Gastric Emptying Studies in the Morbidly Obese Before and After Gastroplasty

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Dual isotope gastric emptying studies were performed on 16 morbidly obese patients before and after gastroplasty to determine the effect of this surgery on the rate of emptying. The solid and liquid phases of gastric emptying were compared with a normal control group. In the 900-g and 50-g meals there was a significant difference in the mean half emptying time between solid and liquid phases of emptying (p < 0.05). Pre-operatively, the 900-g meal half emptying times of both solids and liquids and the 50-g liquid phase meal did not differ significantly between obese patients and the control group. However, in the solid phase of the 50-g meal obese patients differed significantly from a control group (p = 0.007). Three months after gastroplasty, gastric emptying of 50-g meals from the total stomach was not significantly changed from the pre-operative 50-g meal values in ten of 12 patients (p > 0.05) and no change in total stomach emptying times were seen at 12 mo compared to the 3-mo study (p > 0.05). Emptying of the pouch alone for both solids and liquids was significantly faster than the pre-operative and postoperative total stomach studies. Gastric emptying in the obese is normal with large meals, but is delayed in small meals. In most patients, gastroplasty does not result in slower emptying of meals.


Obesity has become a significant health problem in the United States in recent years (1). Morbid obesity is commonly defined as twice ideal body mass or over 100 pounds in excess of ideal weight (2). It is associated with an increased risk of developing a variety of diseases and with increased mortality (2). The etiology of this disorder remains obscure. However, some investigations have described abnormal gastric emptying in the obese (3–5). Gastroplasty is a surgical procedure used in many institutions to treat patients who have failed to lose weight with conventional techniques.

The literature reports discrepant findings on the rate of gastric emptying in morbidly obese patients compared to normal subjects. Lavigne et al. (3) and Horowitz et al. (4) have indicated a correlation between delayed gastric emptying and increased body surface area, while Wright et al. (5) have seen more rapid gastric emptying in obese patients. Abnormal gastric emptying, either rapid or delayed, has thus been linked as a cause in the production of morbid obesity. The purpose of our investigation was to compare gastric emptying patterns in morbidly obese patients with a group of normal weight subjects. In addition, these obese patients had gastric stapling surgery as treatment for their morbid obesity. Each patient served as his or her own control for pre-operative and comparative postoperative gastric emptying studies with 50-g meals to assess the effect of gastroplasty on the emptying of small standardized meals.

MATERIALS AND METHODS

Gastric emptying studies were performed on 16 morbidly obese patients to evaluate their gastric function prior to surgery. The patient group consisted of three males and 13 females with a mean weight of 282 ± 32 lbs. Meal sizes of 50 g and 900 g were used for all patients. A group of 17 normal weight males (mean weight 171 ± 27 lbs.) served as a control group for comparison of 900-g meals. In addition, 12 of these normal weight males (mean weight 169 ± 25 lb) also had 50-mg meal studies for comparison with the pre-operative and postoperative studies obtained on the morbidly obese patients. Informed consent for volunteer subjects was obtained.

Gastroplasty was performed in all patients similar to the method of Gomez (9). In this surgery, a dual

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horizontal staple line is placed across the superior portion of the fundus to a 10-mm dilator positioned in the stomach (Fig. 1). By this technique, a standard 10-mm-sized anastomosis is created that produces a 50-ml proximal pouch.

Two meal sizes were used in this study; 900-g meals were given pre-operatively to all patients and the control group, and 50-g meals were used for the comparative pre-operative studies and for postoperative studies. In all meals, the meal weight was split half and half for solid and liquid food components. The 50-g meal consisted of 25 g beef stew and 25 g orange juice. The 900-g meal contained 200 g beef stew, 200 g applesauce, 50 g bread, 225 g milk, and 225 g orange juice. The solid and liquid radiotracers were mixed with the beef stew and orange juice, respectively.

A solid phase radiotracer of labeled liver paté (7) was prepared by thoroughly mixing 5 mCi of technetium-99m (99mTc) sulfur colloid into 50 g of canned liver paté. This mixture was incubated for 10 min and then placed in a hot pan and stirred occasionally while frying for approximately 10–15 min. During frying, 2- to 5-mm particles of paté are formed. After frying, the preparation was drained on an absorbent towel and 600 μCi of 99mTc-labeled paté was mixed with the solid food. Previous studies have validated the paté method (7) when compared to an in vivo labeled chicken liver technique (8). Liquid gastric emptying was measured using 100 μCi of indium-111 diethylenetriaminepentaacetic acid ([111In]DTPA).

Following an overnight fast, the patient or subject consumed a meal containing 600 μCi of [99mTc]sulfur colloid labeled paté as a solid phase tracer, and 100 μCi of [111In]DTPA as a liquid tracer. All meals were consumed in <10 min. At meal conclusion, images were obtained in the upright position at 15-min intervals using a scintillation camera with a medium-energy collimator. Anterior and posterior images were obtained using 20% energy windows over the 140- and 247-keV photopeaks separately to image each radionuclide. Anterior images for both radionuclides were taken, then the patient was turned for posterior imaging of each

<table>
<thead>
<tr>
<th>Study</th>
<th>Solid T½ ± s.e.m.</th>
<th>Liquid T½ ± s.e.m.</th>
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</thead>
<tbody>
<tr>
<td>Normal subjects (n = 17)</td>
<td>108.8 ± 8.1</td>
<td>74.0 ± 5.6</td>
</tr>
<tr>
<td>Obese patients (n = 16)</td>
<td>108.3 ± 7.8</td>
<td>83.8 ± 7.4</td>
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FIGURE 1
Gomez gastroplasty with formation of 50 cc pouch and 10 mm stoma to stomach

FIGURE 2
Comparison gastric emptying curves of retained stomach activity for 900-g meals. Similar emptying of solids (top) and liquids (bottom) are seen in morbidly obese patients (O, n = 16) as compared with normal weight control group (C, n = 17)
radionuclide. The patients stood during imaging and were seated between images. All images were digitally stored on a nuclear medicine computer system for data processing. Imaging intervals were continued until the half emptying time had been reached for both solids and liquids.

Anterior and posterior regions of interest over the stomach were defined from a computer composite of the anterior technetium images and a composite of the posterior technetium images. Region of interest assignments were made for the total stomach and also for the gastroplasty pouch in postoperative patients. Counts from these regions were corrected for downscatter from the $^{111}$In into the $^{99m}$Tc window and for radioactive decay of $^{99m}$Tc. The geometric mean of the anterior and posterior stomach counts ([anterior count × posterior count]$^{1/2}$) was calculated to correct for the effects of source depth and attenuation (9–12). Linear and exponential curve fitting were respectively applied to the solid and liquid emptying curves, and the half emptying times for liquids and solids were also calculated.

Statistical analysis was performed by the University of Utah Biostatistics Department using the paired Student’s t-test to determine significant pre-operative to postoperative differences in half emptying times. Independent samples t-tests were used to compare obese patients to normals pre-operatively, using the pooled variance t-test or ADF t-test as appropriate (13).

**RESULTS**

Pre-operative comparison of 900-g meals in the 17 normal subjects compared with the 16 obese patients showed equivalent solid and liquid phase half emptying times (Table 1) for the 900-g meals (p >0.05). The solid phase of emptying in both patient and control subjects was linear (Fig. 2); the pattern of liquid emptying was nearly monoexponential. This normal pattern of solid and liquid emptying has been previously described (9, 10). Solid and liquid gastric half emptying times were statistically different in both the obese patients (p = 0.019) and normal subjects (p <0.001).

The 50-g meal studies in 12 of the normal subjects compared with the 16 obese patients prior to their surgery gave solid half emptying times (Table 2 and Fig. 3) that were statistically significantly different (p = 0.007). This was not true for liquids, however (p = 0.087).

The pre-operative and postoperative comparisons on the patients are found in Table 2. All patients received a pre-operative 50-g meal study. At 3 mo (Fig. 4), 12 patients had followup gastric studies and at 12 mo, nine of the patients had followup studies, with all patients having a pre-operative and at least one postoperative study performed. At the 3-mo postoperative period two of the patients had chronic postoperative nausea and vomiting with extended emptying times. Their data

<table>
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<th>Study</th>
<th>Stomach region</th>
<th>Solid T₇/₂ ± s.e.m.</th>
<th>Liquid T₇/₂ ± s.e.m.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal subjects (n = 12)</td>
<td>Total stomach</td>
<td>35.9 ± 5.3</td>
<td>23.9 ± 3.6</td>
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<tr>
<td>Pre-op obese patients (n = 16)</td>
<td>Total stomach</td>
<td>60.5 ± 6.6</td>
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<td>3-mo post-op obese patients (n = 10)</td>
<td>Pouch</td>
<td>26.6 ± 8.2</td>
<td>23.3 ± 6.5</td>
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<td></td>
<td>Total stomach</td>
<td>72.6 ± 10.8</td>
<td>36.0 ± 6.5</td>
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<tr>
<td>12-mo post-op obese patients (n = 9)</td>
<td>Pouch</td>
<td>29.5 ± 9.4</td>
<td>15.0 ± 1.8</td>
</tr>
<tr>
<td></td>
<td>Total stomach</td>
<td>81.2 ± 11.2</td>
<td>28.5 ± 2.5</td>
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**TABLE 2**

Half Emptying Times (min) for 50-g Meals

**FIGURE 3**

Solid (left) and liquid (right) gastric emptying curves for 50-g meals in obese patients prior to surgery, and normal weight control group
were excluded from analysis since they were later diagnosed as having postoperative obstruction.

The pouch—as seen in an example study (Fig. 5)—had very short mean solid and liquid phase half emptying times of 26.6 ± 8.26 min and 23.3 ± 6.5 min. The mean pouch solid phase half emptying time was slightly longer at 12 mo (29.5 ± 9.4 min versus 26.6 ± 8.2 min at 3 mo); however, this was not significantly prolonged. Solid and liquid half emptying times from the pouch at 12 mo were significantly different from the pre-operative measurements (p <0.05).

The total stomach (pouch and residual stomach area assigned in the same region of interest) region half emptying time did not differ significantly between the pre-operative and postoperative studies for either solids or liquids (Table 2). There was a slight increase in the mean solid phase total stomach half emptying time (81.1 ± 11.2 min) at 12 mo.

**DISCUSSION**

The patient and control groups had significant mean body weight differences; however, there was no evidence of a difference in emptying of meals for the larger body size as has been suggested by Lavigne et al. (3) and Horowitz et al. (4). In addition, our studies showed no...
lag period before emptying in our pre-operative obese patients as Horowitz et al. (4) described in their obese patients. The lag period observed by Horowitz et al. (4) may be due to their use of a meal in which all of the solid food is meat, which may require significant mixing before emptying begins.

The 900-g meals were not different in the pre-operative obese patients and the normal weight controls for either solids or liquids. It is curious that the solid phase pre-operative 50-g meal was statistically different than the normal weight group; however, a meal of this size may not be physiologic in the pre-operative stomach. This observation may, however, indicate no difference between obese and normal weight individuals for emptying full meals, while obese people may have slower emptying with very small meals. Lavigne et al. (3) and Horowitz et al. (4) observed longer half emptying in obese patients, which may be due to their use of small meals with low caloric content.

There was a slight increase in solid food half emptying time at 12 mo for both the pouch and total stomach. This longer half emptying time, which has also been observed by Arnstein et al. (14) may relate to the pouch distension after gastroplasty as described by Backman and Rosenborg (15).

Rapid gastroplasty pouch emptying as we have observed has also been seen by two other groups using radionuclide techniques (14,16). Both studies used water as the liquid portion of the meal and solid meals at different composition with lower caloric content resulting in shorter half emptying times. Unlike the more rapid emptying in late postoperative studies which Arnstein et al. (14) observed, we found a slight prolongation in solid food emptying of both the pouch and total stomach in late postoperative studies.

The geometric mean method employed in our studies corrects for depth and attenuation changes within the body as radioactive source positions change (9,10,12). Attenuation variations are more of a problem in the obese than in normal weight individuals and the use of anterior or posterior measurements alone may give rise to artificially prolonged emptying values (10,11).

CONCLUSION

Our study shows that there is no difference in the gastric emptying for solids or liquids in morbidly obese patients when compared with normal weight individuals for 900-g meals. Also, we found no evidence of a lag phase in gastric emptying as has been described by others in obese patients. In addition, in obese patients undergoing gastroplasty, we found the gastric pouch to empty both solids and liquids rapidly, suggesting that the efficacy of the surgical procedure is not related to delayed emptying of food from the pouch but due simply to limitation in the size of the meal permitted by the small pouch.

REFERENCES