The Correlation between The Length of The Small Intestine and Type 2 Diabetes Mellitus

Original Article

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ABSTRACT

Background: With an average length of 22 feet (7m), or three-and-a-half times the body length, the small intestine is the longest segment of the digestive tract.

Aim: :To determine the relationship between small intestine lengths and type 2 diabetes mellitus (DM) after controlling for glycemic control, age, sex, and BMI.

Patients and Methods: A total of 268 patients (167 men and 101 women) who came to Kasr Alainy Hospital with a recommendation for open abdominal exploration were included in this prospective cross-sectional research.

Results: Total small bowel length was significantly longer among nondiabetic group than diabetic group (413±53cm in nondiabetics vs. 383±30cm in the diabetics) with *P* value 0.0001. BMI, random blood sugar (RBS), and glycated hemoglobin were significantly higher among the diabetic group with *P* values 0.0001, 0.0001, and 0.0001, respectively. Type 2 DM can independently predict shorter small bowel length with *P* value 0.011, odds ratio 10.7(95% confidence interval: 1.7–67.6) after adjustment for age, sex, and BMI. RBS can independently predict shorter small bowel length with *P* value 0.006, odds ratio 0.96(0.94–0.99).

Conclusion: Type 2 DM is associated with shorter small bowel, poor glycemic control is associated with shorter small bowel. Total length of small bowel was significantly shorter in patients with higher RBS more than 200mg/dl and higher glycated hemoglobin more than 6.5%. Type 2 DM can independently predict shorter small bowel length. Higher RBS can independently predict shorter small bowel length.

Key Words: Length, Small intestine, Type 2 diabetes mellitus.

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INTRODUCTION

With an average length of 22 feet (7m), or three-and-a-half times the body length, the normal small intestine is the longest segment of the digestive tract [1].

Nearly all of the nutrients you receive from meals are absorbed into your circulation via the small intestine, which also performs the majority of the digestion process. This is accomplished via the production of digestive fluids, or enzymes, by the walls of the small intestine, which combine with pancreatic and liver enzymes [2].

Understanding the small intestine's varying length is crucial for bariatric surgery, intestinal bypass surgery, enteroscopy, major resection of the small bowel, and other small bowel length-related surgeries, not simply for academic purposes [3].

Small intestine length has been linked in the past to factors including sex, age, height, weight, and ethnicity. According to some research, small intestine length and BMI are positively correlated. According to some research, avoiding the proximal small intestine can help regulate diabetic mellitus (DM). The goal of the current investigation was to determine if short intestine length and type 2 DM were correlated [4].

The purpose of this study was to determine if small intestinal length and type 2 DM were correlated after controlling for glycemic control, age, sex, and BMI.

PATIENTS AND METHODS:

A total of 268 patients (167 men and 101 women) who came to Kasr Alainy Hospital with a recommendation

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for open abdominal exploration were included in this prospective cross-sectional research.

Inclusion criteria

Adult patients who are at least 18 years old and who exhibit signs of open abdominal exploration, such as piercing or traumatic abdominal injuries, or para-umbilical hernias that are strangled or incarcerated. The American Diabetes Association's (ADA, 2021) diagnostic criteria [5]–fasting blood glucose more than 110mg/dl, random blood sugar (RBS) more than 200mg/dl, and glycated hemoglobin (HbA1C) more than 6.5%–were used to diagnose type 2 diabetes. To rule out type 1 DM, a fasting C-peptide level will be measured; a result more than 1ng/dl will be regarded as type 2 DM.

Exclusion criteria

Patients under the age of 18, patients having a history of abdominal surgery to prevent intestinal adhesions that might impede the accurate measurement of small intestine length, patients with gastrointestinal tract cancer, patients with peritonitis, and patients with type 1 DM were all seen.

Methods

All patients were subjected to the following:

The past taking vital signs, doing abdominal and general exams, imaging: computed tomography, ultrasound, radiographs of the chest and abdomen; laboratories: complete blood count, sodium, potassium, urea, creatinine, alanine aminotransferase, aspartate aminotransferase, RBS, and HbA1C. Unstable patients were sent to the operating room right away, such as full from height or abdominal stabs with eviscerated colon.

Intraoperative findings

Quantification using a sterile 10-cm piece of tape placed to the antimesenteric border of an unstretched small intestine, the length of the small bowel was measured in centimetres, beginning at the ligament of Treitz and terminating at the ileocecal junction. When anesthesia was induced, a spasmolytic (visceralgine 5mg/2 ml intravenous) was administered to lessen minor bowel contractions. To improve measurement accuracy, two skilled surgeons took all of the measures. Diabetic patients were defined as those with RBS more than 200mg/dl, HbA1C more than 6.5%, and fasting blood glucose more than 110mg/dl.

Sample size

The sample size was determined using the following parameters in STATA 14.2, version (Stata Corp company, United States, September 2016). A prior study found that the mean±SD small bowel length in patients with uncontrolled DM was 874.9±254.5cm, while the mean small intestine length in patients with managed DM was 769.3±177.9cm. The significance threshold was set at 0.05, the confidence interval (CI) was 95%, and the power was 80%. An estimated 68 patients each group made up the sample size.

Statistical analysis

SPSS, 22nd version, was used for statistical analysis. Continuous data (quantitative) was reported in mean±SD and compared using the Student t test and the paired t test. The X^2 test was used to compare qualitative categorical data that were shown as frequencies and percentages. Following normality testing, the Pearson correlation test was used to determine the relationship between HbA1C and small intestine length. A *P* value of less than 0.05 was deemed significant.

RESULTS:

Age mean±SD 46±16 years, ranging from 18 to 80 years. Males represented two thirds of the included patients (62.3%), while females represented one third (37.7%). Mean±SD weight of the included patients was 79±7kg, mean±SD height 167±7cm, mean±SD BMI 28.4±2.76kg/m^2 (Table 1).

Mean±SD length of the small intestine 409±52cm, mean±SD RBS was 136±38 mg/dl and mean±SD HbA1C 6.14±0.67% among the included patients (Table 2).

Diabetic group was significantly older when compared to nondiabetic groups (59±9 vs. 44±16 years old) with P value 0.0001. Females were more prominent in the diabetic group (65.8 vs. 33%) with *P* value 0.0001. BMI was significantly higher among diabetic groups (30.03±2.15kg/m^2 for diabetic vs. 28.13±2.7 kg/m^2 for nondiabetic) with *P* value 0.0001 (Table 3).

Total small bowel length was significantly longer among the nondiabetic group than the diabetic group (413±53cm in nondiabetics vs. 383±30cm in the diabetics) with a *P* value of 0.0001. BMI, RBS, and HbA1C were significantly higher among the diabetic group with *P* values of 0.0001, 0.0001, and 0.0001, respectively (Table 4).

Small bowel length was significantly shorter among patients with poor glycemic control, as patients with HbA1C more than 6.5% had significantly lower small bowel length (382.9±30.4 vs. 413.3±53.3cm), with *P* value 0.0001.

Logistic regression model showed that sex is significantly affecting the length of small bowel with *P* value 0.0001, and odds ratio (OR) 4.8 (95% CI 2.3–9.89), type 2 DM significantly affect the length of small bowel with *P* value 0.011, and OR 12.78 (1.79–90.9). RBS

significantly affects the length of the small bowel with a *P* value of 0.006 and OR 0.96 (95% CI 0.93–0.98).

Table 1: Demographics among the included patients.

	Mean±SD	Range
Age	46±16	18–80
Sex (n/%)		
Male	167	62.3
Female	101	37.7
Weight (kg)	79±7	63–105
Height (cm)	167±7	152–186
BMI (kg/m^2)	28.4±2.76	21.6–36.73

Type 2 DM can independently predict shorter small bowel length with P value 0.011, OR 10.7 (95% CI 1.7–67.6) after adjustment for age, sex, and BMI. RBS can independently predict shorter small bowel length with a P value of 0.006, OR 0.96 (0.94–0.99).

Table 2: Total bowel length and glycemic profile among the included patients.

	Mean±SD	Range
TSBL (cm)	409±52	280–610
RBS (mg/dl)	136±38	89–241
HbA1C (%)	6.14±0.67	4.67–8.21

HbA1C: Glycated Hemoglobin; RBS: Random Blood Sugar.

Table 3: Comparison of demographics among study groups.

	Diabetes mellitus				
	No		Yes		
	Mean±SD	Range	Mean±SD	Range	*P* value
Age	44±16	18–80	59±9	43–80	0.0001
Sex					
Male (n/%)	154	67.0	13	34.2	0.0001
Female (n/%)	76	33.0	25	65.8	
Weight	79±8	63–105	80±6	65–93	0.41
Height	168±7	152–186	163±6	155–175	0.0001
BMI	28.13±2.7	21.6–36.73	30.03±2.15	25.26–35.44	0.0001

Table 4: Total small length and glycemic profile among the included patients.

	Nondiabetic		Diabetic		
	Mean±SD	Range	Mean±SD	Range	*P* value
TSBL (cm)	413±53	280–610	383±30	310–470	0.0001
RBS (mg/dl)	123±18	89–178	218±12	194–241	0.0001
HbA1C %	5.90±0.33	4.67–6.42	7.56±0.34	6.68–8.21	0.0001

HbA1C: Glycated Hemoglobin; RBS: Random Blood Sugar.

DISCUSSION

Obesity and overweight are characterized by abnormal or excessive fat buildup that may have negative health effects. According to WHO estimates, over 1.9 billion persons globally are overweight (BMI>25kg/m^2), and an additional 600 million are obese (BMI ≥30 kg/m^2) [6,7].

Small bowel length has been proved to positively correlate with BMI, while some studies proposed that bypassing the proximal part of the small intestine provides better glycemic control for type 2 diabetic patients [8].

This study included 268 patients, who had a mean±SD age of 46±16 years, ranging from 18 to 80 years. Males represented two thirds of the included patients, while females represented one third. They had a mean±SD weight of 79±7kg, mean±SD height 167±7 cm, mean±SD BMI 28.4±2.76kg/m^2.

Mean±SD length of the small intestine 409±52cm, mean±SD RBS was 136±38mg/dl, and mean±SD HbA1C 6.14±0.67% among the included patients.

These findings were consistent with the studies conducted by Teitelbaum *et al*., [9] who reported a mean±SD length of small intestine in vivo 506±105cm and Ruiz-Tovar *et al*., [10], who reported a mean±SD length of small bowel 506.5±23.2cm (range, 430–600cm). While our findings were not consistent with the study conducted by Tacchino [11], who reported a mean±SD small bowel length of 690±93.7cm, and Purandare *et al*., [4] who reported a mean±SD length of small bowel of 777.1±186.2cm.

In this study, BMI was positively correlated with RBS with r=0.47 and P value 0.0001, and positively correlated with HbA1C with r=0.41 and P value 0.0001. These findings were similar to many studies in the literature, which correlated the prevalence of obesity with high BMI with higher incidence of type 2 DM, which manifests by elevated RBS more than 200mg/dl and HbA1C more than 6.5% [7,12,13].

In the current study, total small bowel length was significantly longer among the nondiabetic group (413±SD 53 vs. 383±SD 30cm) in the diabetic group with P value 0.0001. Small bowel length was significantly shorter among patients with poor glycemic control, as patients with HbA1C more than 6.5% had significantly lower small bowel length (382.9±30.4 vs. 413.4±53.3) with a P value 0.0001. As well, patients with RBS more than 200mg/dl had significantly shorter small bowel (381.7±30.6 vs. 413±53.1) with P value 0.0001.

Our results are supported by the findings reported by Ruiz-Tovar *et al*., [10] who stated that patients with shorter bowel length benefit from bariatric surgeries in terms of type 2 DM remission postoperatively, as patients with small bowel length 200–220cm had higher type 2 DM remission (92.5 vs. 88.2%) among patients with small bowel length more than 220cm, however this difference was not statistically significant.

Our results contradict the Indian study reported by Purandare *et al.,* [4] who assessed the length of small bowel among patients with type 2 DM, the results showed that small bowel length was significantly longer among patients with HbA1C more than 6.5%, and RBS more than 200mg/dl, and stated that diabetic patients are prone to have longer small bowel.

The conflict between our study and the Indian study conducted by Purandare *et al.,* [4] could be attributed to the ethnic differences between the Egyptian and Indian populations.

Logistic regression model in our study showed that type 2 DM significantly affects the length of small bowel with P value 0.011, and OR 12.78 (1.79–90.9). RBS significantly affects the length of the small bowel with a P value of 0.006 and OR 0.96 (95% CI 0.93–0.98).

This study's logistic regression model also revealed that sex has a significant impact on small bowel length (P value 0.0001, OR 4.8, 95% CI 2.3–9.89); however, these results are in contrast to those of Tacchino [11], who found no significant correlation between age, weight, and sex and small bowel length using a linear regression model.

After controlling for age, sex, and BMI, type 2 DM can independently predict shorter small bowel length with a P value of 0.011, OR 10.7 (95% CI 1.7–67.6). Shorter small bowel length can be independently predicted by RBS with a P value of 0.006, OR 0.96 (0.94–0.99).

CONCLUSION

We concluded that type 2 DM is associated with shorter small bowel, and poor glycemic control is associated with shorter small bowel. The total length of small bowel was significantly shorter in patients with higher RBS more than 200 mg/dl and higher HbA1C more than 6.5%. Type 2 DM can independently predict shorter small bowel length. Higher RBS can independently predict shorter small bowel length.

LIMITATIONS

In our study we faced the limitations of cross section study which couldn't identify any risk factors associated with small bowel length such as Crohn's disease, and also could not identify the confounding factors associated with shorter bowel length (confounding means the distortion of the association between type 2 DM and total small bowel length because a third variable, for example ethnic difference and BMI is independently associated with both). There is a lack of standard small bowel length among Egyptians. In spite of our study assessing this anatomical variation among the included patients, it did not offer a reference value for normal total small bowel length among Egyptians, because of the small sample size (268 cases only).

RECOMMENDATIONS

In addition to the recommendation of monitoring the small bowel transit time and GLP-1 level in patient with short TSBL, we also recommend conduction of large prospective cohort studies that include patients with type 2 DM and assess the length of small bowel, assessment of other risk factors associated with decreased length of small bowel, assessment of the role of other comorbidities in correlation of small bowel length and assessment of nutritional deficiencies associated with short small bowel length.

CONFLICT OF INTEREST

There are no conflicts of interest.

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