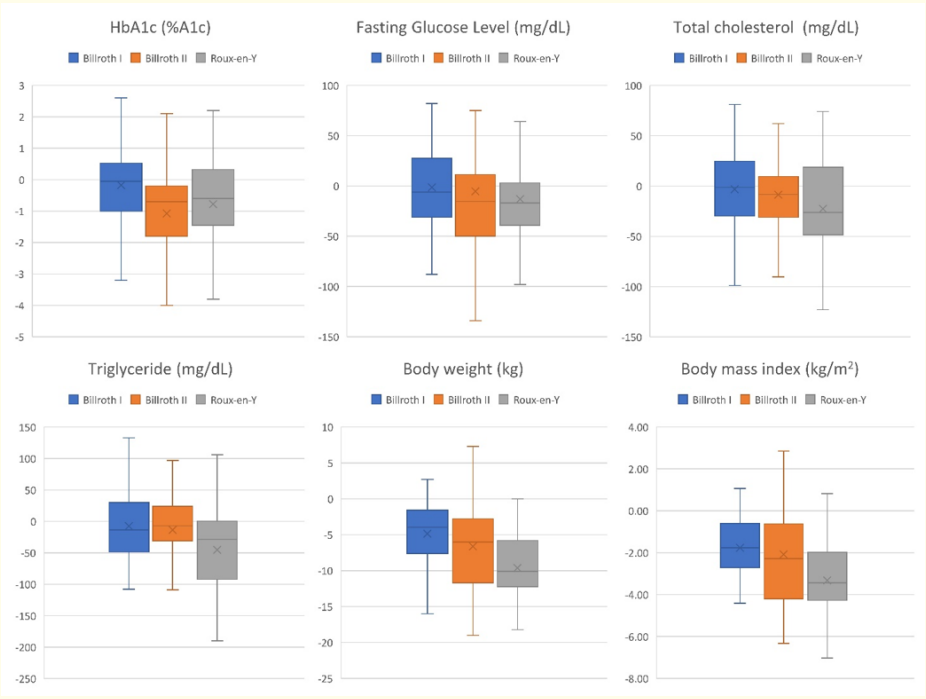

Figure 1: *Laboratory data, weight, and body mass index before and after the operation.*

However, in a comparison of the BI and BII groups, no significant differences were observed in factors related to weight loss, changes in BMI, or lipid profile-related laboratory data. The reduction in the HbA1c levels was the only factor showing a significant difference between the BI and BII groups ($p = 0.002$ and 0.007 in comparison with the RY(TG) group) (Table 2). Although the BI group also showed an improvement in T2DM with a deceased mean HbA1c level of 0.18, the BII and RY(TG) groups showed statistically more significant improvements in T2DM.

Discussion

The number of patients with T2DM is increasing worldwide and despite advances in medical therapy, the disease is only controllable, not curable, which can lead to numerous complications, including systemic and vascular diseases [10]. Bariatric surgery is widely known to yield successful weight loss and improved blood glucose control in patients with morbid obesity and diabetes [11]. Several studies have suggested that the improvement in diabetes can be attributed to the restricted food intake as a result of the reduced stomach volume and the consequent reduction in body weight [12]. However, some bariatric procedures seem to achieve a more profound improvement in T2DM than others. For example, while the short- and long-term remission rates associated with RY gastric bypass are 86% and 60%, respectively, the corresponding rates for sleeve gastrectomy are 83% and 55%, which is about 10% lower than that of Roux-en-Y gastric bypass. Additionally, it showed a relatively high rate of 33%: 42% in the recurrence of T2DM [13].

The Billroth procedure was first reported by Christian Albert Theodore Billroth in 1881 [14]. Since then, BI and BII anastomosis have become the most widely used methods for reconstruction of the gastrointestinal continuity after gastrectomy for gastric cancer in the distal portion. However, in the surgical community, there is no clear consensus regarding which technique is superior [15]. BI reconstruction offers the advantages of relative technical simplicity of one anastomosis, greater physiological food passage through the duodenum and easier endoscope access to the ampulla of Vater for biliary or pancreatic disease in comparison with other anastomosis methods [16]. Although BI and BII reconstruction show no clear differences in the postoperative outcomes, including survival time, the risk of afferent or efferent loop syndrome and internal hernia, including Petersen's hernia, is associated only with BII or RY anastomosis [17]. Some studies have also shown that the postoperative readmission and complication rates for BII tend to be higher than those for BI reconstruction [18].

The reconstruction methods after gastric resection for gastric cancer are similar to those used in bariatric and metabolic surgery for morbid obesity. A large portion or most of the stomach is resected and in some cases, anatomical changes are induced through a bypass of the duodenum and part of the jejunum. These anatomical changes can cause changes in the factors affecting insulin secretion and insulin sensitivity, including glucagon-like peptide-1, gastric inhibitory polypeptide and peptide YY [19]. These factors influence the improvement in T2DM, especially after gastric bypass surgery, through changes in bowel motility, inducing proliferation of beta cells and promoting insulin secretion in the pancreas. In this study, the BII anastomosis method, which bypasses the upper part of the small bowel, was found to yield a significantly better improvement in diabetes in comparison with the BI, which is a relatively physiologic reconstruction method.

Limitation of the Study

This study had several limitations. Due to the retrospective study design, the reconstruction method after DG was not randomised and was determined by the operator's preference. Because the investigation was conducted on cancer patients, adjuvant chemotherapy after surgery may have affected patients' food intake and diabetes control and the statistical analyses did not account for the potential influence of this factor. In addition, as confirmed in other studies, the T2DM remission rate over a long-term follow-up period of 5 years or more can show a big difference, so additional studies with a long-term prospective design are needed to further validate the findings of this study.

Conclusion

The BII reconstruction method, which involved bypassing the duodenum and upper part of the jejunum after DG, yielded a significantly better improvement in diabetes than BI reconstruction in gastric cancer patients with T2DM. Thus, this anastomosis method can be recommended for better glycaemic control in gastric cancer patients with T2DM.

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Ki Hyun Kim and Seunghun Lee contributed equally to this study as co-first authors.

Conflict of Interest

The author has no conflict of interest.

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