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ORIGINAL CONTRIBUTIONS

# Does Size Matter? Correlation of Excised Gastric Specimen Size in Sleeve Gastrectomy to Postoperative Weight Loss and Comorbidities

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**Abstract**
*Background* We present the correlation between excised specimen size in laparoscopic sleeve gastrectomy and patient demographics, comorbidities, and postoperative weight loss.
*Objective* This study aims to address whether the size of gastric specimen excised during laparoscopic sleeve gastrectomy has any correlation with patient demographics, comorbidities, and postoperative percent of excess body weight lost.
*Setting* Study was performed at a community teaching hospital in Michigan.
*Methods* We examined data from 204 patients who underwent sleeve gastrectomy between August 2011 and January 2015. Data was collected retrospectively including demographics, comorbidities, body mass index (BMI), percent of excess body weight lost, and the size of the gastric specimen removed including specimen volume in cubic centimeters, length, width, and thickness in centimeters.
*Results* We found that gastric specimen size does not correlate with initial BMI or change in BMI at 3, 6, or 12 months. Larger specimen sizes were found in males, increasing age, and patients with diabetes mellitus.
*Conclusions* There was no correlation between excised stomach size in laparoscopic sleeve gastrectomy and postoperative weight loss (percent of excess body weight lost) or change in BMI. Male gender, diabetes, and increasing patients' age correlated with larger excised stomach size. Initial BMI and having histological gastritis did not correlate with excised stomach size.

**Keywords** Gastrectomy specimen size · Stomach size and weight loss · Laparoscopic sleeve gastrectomy · Weight loss after sleeve gastrectomy · Stomach and diabetes

## Introduction

The obesity epidemic continues to negatively impact the health of our communities. The financial burden of obesity continues to grow; the Center for Disease Control and Prevention estimated that the cost of medical care for obesity-related illnesses exceeded $147 billion in 2008 [1]. In addition, the estimated economic impact due to the lack of productivity for obesity-related absence was between $3.38 and $6.38 billion [1]. The field of bariatric surgery has grown rapidly over the past decade in an effort to gain control of this growing problem. Bariatric surgery provides a reliable and consistent solution for weight loss and improvement or resolution of many comorbidities associated with obesity [2].

Laparoscopic sleeve gastrectomy is a technique initially performed as the initial stage of a biliopancreatic diversion with duodenal switch, but it has gained popularity as a standalone procedure with adequate outcomes and fewer comorbidities when compared to earlier bariatric procedures including biliopancreatic diversion with duodenal switch and Roux-en-Y gastric bypass [2]. Sleeve gastrectomy involves transection of the stomach in the longitudinal fashion removing the fundus, body, and antrum of the stomach leaving a narrow tubular stomach along the lesser curvature.

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The aim of our study is to determine whether the size of the gastric specimen has an effect on the postoperative excess body weight loss or any correlation to comorbidities. For the purpose of this paper, we focused on our experience with 204 laparoscopic sleeve gastrectomy patients in a community hospital setting completed by a single surgeon.

## Materials and Methods

This study received institutional review board approval. This study included all patients undergoing laparoscopic sleeve gastrectomy in our facility by one surgeon from August 1, 2011 to January 26, 2015. Patient selection was based on the National Institutes of Health/American Society for Metabolic and Bariatric Surgery criteria for bariatric surgery taking into consideration specific patient insurance requirements. Body mass index (BMI) greater than 40 kg/m$^2$ with or without coexisting medical problems or greater than 35 kg/m$^2$ with one or more obesity-induced comorbidities were used as selection criteria as defined in the guidelines paper [3]. No patients were excluded from this study as there were no exclusion criteria.

We used a standardized surgical technique in our sleeve gastrectomy patients. A 34-F bougie was used for all patients. Patients followed up at 3 months (191, 93.6%), 6 months (164, 80.4%), and 1 year (134, 65.7%). During follow-up visits, patients' weight loss, BMI, and status of obesity-related comorbidities were recorded.

## Data Collection and Analysis

Data collected from initial clinic visits included demographics, weight, BMI, and comorbidities. The pathology reports were used to obtain the specimen's length, width, and height (thickness) in centimeters and the volume was calculated by multiplying those three dimensions. *Helicobacter pylori* histological testing was only performed if gastritis was present. The patients were followed at 3, 6, and 12 months and percent of excess body weight loss and BMI were recorded. All continuous variables are described using means and standard deviations, while all categorical variables are described using counts and percentages. Continuous variables are compared between groups using Wilcoxon rank-sum tests due to non-normal distributions. Categorical data are compared between groups using chi-square tests (or Fisher's exact when cell counts are sparse). Statistical significance was set at $p < 0.05$. All analyses are performed using SAS 9.4 (SAS Institute Inc., Cary, NC).

## Results

A total of 204 patients were included in the analysis. There were 150 (74%) females and 54 (26%) males. Mean age was 45.1 years (± 10.8). Mean initial BMI was 49.2 kg/m$^2$ (± 8.2). Seventy-two (37%) patients had diabetes mellitus, 55 (28%) had gastroesophageal reflux disease, 74 (36%) had gastritis, and 6 (3%) had *H. pylori* on specimen pathological examination (Table 1). Our follow-up data was available for 191 patients (93.6%) at 3 months, 164 patients (80.4%) at 6 months, and 134 patients (65.7%) at 12 months.

The descriptive statistics and univariate comparisons between each variable of interest and specimen size (volume, length, width, and thickness) are shown in Table 2. There is a statistically significant and weakly positive correlation between age and specimen volume ($p = 0.003$), meaning that when one increases, the other also increases. Specimen volume differs significantly between males and females, with men having significantly larger mean and median specimen volume than women ($p = 0.004$). Diabetic patients had larger excised stomach volume compared to none diabetic patients ($p = 0.013$).

Table 3 contains the Spearman correlation coefficient ($r$) and $p$ value for each measure of specimen size as it relates to percent of excess body weight lost. It shows that at 6 and 12 months postoperatively, there is a statistically significant, slightly negative correlation between length of specimen and

**Table 1** Descriptive statistics

| Variable | Response | All patients ($N$ = 204) |
|---|---|---|
| Initial BMI (kg/m$^2$) | $N$ mean (SD) | 204 49.2 (8.2) |
| Age | $N$ mean (SD) | 204 45.1 (10.8) |
| Sex | F | 150 (74%) |
| | M | 54 (26%) |
| DM | No | 124 (63%) |
| | Yes | 72 (37%) |
| GERD | No | 140 (72%) |
| | Yes | 55 (28%) |
| Gastritis | No | 130 (64%) |
| | Yes | 74 (36%) |
| *H. pylori* | No | 195 (97%) |
| | Yes | 6 (3%) |
| % EBW lost at 3 months (93.6%)* | $N$ mean (SD) | 191 43.8 (13.6) |
| % EBW lost at 6 months (80.4%)* | $N$ mean (SD) | 164 58.0 (16.6) |
| % EBW lost at 12 months (65.7%)* | $N$ mean (SD) | 134 68.1 (19.2) |
| Change in BMI at 3 months | $N$ mean (SD) | 191 10.2 (3.2) |
| Change in BMI at 6 months | $N$ mean (SD) | 164 13.4 (4.2) |
| Change in BMI at 12 months | $N$ mean (SD) | 134 15.9 (4.9) |

*Follow up rate

Table 2 Correlations with specimen size

| Variable | Result | Specimen volume ($cm^3$) | Length (cm) | Width (cm) | Thickness (cm) |
|---|---|---|---|---|---|
| Initial BMI | *r* | −0.023 | 0.054 | 0.006 | 0.001 |
| | *p* value | 0.747 | 0.447 | 0.936 | 0.990 |
| Age | *r* | 0.208 | 0.300 | 0.045 | 0.105 |
| | *p* value | 0.003 | < 0.001 | 0.518 | 0.137 |
| Gender (F) | Mean (SD) | 286.5 (190) | 20.3 (3.1) | 4.9 (1.6) | 2.7 (0.7) |
| | Median (min, max) | 231 (63, 1512) | 20 (3, 28) | 4.5 (2.5, 18) | 2.5 (1, 5) |
| Gender (M) | Mean (SD) | 364.0 (213.4) | 21.4 (2.6) | 5.2 (1.1) | 3.1 (1.1) |
| | Median (min, max) | 320.6 (120, 1012) | 21.5 (15.5, 28) | 5 (3.5, 8) | 2.8 (1, 6) |
| Gender | *p* value | 0.004 | 0.012 | 0.016 | 0.049 |
| Weight (preop) | *r* | −0.018 | 0.127 | 0.001 | −0.013 |
| | *p* value | 0.796 | 0.071 | 0.989 | 0.858 |
| DM (no) | Mean (SD) | 293.1 (196.6) | 20.1 (3.0) | 5.0 (1.7) | 2.8 (0.9) |
| | Median (min, max) | 230.5 (63, 1512) | 20 (3, 27) | 4.5 (2.5, 18) | 2.5 (1, 6) |
| DM (yes) | Mean (SD) | 334.3 (209.5) | 21.5 (2.9) | 5.0 (1.1) | 2.9 (0.8) |
| | Median (min, max) | 283 (108, 1512) | 22 (15, 28) | 5 (3, 10) | 2.8 (1, 5.5) |
| DM | *p* value | 0.013 | 0.001 | 0.229 | 0.209 |
| GERD (no) | Mean (SD) | 302.0 (197.9) | 20.5 (2.7) | 5.0 (1.6) | 2.8 (0.8) |
| | Median (min, max) | 251.5 (114, 1512) | 20 (15, 28) | 4.6 (2.5, 18) | 2.6 (1, 6) |
| GERD (yes) | Mean (SD) | 323.3 (212.3) | 20.8 (3.8) | 5.0 (1.2) | 2.9 (1.0) |
| | Median (min, max) | 248.5 (63, 1012) | 21 (3, 28) | 5 (3, 10) | 2.5 (1.5, 6.0) |
| GERD | *p* value | 0.642 | 0.208 | 0.679 | 0.751 |
| Gastritis (no) | Mean (SD) | 312.0 (214.2) | 20.8 (2.8) | 5.0 (1.6) | 2.7 (0.9) |
| | Median (Min, Max) | 251 (108, 1512) | 20.5 (15.0, 28.0) | 5.0 (2.5, 18.0) | 2.5 (1.0, 6.0) |
| Gastritis (yes) | Mean (SD) | 297.7 (169.3) | 20.2 (3.4) | 4.9 (1.0) | 2.9 (0.8) |
| | Median (min, max) | 247 (63, 1012) | 20.0 (3, 28) | 4.6 (3.0, 8.0) | 2.8 (1.5, 6.0) |
| Gastritis | *p* value | 0.926 | 0.196 | 0.531 | 0.251 |
| *H. pylori* (no) | Mean (SD) | 306.3 (201.6) | 20.6 (3.1) | 5.0 (1.5) | 2.8 (0.9) |
| | Median (min, max) | 250 (63, 1512) | 20 (3, 28) | 4.8 (2.5, 18) | 2.5 (1, 6) |
| *H. pylori* (yes) | Mean (SD) | 327.0 (121.1) | 20.8 (1.7) | 4.8 (0.9) | 3.1 (0.7) |
| | Median (min, max) | 345 (189, 506) | 20 (19, 23) | 4.8 (3.5, 6) | 3.1 (2.1, 4.0) |
| *H. pylori* | *p* value | 0.353 | 0.726 | 0.771 | 0.296 |

percent of excess body weight lost, but no correlation was found with the total size of the excised specimen.

Table 4 contains the Spearman correlation coefficient (*r*) and *p* value for each measure of specimen size as it relates to change in BMI. It shows no statistically significant correlations at any of the three time points.

## Discussion

Review of the literature on gastric specimen size and correlation with postoperative loss of excess body weight showed that there are limited studies available. There are several papers that evaluate the effect of the bougie size used and the size of the remaining stomach on postoperative weight loss and postoperative complications [4, 5]. A study by Toro et al. discussed the level of compliance, and therefore, capacity of the stomach causing variability in the feeling of fullness and control of satiety [6]. The study suggested that the amount of gastric tissue that should be resected on average is 120 g in females and 160 g in males. This is an equivalent of decreasing the gastric capacity by 1200–1600 ml. Our data showed that males have a statistically significant larger specimen size than females.

We found no correlation between specimen size and percent of excess body weight lost. We hypothesized that a larger excised specimen size would result in increased weight loss, because it indicates that patients had a larger stomach size preoperatively and would likely mean a larger capacity and higher caloric intake preoperatively, thus, resulting in a greater decrease in caloric intake postoperatively compared to their baseline. Another study by Pawanindra et al. found an increase in weight loss in the early postoperative period (3 months) with a larger specimen size, but no correlation with the size of the gastric sleeve [7]. However, it showed no correlation at 6 months or 1 year. We also found that the patient's age correlated with specimen size in that older patients had a larger specimen volume, specifically an increased length.

**Table 3** Specimen size vs postop EBW lost percentage at 3, 6, and 12 months

| Variable | Response | Result |
|---|---|---|
| 3 months postop | | |
| Specimen volume (cm3) | *r* | 0.051 |
| | *p* value | 0.490 |
| Length (cm) | *r* | −0.077 |
| | *p* value | 0.288 |
| Width (cm) | *r* | 0.076 |
| | *p* value | 0.298 |
| Thickness (cm) | *r* | 0.051 |
| | *p* value | 0.486 |
| 6 months postop | | |
| Specimen volume (cm3) | *r* | −0.038 |
| | *p* value | 0.630 |
| Length (cm) | *r* | −0.208 |
| | *p* value | 0.008 |
| Width (cm) | *r* | −0.003 |
| | *p* value | 0.973 |
| Thickness (cm) | *r* | 0.004 |
| | *p* value | 0.955 |
| 12 months postop | | |
| Specimen volume (cm3) | *r* | −0.137 |
| | *p* value | 0.116 |
| Length (cm) | *r* | −0.286 |
| | *p* value | < 0.001 |
| Width (cm) | *r* | −0.160 |
| | *p* value | 0.065 |
| Thickness (cm) | *r* | −0.030 |
| | *p* value | 0.739 |

**Table 4** Specimen size vs change in BMI at 3, 6, and 12 months

| Variable | Response | Result |
|---|---|---|
| 3 months postop | | |
| Specimen volume (cm3) | *r* | 0.131 |
| | *p* value | 0.072 |
| Length (cm) | *r* | 0.089 |
| | *p* value | 0.222 |
| Width (cm) | *r* | 0.125 |
| | *p* value | 0.085 |
| Thickness (cm) | *r* | 0.099 |
| | *p* value | 0.175 |
| 6 months postop | | |
| Specimen volume (cm3) | *r* | 0.061 |
| | *p* value | 0.441 |
| Length (cm) | *r* | −0.027 |
| | *p* value | 0.732 |
| Width (cm) | *r* | 0.063 |
| | *p*-value | 0.425 |
| Thickness (cm) | *r* | 0.069 |
| | *p* value | 0.381 |
| 12 months postop | | |
| Specimen volume (cm3) | *r* | −0.036 |
| | *p* value | 0.680 |
| Length (cm) | *r* | −0.039 |
| | *p* value | 0.656 |
| Width (cm) | *r* | −0.068 |
| | *p* value | 0.433 |
| Thickness (cm) | *r* | 0.047 |
| | *p* value | 0.589 |

We found that diabetes mellitus correlated with increased length and size of the gastric specimen. This could be secondary to diabetic gastropathy from autonomic neuropathy causing slowed gastric emptying. A study by Park et al. compared gastric tissue from patients with and without diabetes mellitus after gastrectomy, and the results showed that those patients with diabetes mellitus had excessive amounts of fibrosis in their gastric smooth muscle and decreased density of interstitial cells of Cajal and platelet-derived growth factor receptor alpha, which are important for gastric motility [8]. It is possible that diabetes-related delayed gastric emptying combined with chronic overdistention of the stomach is the reason patients with diabetes mellitus were found to have larger stomachs.

We also found that there was a weak correlation between increased length of the specimen size and decreased postoperative weight loss, but no correlation was found with total excised stomach size. This could be explained in that having a longer specimen would correlate to an increased remnant stomach volume therefore allowing more caloric intake postoperatively before the patient feels full.

Our results did not show any significant correlation between the size of the excised stomach and preoperative BMI, gastroesophageal reflux disease, presence of gastritis on pathology, postoperative weight loss, or change in BMI. However, Rawlins et al. noted in one study that the tissue thickness of the gastric specimen at the antrum was increased in males and those with a BMI of greater than 50 kg/m$^2$ [9].

## Conclusion

Data regarding correlation of excised gastric specimen size during sleeve gastrectomy, comorbidities, and postoperative success is limited. The aim of our study was to determine whether there was a statistically significant correlation in the excess body weight lost and the size of the gastric specimen removed as well as if there is any correlation with comorbidities and the gastric specimen size. Our data showed no significant correlation between excised stomach size with the patient's initial BMI, postoperative percent of excess body weight lost, or BMI change up to 1 year after surgery. This may indicate that the size of a person's stomach does not correlate with their initial BMI or weight loss success after sleeve gastrectomy. Male gender, diabetes, and increasing patients' age correlated with larger excised stomach size.

**Funding Source** Community teaching hospital GME support.

**Compliance with Ethical Standards**

**Conflict of Interest** The authors declare that they have no conflict of interest.

**Ethical Approval** All procedures—if any—performed in studies involving human participants were in accordance with the ethical standards of the Institutional and/or National Research Committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of study, formal consent is not required.

**Informed Consent** Informed consent does not apply to this retrospective study.

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