Effect of post-gastric sleeve pyloric length on control of type II diabetes mellitus

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Background
Although the effectiveness and safety of laparoscopic sleeve gastrectomy (LSG) have been demonstrated, there is still debate about the best surgical method, with the resection distance from pylorus (DP) being among the most contentious topics. In patients who had LSG for morbid obesity, the effect of the resection distance from the pylorus on the management of type II diabetes mellitus during the postoperative phase was examined.
Patients and methods
After receiving each patient's agreement, a total of 46 obese individuals were enrolled. Patients were prospectively randomized into two groups, group A ('AP group') and group B ('AR group'), based on the distance between the initial reload firing and the pylorus (4 cm for group A and 2 cm for group B, respectively). Blood sugar levels were measured three, six months, and one year following LSG. After a year of follow-up, the percentage of excess weight loss (%EWL) was calculated.
Results
Postoperative weight was statistically significant lower and EWL% was statistically significant higher in group B: LSG '2 cm' compared to group A: LSG '4 cm'. As regard outcomes of type 2 diabetes mellitus after LSG, in spite of nonsignificant statistical value, we reported that there was higher frequency of complete remission after 3, 6 and 12 months in group B: LSG '2 cm' compared to group A: LSG '4 cm' and cases with complete remission were associated with significant higher EWL%.
Conclusion
Patients undergoing laparoscopic sleeve gastrectomy are recommended to have shorter resection distance from pylorus (DP) done. It has been linked to superior surgical results, weight reduction, and diabetes mellitus management with no problems recorded.

Keywords:
diabetes mellitus, post-gastric sleeve, pyloric length

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Introduction

Almost 300 million individuals are fat and over a billion persons are overweight globally [1].

According to the World Health Organization (WHO) categorization, individuals in each obesity class have a higher risk of developing diseases associated with obesity than people with a normal body mass index (BMI) [2].

For individuals with obesity types II or III who are severely obese, surgery is the only evidence-based option to achieve clinically successful weight loss [3].

More primary care physicians are recommending surgical therapy for patients who are morbidly obese as a result of the medical and therapeutic advantages of laparoscopic bariatric surgery, and more patients have chosen to have this operation done as a result [4].

Laparoscopic sleeve gastrectomy has recently gained recognition as a successful kind of bariatric surgery. In this operation, the stomach's greater curvature is removed to create a tiny, tubular stomach that resembles a banana in both size and shape [5].

Because this procedure does not include a gastrointestinal anastomosis or bypass and is less technically challenging than laparoscopic Roux-en-Y gastric bypass and laparoscopic one anastomosis gastric bypass, it attracted a lot of surgeons to perform it [6].

Also, it prevents the external system (reservoir) that is implanted during laparoscopic adjustable gastric band around the stomach [7].

Two elements contribute to the sleeve operation's efficacy. Initially, a short lumen is converted into a high-pressure system with the pylorus intact, producing maximal constraint and heightened satiety. Second, the gastric fundus, which releases the hormone ghrelin, is removed in order to reduce appetite [8].

The ideal surgical technique for laparoscopic sleeve gastrectomy is still up for debate despite its demonstrated effectiveness and safety; the most contentious issues are bougie size, the distance from the pylorus, the segment from the angle of His, strengthening of the staple line, and performing an intraoperative leak test [9].

According to many academics, the pyloric resection distance should be between 2 and 6–7 cm from the pylorus. In more conventional procedures, the segment is performed farther away to promote stomach emptying, preserve function, prevent pyloric stenosis, and lower pressure, enabling the stomach (sleeve) to heal without leaking [10].

By removing a portion of the fundus and body, the laparoscopic sleeve gastrectomy, on the other hand, aims to significantly reduce the stomach volume. With such a small size, distensibility is reduced, improving intragastric pressure and promoting satiety with less oral intake. Thus, closer proximity to the pylorus is maintained in more conservative procedures in an effort to reduce gastric residue and improve weight reduction results [11].

Despite the laparoscopic sleeve gastrectomy's proven effectiveness and safety, there is still debate about the best surgical method, with the resection distance from the pylorus (DP) being among the most contentious topics. There is not enough data to determine how the size of the antrum affects stomach emptying and the results of weight reduction [12].

In patients who received LSG for morbid obesity, this study sought to investigate the impact of the resection distance from the pylorus on the management of type II diabetes mellitus throughout the postoperative period.

Methods

From July 2019 through January 2021, a non-randomized clinical study was done at Cairo University Hospitals' general surgery department, faculty of medicine, on patients with type II diabetes mellitus and morbid obesity whose BMI was greater than 40 kg/m2.

Sampling method

Patients who met the eligibility requirements were randomly allocated to either group using systematic random selection. A randomization table was used to place the matching letter, which indicated the assigned group, in each of the forty sex opaque envelopes. Afterwards, every envelope was sealed and placed in a single box. Using MedCalc version 13, a computer-generated randomization sheet was used for the randomization process.

Sample size

After receiving each patient's agreement, a total of 46 obese individuals were enrolled and split into two equal groups: group A: LSG '4 cm' (n=23) and group B: LSG '2 cm' (n=23).

Study procedures

Patients were prospectively randomized into two groups, AR (antrum resection-2 cm from the pylorus) and AP, based on the distance between the initial firing and the pylorus (antrum preservation-4 cm from the pylorus).

After LSG, blood sugar levels were measured three, six months and one year afterwards.

After a year of follow-up, the percentage of excess weight loss (%EWL) was calculated.

The goal of the study was to standardize gastric sleeve resection for managing morbid obesity and managing diabetes.

Statistical analysis

Using the statistical program for social sciences, version 23.0, recorded data was examined (SPSS Inc., Chicago, Illinois, USA). In terms of the quantitative data, mean, standard deviation, and ranges were reported. Qualitative factors were also shown as percentages and numbers. Using the Shapiro-Wilk Test and Kolmogorov-Smirnov tests, data were examined for normality.

Results

This study included 46 subjects with matched age, Sex, initial BMI and initial weight (Table 1).

There is no statistically significant difference between groups according to type of treatment, duration of DM (years) and HbA1c, with P value (P>0.05) (Table 2).

There was a highly statistically significant lower mean value in Group B: LSG '2 cm' compared to Group A:

LSG '4 cm' according to weight 'kg' after 3 m, 6 m and 12months ($P<0.001$; $P<0.001$ & 0.002) respectively, and that the lower mean weight loss for group B than group A (Table 3).

There was a highly statistically significant higher EWL % in Group B: LSG '2 cm' than Group A: LSG '4 cm' according to EWL% after 3 m, 6 m and 12 months ($P<0.001$; $P<0.001$ & 0.006), respectively (Table 4).

As for the outcome of type 2 DM after LSG, it was higher frequency of complete remission after 3 months were 17 patients (73.9%) for group B: LSG '2 cm' compared to 13 patients (56.5%) for Group A: LSG '4 cm', but insignificant, with *P*-value ($P=0.216$). Also, it was higher frequency of complete remission after 6 months were 18 patients (78.3%) for group B: LSG '2 cm' compared to 15 patients (65.2%) for Group A: LSG '4 cm', but insignificant, with *P* value ($P=0.326$). Additionally, there was a higher frequency of complete remission after 6 months were 20 patients (87%) for group B: LSG '2 cm' compared to 18 patients (78.3%) for Group A: LSG '4 cm', but insignificant, with *P* value ($P=0.437$). This indicates that the higher frequency for complete remission in group A than group B, but insignificant through (Table 5).

Table 1 Demographic data demonstrating in each group

Demographic data	Group A: LSG '4 cm' ($n=23$)	Group B: LSG '2 cm' ($n=23$)
Age (years)		
Mean±SD	41.87±7.72	42.78±5.84
Range	31–52	32–51
Sex		
Female	17 (73.9%)	15 (65.2%)
Male	6 (26.1%)	8 (34.8%)
Initial BMI [wt/ (ht)^2]		
Mean±SD	43.30±2.96	44.00±4.01
Range	39–48	38–49
Initial weight (kg)		
Mean±SD	162.57±14.28	165.30±13.34
Range	142–183	144–186

Table 2 Comparison between group A: LSG '4 cm' and Group B: LSG '2 cm' according to type II DM data

Type II DM data	Group A: LSG '4 cm' ($n=23$)	Group B: LSG '2 cm' ($n=23$)	x^2	*P* value
Type of treatment				
Insulin	2 (8.7%)	3 (13.0%)	0.224	$^{FE=}$0.636
Oral	21 (91.3%)	20 (87.0%)		
Duration of DM (years)				
<1 year	4 (17.4%)	5 (21.7%)	0.386	0.824
1–3 years	9 (39.1%)	10 (43.5%)		
4–6 years	10 (43.5%)	8 (34.8%)		
HbA1C				
≤6.5%	7 (30.4%)	9 (39.1%)	0.383	0.536
>6.5–8%	16 (69.6%)	14 (60.9%)		

Table 3 Comparison between group A: LSG '4 cm' and Group B: LSG '2 cm' according to weight (kg)

Weight (kg)	Group A: LSG '4 cm' ($n=23$)	Group B: LSG '2 cm' ($n=23$)	*t*-test	*P* value
Initial weight (kg)	162.57±14.28	165.30±13.34	−0.672	0.505
Weight After 3 months	100.61±10.19	82.30±8.90	6.489	<0.001**
Weight After 6 months	79.61±5.19	67.83±6.64	6.705	<0.001**
Weight After 12 months	70.26±10.57	60.43±9.08	3.383	0.002*

Table 4 Comparison between group A: LSG '4 cm' and Group B: LSG '2 cm' according to EWL%

EWL%	Group A: LSG '4 cm' ($n=23$)	Group B: LSG '2 cm' ($n=23$)	t-test	*P* value
EWL% after 3 m	37.73±7.80	50.01±5.67	−6.111	<0.001**
EWL% after 6 m	50.80±3.88	58.73±5.17	−5.883	<0.001**
EWL% after 12 m	56.51±7.46	63.23±8.13	2.921	0.006*

This table shows a statistically significant higher EWL % in complete remission than controlled by Oral Hypoglycemic Agent (OHG) according to EWL% after 3 m, 6 m and 12 months (P=0.017; P=0.034 & 0.005) respectively in group A: LSG '4 cm', this indicates that the association was found between the % EWL and complete resolution of Diabetes compared to control by OHG (Table 6).

This table shows a statistically significant higher EWL % in complete remission than controlled by OHG according to EWL% after 3 m, 6 m and 12months (P<0.001) in group B: LSG '2 cm', this indicates that the association was found between the % EWL and complete resolution of Diabetes compared to control by OHG (Table 7).

There was a highly statistically significant higher EWL % in complete remission than controlled by OHG according to EWL% after 3 m, 6 m and 12months (P<0.001) among all patients, this indicates that the association was found between the % EWL and complete resolution of Diabetes compared to control by OHG (Table 8).

Regarding complications there were 2 (8.7%) patients of group A and in 3 (13%) patients of group B. There was no statistically significant difference between the two groups, with P value (P=0.643) (Table 9).

Discussion

Our study revealed that postoperative weight was statistically significantly lower and EWL% was

Table 5 Comparison between group A: LSG '4 cm' and Group B: LSG '2 cm' according to outcome of type 2 diabetes mellitus after LSG

Outcome of type 2 DM after LSG	Group A: LSG '4 cm' (n=23)	Group B: LSG '2 cm' (n=23)	x^2	P value
After 3 months				
Complete remission	13 (56.5%)	17 (73.9%)	1.533	0.216
Controlled by OHG	10 (43.5%)	6 (26.1%)		
After 6 months				
Complete remission	15 (65.2%)	18 (78.3%)	0.965	0.326
Controlled by OHG	8 (34.8%)	5 (21.7%)		
After 12 months				
Complete remission	18 (78.3%)	20 (87.0%)	0.605	$^{FE=}$0.437
Controlled by OHG	5 (21.7%)	3 (13.0%)		

Table 6 Association between percentage of EWL and resolution of type 2 Diabetes mellitus in group A: LSG '4 cm'

	Outcome of type 2 DM after LSG			
EWL%	Complete remission	Controlled by OHG	*t-test*	*P value*
After 3 months	41.9±4.27	34.00±5.95	2.594	0.017*
After 6 months	54.03±3.79	45.49±3.06	2.269	0.034*
After 12 months	58.81±3.84	50.82±3.38	3.152	0.005*

Table 7 Association between percentage of EWL and resolution of type 2 Diabetes mellitus in group B: LSG '2 cm'

	Outcome of type 2 DM after LSG			
EWL%	Complete remission	Controlled by OHG	*t-test*	*P value*
After 3 months	52.54±4.12	42.85±2.02	5.475	<0.001**
After 6 months	62.93±5.30	53.98±5.18	3.358	<0.001**
After 12 months	66.44±3.78	58.80±6.93	4.633	<0.001**

Table 8 Association between percentage of EWL and resolution of type 2 Diabetes mellitus in all patients

	Outcome of type 2 DM after LSG			
EWL%	Complete remission	Controlled by OHG	*t-test*	*P value*
After 3 months	48.36±6.37	35.44±7.59	6.129	<0.001**
After 6 months	58.79±5.78	48.14±6.12	5.901	<0.001**
After 12 months	63.77±4.72	52.56±6.85	5.619	<0.001**

Table 9 Comparison between group A: LSG '4 cm' and Group B: LSG '2 cm' according to complications

Complications	Group A: LSG '4 cm' (*n*=23)	Group B: LSG '2 cm' (*n*=23)	x^2	*P* value
No complications	21 (91.3%)	20 (87.0%)	0.215	0.643
Complications	2 (8.7%)	3 (13.0%)	0.215	0.643
Calf DVT	0 (0.0%)	1 (4.3%)	1.022	0.312
Bleeding	1 (4.3%)	0 (0.0%)	1.022	0.312
Nausea & Vomiting	1 (4.3%)	2 (8.7%)	0.357	0.550

statistically significantly greater in group B: LSG '2 cm' compared to group A: LSG '4 cm'. However, there are still numerous technical concerns with the LSG approach and it is not entirely standardized. The start of gastric resection is one of these problems. In order to preserve the stomach antrum, some surgeons prefer antral resection and start stapling 2 cm from the pylorus, while others start 6 cm from the pylorus (Sánchez, 2009).

Maklad *et al.* (2021) came to the conclusion that following surgery, LSG with a 2 cm or 6 cm initial staple fired from the pylorus causes a considerable loss of weight. They dissented with our findings, reporting that the 2 techniques were equally beneficial in terms of EWL, morbidity, quality of life, and the improvement of co-morbidities, with little advantages for the 6 cm group [13].

Contradicting our findings, Hussein *et al.* (2020) found no relationship between the distance from the pylorus resection distance and the short-term effects of laparoscopic sleeve gastrectomy in terms of excess weight loss percentage, comorbidity resolution, quality of life change, or occurrence of complications. With considerable short-term weight loss, laparoscopic sleeve gastrectomy was an efficient and safe treatment for morbid obesity and its associated comorbidities. It significantly enhanced quality of life for those who were overweight and had a manageable complication rate [14].

The mean distance from the pylorus to the resection site was 5.6±1.5 cm, according to the consensus panel for LSG. While some surgeons like to start 6 cm from the pylorus, others like to start 2 cm away. More recently, 120 professional bariatric surgeons conducted a web-based survey in 2014 to determine best practices for various elements of LSG. 103 bariatric surgeons who were in attendance at the fifth International Congress on Sleeve Gastrectomy in 2014 were given the same survey. The majority of specialists (77.5%) concur that the pylorus should be at least 3 cm away before the stapling line is started (Gagner, 2016) [15].

The most prevalent objection to radical pyloric antrum excision is that surgery could change the way that food is evacuated from the stomach. LSG is expected to have an effect on gastric motility patterns since it significantly alters both the proximal and distal stomach. In general, LSG may impair stomach emptying through a number of mechanisms, including the removal of the fundus with its capacity and propulsive abilities, altered compliance and contractility of the resulting narrow and non-distensible sleeve, which increases intra-gastric pressure, and the removal of the gastric pacemaker region in the stomach's body. Nevertheless, research on stomach emptying after LSG has shown inconsistent findings (Elli, 2015) [16].

Research examining how pyloric antral excision affects weight reduction have shown contradictory findings. In the proportion of extra weight lost after the formation of a 4- versus 7- cm antral pouch, Jacobs *et al.* found no statistically significant difference (Jacobs, 2010) [17].

At 6 months following surgery, ElGeidie *et al.* found that patients with a 2-cm resection margin lost weight more effectively than those with a 6-cm resection margin; however, at 12 months, this difference disappeared, and the authors linked this weight loss outcome to transient vomiting episodes (ElGeidie, 2015) [18].

According to McGlone *et al.*, weight loss at 24 months was better in antral resection group (AR) than in antral preservation (AP) group, a characteristic that is not present at 12 months. According to these results, AR has a growing weight reduction advantage over AP. 2018 (McGlone) [19].

According to the International Hepatology Committee, LSG improves metabolic conditions beyond simple weight reduction, making the procedure more metabolic in nature than previously believed to be purely restrictive (Nobili, 2015) [20].

According to Abdallah *et al.*, the greatest rate of comorbidity improvement and resolution was for

hypertension (88%) followed by OSAS (72%), and the lowest was for joint pain (34%). Better rates of improvement and remission of these comorbidities are related with more antral resection (Abdallah, 2014) [21].

Bleeding is a severe early consequence of LSG that can occur up to 5% of the time. As the staple-line runs through the antrum, which has a thicker wall than other areas of the stomach and is therefore probably more prone to stapler failure, one may naturally anticipate that AR would result in a higher incidence of staple line hemorrhage than AP. Nonetheless, this study shows no difference between AR and AP in incidence of postoperative bleeding ***(Janik, 2017)*** [22].

Rudolf strongly advised protecting the antrum to stop nausea and vomiting (Weiner, 2007). Many surgeons leave the majority of the antrum for its pumping and emptying activity [1].

In their study, Mohamed *et al.* found that in the first six months, 90.6% of the 3 cm group and 60.7% of the 6 cm group experienced frequent vomiting (twice or more per day), with a substantial significant difference (*P*-value 0.021) between the two groups. On the other side, they discover that (6.3% of the 3 cm group) had no vomiting at six months compared to 32.1% of patients in the 6 cm group (Mohamed *et al.*, 2015) [23].

The results of 562 individuals who underwent LSG were published by Kirkil *et al.* Bivariate analysis revealed a strong (*P* 0.001) correlation between the revised BAROS score and the percentage of EWL, with the following findings: 26 patients (4.6%) were deemed failures, 86 (15.3%) fair, 196 (34.9%) good, 144 (25.6%) very good, and 110 (19.6%) outstanding outcomes (Kirkil, 2018) [24].

In order to examine stomach movement in patients who had antrum preserving laparoscopic sleeve gastrectomy, Baumann *et al.* (2011) created a novel study instrument. Five patients had magnetic resonance imaging six days before and six months following laparoscopic sleeve gastrectomy. Because the sleeve itself lacked propulsive peristalsis, it was demonstrated that the accelerated antral gastric emptying was directly connected to the preservation of the antrum [25].

This is inconsistent with Quercia *et al.* (2014) study which demonstrated improved stomach emptying following full antral resection [26].

Contrarily, in a prospective trial of 21 patients who underwent an antrum preserving sleeve gastrectomy and conducted a scintigraphy test before and 3 months following laparoscopic sleeve gastrectomy, Bernstine *et al.* (2009) found no significant alterations in stomach emptying [27].

Similar findings were demonstrated in the study by Garay *et al.* (2018). Patients who had their antrums removed 2 cm from the pylorus compared to those who had theirs removed 5 cm from the pylorus did not experience any statistically significant differences in excess weight loss percentage at 1 year following laparoscopic sleeve gastrectomy (54.9% 15% vs. 57.7% 23%, respectively; P=0.74). In our work, comorbidities resolved in both study groups during the course of the postoperative follow-up period, however there were no statistically significant differences between the two groups (P>0.05) [28].

After a year, Lakdawala *et al.* (2010) reported that 98% of DM, 91% of HTN, 75% of dyslipidemia, 97% of joint pain, and 100% of sleep apnea had been resolved [29].

According to Brethauer *et al.* (2009), following laparoscopic sleeve gastrectomy, obstructive sleep apnea syndrome was relieved in 93% of patients, HTN was controlled or cured in 78% of patients, and DM resolved and disappeared in 56% of patients with another 37% indicating improvement. These results are in line with those of our study, which revealed that osteoarthritis (50%) and HTN (75%) were the conditions with the best resolution rates, respectively. In terms of quality-of-life factors connected to health, we discovered that the postoperative quality of life score significantly outperformed the preoperative score and was virtually comparable in the two groups [30].

We utilized the Elrefai *et al.* (2017) quality of life score, which has a minimum of 13 and a maximum of 65. A score>52 indicates extremely excellent quality of life. The typical score begins at 50. There were no statistically significant differences between the two study groups in terms of quality of life score during the course of the postoperative follow-up period (P>0.05), and the bariatric quality of life improvement was larger at 12 months postoperatively than at 1, 3, and 6 months [31].

Similar findings were published by Bobowicz *et al.* (2011) using the Bariatric analysis and reporting outcome system (BAROS), who found that 66% of

laparoscopic sleeve gastrectomy patients had high or very good quality of life at 12 months [32].

Just a few longitudinal studies with follow-up periods of at least two years made comments on the quality of life following any bariatric surgery. One year following a laparoscopic sleeve gastrectomy, Strain *et al.* (2011) observed a decline in the Effect of weight on Quality-of-Life score [33].

At five years after surgery, D'Hondt *et al.* (2011) saw a tendency towards weight increase and a decline in quality of life [34].

According to different research, between the third and fifth years of follow-up, the average excess weight loss percentage and quality of life decreased. Carlin *et al.* (2013), in contrast, described consistent quality of life findings from the first through the fifth years of follow-up. According to recent research from the American Society for Metabolic and Bariatric Surgery, death rates for sleeve gastrectomy ranged from 0 to 1.2%, while morbidity rates ranged from 0 to 17.5% [35].

According to Ali *et al.* 2017's review of the literature, the mortality rate following a sleeve gastrectomy was 0.6%, and the most frequent complications were the need for another procedure (4.5%), gastric leakage (0.9%), stricture formation (0.7%), pulmonary embolism (0.3%), bleeding (0.3%), delayed gastric emptying (0.3%), wound infection (0.1%), intraabdominal abscess (0.1%), port site hernias [36].

According to the authors, the risk of various consequences varied, with bleeding ranging from 0% to 16% and gastric leakage from 0% to 5.5%. According to Gumbs *et al.* (2007), leak, which is known to be the most common cause of mortality, ranged from 0 to 1.7% [37].

According to several studies, initiating the division more than 5 cm from the pylorus would improve gastric emptying by protecting the antrum and lowering intragastric pressure (and thereby reducing leakage). Others believed that this item had no effect on the leakage rate or weight loss Ferrer-Márquez *et al.* (2012) [9].

As regard outcomes of type 2 diabetes mellitus after LSG, in spite of nonsignificant statistical value, we reported that there was higher frequency of complete remission after 3, 6 and 12 months in group B: LSG '2 cm' compared to group A: LSG '4 cm' and cases with complete remission were associated with significant higher EWL%.

Finally, we reported that there were no differences between study groups regarding postoperative complications as calf DVT, bleeding, nausea and vomiting.

In a 2018 study, Hanna *et al.* assessed the effectiveness of laparoscopic sleeve gastrectomy (LSG) in treating type 2 diabetes mellitus in individuals who were morbidly obese. They concurred with us and noted that LSG may be regarded as a metabolic surgery because it caused complete remission of T2DM in 87.5% of patients and easy management of diabetes in 12.5% of patients [38].

According to a thorough analysis by Buchwald *et al.* (2004), T2DM resolves similarly following various bariatric surgery techniques [39].

Also, the Swedish obese individuals' research shown that, in comparison to Sjostrom *et al.* (1999), the 2-year restoration rate from DM in the group treated with bariatric surgery becomes much higher [40].

Also, they confirmed that the surgical group had an annual death rate that was 80% lower than the medical group, according to Rubino *et al.* [41].

Similarly, MacDonald *et al.* (1997) discovered that gastric bypass slowed the development of type 2 diabetes in patients who had surgery [42].

The published research largely concurs that patient with long-standing T2DM had reduced remission rates following LSG, mostly because of their suboptimal residual ß-cell activity. Based on Silecchia *et al.* [43].

The primary indicator of diabetes remission following LSG is the length of diabetes. According to the established criteria for diabetic remission, Capoccia *et al.* (2015) reported that individuals with a history of diabetes lasting less than 10 years were cured of the disease [44].

Conclusion

Patients having laparoscopic sleeve gastrectomy are encouraged to have shorter resection distance from pylorus (DP) wherever possible. It has been linked to superior surgical results, weight reduction, and

diabetes mellitus management with no problems recorded.

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