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RESEARCH ARTICLE

# An Analysis of Gastric Pouch Anatomy in Bariatric Surgery

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**Abstract**
*Background* The goal of most bariatric surgeons has been to construct small volume pouches in the proximal stomach to restrict the intake of food. The purpose of this study is to demonstrate that in addition to pouch volume, specific gastric pouch anatomy plays a significant role in weight loss.
*Materials and Methods* The physical properties and dynamics of the pouch in our form of gastric bypass were compared with those in the most commonly performed bariatric procedures by creating a model. Our weight loss data were reviewed and compared with data reported in the literature.
*Results* According to LaPlace's and Poiseulle's Laws, a long narrow cylinder will have less wall tension and slower flow rate of material than a wider cylinder. Bariatric procedures with narrow pouches appear to produce better weight loss.
*Conclusions* Long narrow pouches should have less tendency to enlarge and should delay the transit of material to a greater degree than wider pouches according to the LaPlace's and Poiseuille's Laws. Our data and the data of others strongly suggest that long narrow pouches are the most effective operations in bariatric surgery.

This article analyzes the physical properties of gastric pouches with different anatomy. Physical laws related to wall tension and the flow of material through different shaped structures have been studied.

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**Keywords** Gastric bypass · Roux-en-Y gastric bypass · Vertical banded gastroplasty · Adjustable gastric band · Biliopancreatic bypass · Duodenal switch bypass · LaPlace's Law · Poiseulle's Law · Bariatric surgery · Post-bariatric weight loss

## Introduction

Since the first gastric bypass for morbid obesity was first performed by Dr. Edward E. Mason in May 1966 [1], bariatric surgeons have used a myriad of gastric pouches of different sizes and locations for weight reduction. The general tendency has been to construct small pouches in the proximal stomach with the goal of restricting the intake of food. Bariatric surgeons rely almost entirely on anatomic changes to the gastrointestinal tract to produce weight loss. Other complex behavioral and physiologic variables are poorly understood and in general outside their control. Aside from the goal of producing small pouches, there has been limited scientific discussion about the role of pouch anatomy in weight loss. The purpose of this study is to demonstrate that in addition to pouch volume, specific gastric pouch anatomy plays a significant role in weight loss.

## Materials and Methods

The physical properties and dynamics of the pouch in our form of gastric bypass were compared with those of the pouch in the most commonly performed gastric bypass by creating of a model. In addition, an analysis was made of our experience with various materials for restricting the pouch outlet and the experience of other surgeons.

## The Model

Gastric pouches in gastric bypass surgery are conduits for fluids of different viscosity to the rest of the gastrointestinal tract. To analyze certain physical laws that could be applied to gastric reservoirs, we developed a model (Fig. 1). The model compares wall pressure and displacement of material through different shaped structures. Not completely understood behavioral and physiologic variables such as satiety, pattern of eating, ability of the body to retain, or dispose of excessive calories, hormonal and enzymatic action, levels of peristalsis, intrinsic wall resistance and patient compliance are not considered in this model. The model consists of two cylinders of different width and length but of equal volume, 10 $cm^3$. Cylinder Aa has a radius of 0.5 cm and a length of 13 cm. Cylinder Ba has a radius of 1 cm and length of 3.25 cm. To compare the physical properties of these unequally shaped cylinders, we applied both LaPlace's and

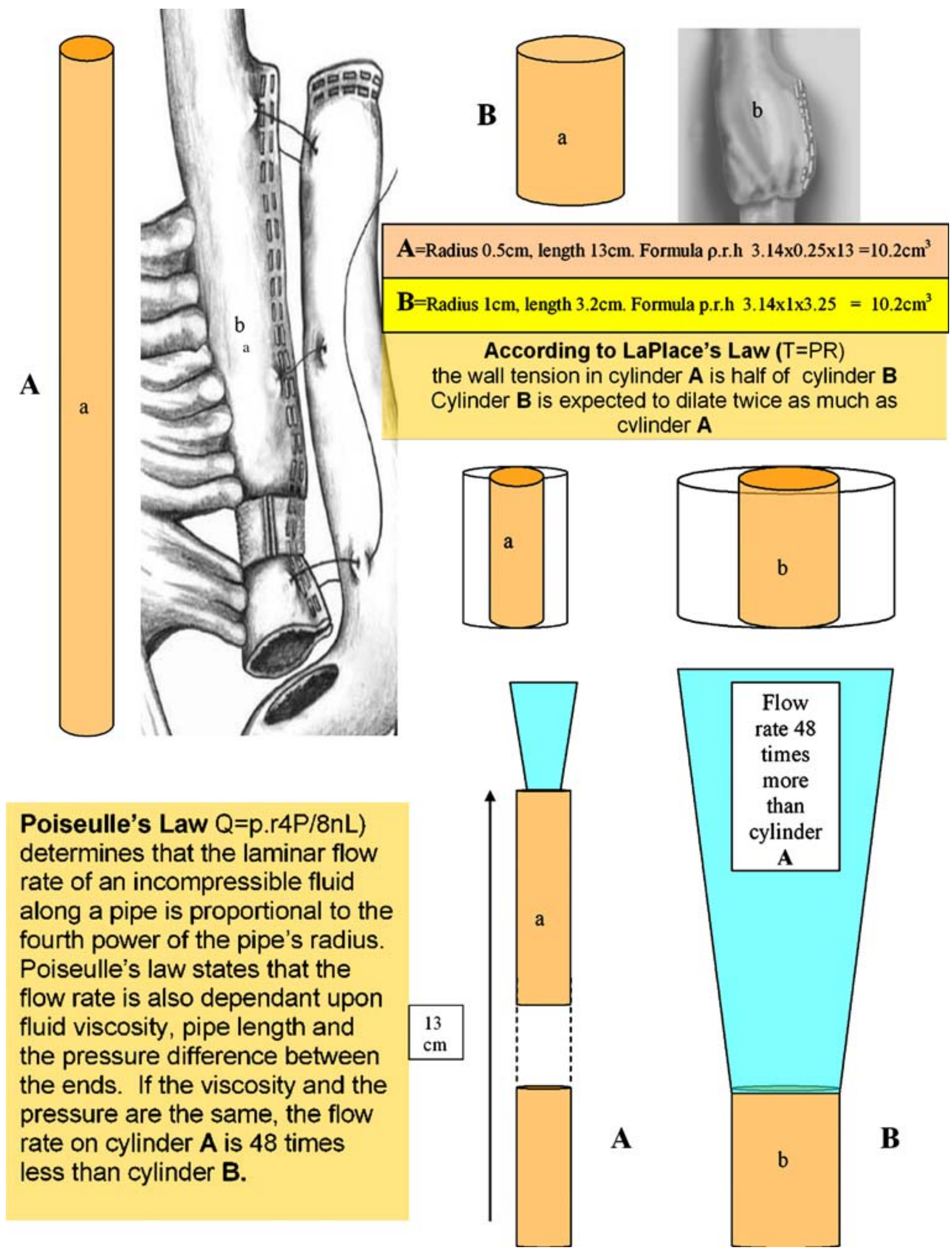



**Fig. 1** Application of LaPlace and Poiseulle's Laws to pouch construction using a model. A long narrow cylinder (13cm × 1 cm) represents our pouch and is compared to a 3.2cm × 2cm cylinder, representing the most common pouch used in laparoscopic surgery

Poiseuille's Laws. Cylinder Aa approximates the dimensions of the pouch in our form of gastric bypass (Ab), and cylinder Ba represents the dimensions of the most commonly constructed pouch in gastric bypass operations (Bb).

## Pouch Anatomy

We analyzed the anatomy of our pouch and the anatomy of the pouch in the most frequently performed gastric bypass. When constructing our pouch, more concern is given to pouch diameter than overall volume; for this reason we construct a relatively long, tubular structure. To create our pouch we follow certain guidelines:

- The pouch should have an internal diameter of no more than 1 cm.
- The tubular structure should be as long as possible without entering the area of the antrum (gastrin producing cells)
- The pouch should be constructed entirely along the lesser curvature. No gastric fundus should be included.
- A restrictive band should be placed around the pouch to prevent the outlet of the pouch from widening.

Our technique for pouch construction has been described. In summary, a long and narrow reservoir is constructed entirely along the lesser curvature of the stomach. Using a no. 28 French buggie or Ewald tube as a guide, a pouch is formed with an internal diameter of 1 cm and a length of between 10 and 18 cm. The pouch is made as long as possible without entering into the gastrin producing cells of the stomach. The distal end of the pouch extends to the level of the Crow's foot. A trapezoid area is designed at the distal end to facilitate the gastrojejunostomy (Fig. 1Ab).

The majority of bariatric surgeons performing restrictive procedures or gastric bypass construct small pouches at the proximal stomach. Most of the pouches created with these techniques, particularly with a laparoscopic approach for gastric bypass, are short and wide enough to accommodate a 25-mm circular stapler (Fig. 1Bb and Table 1) [2].

## Outlet Restriction

As a restrictive prosthesis, we have used silastic rings, Gore-tex, silastic bands, and polypropylene meshes. Since 1990, polypropylene mesh was utilized in 2,425 primary cases, silastic tubing in 566 cases, a wide band of silastic in 49 cases and Gore-tex in one case. No restrictive band was applied for technical reasons in 11 cases and in 14 patients cases, the material used were not recorded (Fig. 2a–c). When applying the 8-French Silastic tube, the length of the material was 6 cm and contained a no. 1 polypropylene suture that was tied over a 13-mm cervical dilator. When utilizing flat bands such as propylene mesh, the silastic band and Gore-tex, the materials were cut to measure 7.5 cm in length and 1.2 cm in width. The bands were marked with stitches 1 cm

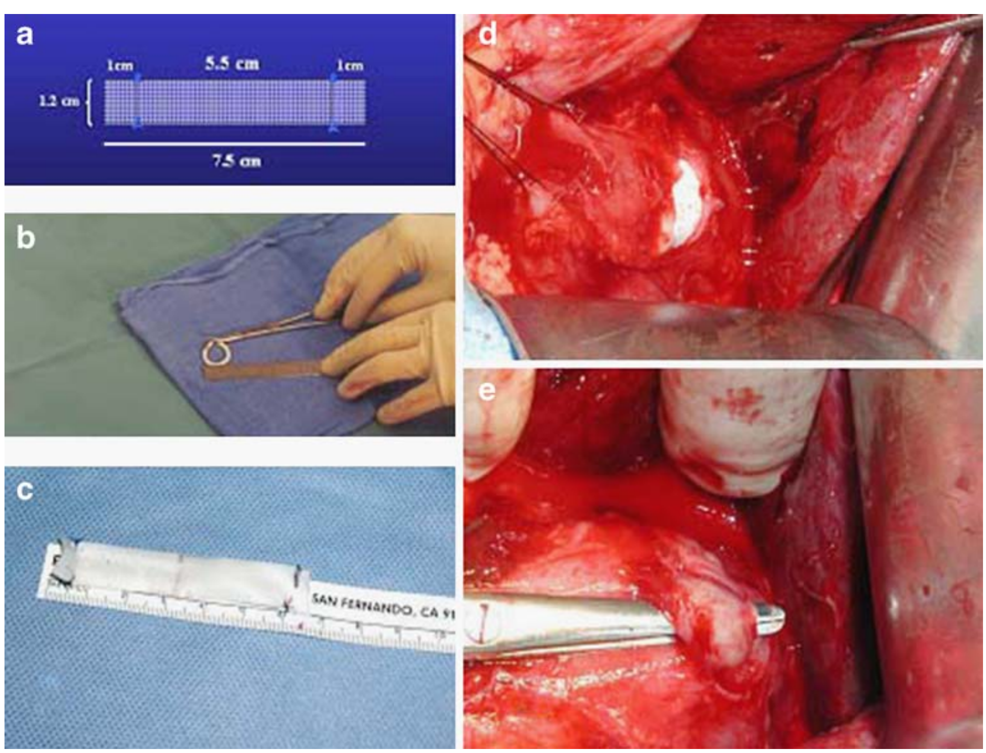
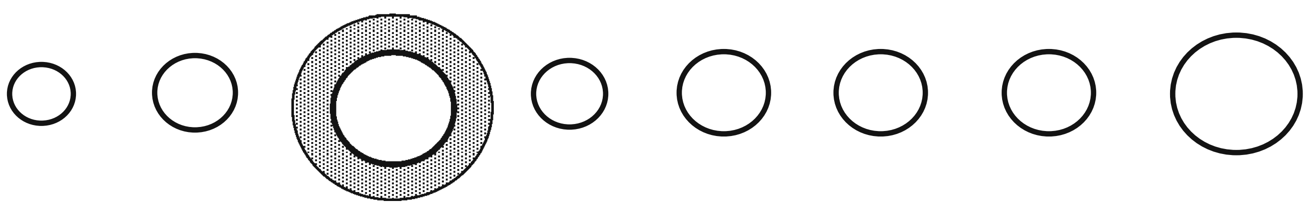



**Fig. 2** Preparations for gastric bypass proccedure

**Table 1** Lumen of the gastric outlet assuming a gastric wall thickness of 3 mm

| Gastric bypass | | | VBG | | Gastric bypass | | |
|---|---|---|---|---|---|---|---|
| Anastomosis | | | | | Restrictive bands | | |
| Mono filament propylene | Dexon sutures | Circular stapler 25 mm | Polypropylene band | Polypropylene band | Silastic band | Silastic band | Silastic band |
| Pories et al. | Sugerman et al. | Stahl R et al. | Mason and Ito | Capella et al. | Fobi et al. (1991) | Fobi et al. (1998) | Fobi et al. (2005) |
| | | | Formula: C=π.d gastric wall thickness approximately 3 mm | | | | |
| | | | Circumference 5.0 cm | Circumference 5.5 cm | Circumference 5.5 cm | Circumference 5.5 to 6.5 cm | Circumference 6.0 to 7.0 cm |
| | | | Diameter=1.59; 1.59−0.6= 0.9 cm | Diameter=1.75; 1.75−0.6= 1.1 cm | Diameter=1.75; 1.75−0.6= 1.1 cm | Diameter=1.90; 1.90−0.6= 1.3 cm | Diameter=2.2; 2.2−0.6= 1.6 cm |
| 0.8 cm | 1.0 cm | 1.5 cm | 0.9 cm | 1.1 cm | 1.1 cm | 1.3 cm | 1.6 cm |



from each end to create a working circumference of 5.5 cm (Fig. 2a–c). The majorities were secured around the pouch with two large metal clips placed at the level of previously marking sutures; the excess band was excised. At present, we exclusively use the polypropylene mesh. It is placed approximately 2 cm proximal to the anastomosis. The band transverses a portion of the gastrohepatic omentum to prevent migration distally (Fig. 1Ab). When in position, the mesh should fit loosely around the pouch. Our form of gastric bypass has been described in detail before [3]. Techniques for gastric bypass not utilizing restrictive bands have restricted the outlet of the pouch by limiting the size of the anastomosis. Pories et al. and Livington et al. construct anastomosis with a diameter of 0.8 cm [4] and 1.0 cm [5], respectively. Early laparoscopic gastric bypasses were performed with gastrojejunostomies measuring 1.2 cm [6] in diameter. The trend recently has been to use a circular stapling device with a diameter of 25 mm. The resulting internal lumen measures 1.5 cm (Table 1) [7–9]. We review our experience with the four different prosthetic materials used to restrict the pouch outlet including the number of erosions, stenosis, and cases of band intolerance requiring removal (Table 2).

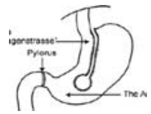
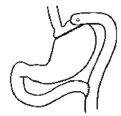
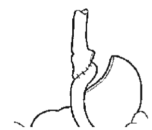
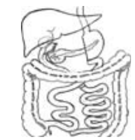
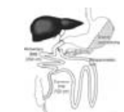
**Table 2** Complications related to the restrictive band

| Material | Number | Erosions | Percent | Intolerance/ removal | Percent |
|---|---|---|---|---|---|
| Goretex | 1 | 1 | 100 | | |
| Silastic tubing | 566 | 8 | 1.4 | 6 | 1 |
| Silastic band | 49 | 0 | 0 | 8 | 16 |
| Polypropylene | 2425 | 7 | 0.2 | 6 | 0.2 |

## Weight Loss Analysis

We review weight loss data at 3, 5, and 10 years for our technique that has been published in journals or presented in medical forums. These reports include data on our overall morbidly obese patient population, the superobese [3], adolescents [10] and the supersuper obese (tripleobesity) [11]. We also compare our results with weight loss following other bariatric procedures reported in the literature over the last 14 years (Table 3). When comparing the efficacy of different procedures, specific important parameters were recorded when available: initial weight or BMI, number of superobese individuals (≥225% of ideal weight), specifically defined postoperative contact intervals, and patient eligibility at each interval as recommended by the International Bariatric Surgery Registry (IBSR) [12]. In analyzing short-term (3 year), midterm (5 year) and long-term (10 year) weight loss results reported in the literature (Table 3), we grouped the cases into three different categories: purely restrictive operations, proximal gastric bypasses and mal-absorption procedures. The purely restrictive procedures were divided into banded and non-banded; the gastric bypass category was subdivided into three groups: non-narrow pouches, narrow pouches without

**Table 3** Weight loss 3–10 years as reported in the literature

| | Restrictive | | Roux-en-Y gastric bypass | | | | | | | | Malabsorption procedures | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Author(s) | O'Brien et al. | Robinson et al. | Yale | Pories et al. | Balsiger, et al. | Wittgrove and Clark | Higa et al. | MacLean et al. | Fobi et al. | Capella and Capella | Marceau, et al. | Marceau, et al. |
| Publication<br>Year publication | Obes Surg<br>2002; 12:<br>652–660 | Obes Surg<br>2003; 13:<br>10–16 | Arch Surg<br>1989; 124:<br>941–946 | Ann Surg<br>1995; 222:<br>339–352 | Mayo Clin<br>2000; 75:<br>673–680 | Pro Obes Surg<br>2000; 10:<br>233–239 | Laparoendoscopic<br>2001; 6:<br>377–382 | Ann Surg<br>1999; 231:<br>524–528 | World J. Surg<br>1998; 9:<br>925:935 | Am J Surg<br>2002; 183:<br>117–123 | World J. Surg<br>1998; 22: 947–954 | World J. Surg<br>1998; 22:<br>947–954 |
| Type of surgery | Restrictive Lap Band | Restrictive lesser curvature | GBP-greater curvature | GBP-Greater curvature | GBP-Oblique | GBP-Sacular | GBP-Short vertical pouch | GBP-lesser curvature | GBP-lesser curvat./B | GBP-lesser curvat./B | Malabsorption-BPD | Malabsorption-Duodenal switch |
| |  |  |  |  |  |  |  |  |  |  |  |  |
| Preoperative | | | | | | | | | | | | |
| Number of patients | 709 | 100 | 251 | 608 | 191 | 500 | 1500 | | 25 | 652 | 233 | 457 |
| Initial BMI | 45 | 46 | | 49 | 49 | | 46 | 44[a] | 46 | 50 | 46 | 47 |
| Percent ideal weight | | 206 | | | 221 | | | | 208 | 221 | 101 | 105 |
| Weight kilograms | 125.9 | 127 | 132 | 138 | 138 | | | | | 140 | 122 | 126 |
| Weight pounds | 277 | 279 | 290 | 304 | 303 | | | | | 308 | 268 | 277 |
| Percent morbidly obese | | | 75 | | | | | 54 | | 58 | | |
| Initial BMI superobese | | | | | | | | 56 | | 60 | | |
| Percent superobese | | | 25 | | | | | 46 | | 42 | | |
| Postoperative all patients | | | | | | | | | | | | |
| Years follow-up | 5 | 5 | 5 | 5 | 3 | 5 | | 3–8 | 4 | 5 | 8.3 | 1.7–6 |
| Patients eligible | | 16 | | | 98 | 4 | | | 25 | 112 | | |
| Time interval months | 60 | | | | | | | | | 53–65 | | |
| Percent follow-up | | 70 | 90 | 98 | 74 | | | 87 | 96 | 63 | 93 | 93 |
| Final BMI | | | | 31 | 34[a] | x | | 29[a] | | 29 | 32 | 30 |
| weight loss kg | | 41 | 42 | | 52 | | | | | 58 | 37 | 46 |
| Weight lost pounds | | | 92 | 98 | | | | | | 128 | 81 | 101 |
| Percent excess lost BMI | | | | | | | | | | | | |
| Percent excess wt lost | 54 | 61 | 60 | 58 | 66 | 77 | 62 | | 75 | 77 | 61 | 73 |
| >50% excess wt. loss | | 43 (72) | | | 53(72) | 80 | | (93)[a] | 100 | 72 (93) | 74 | 87 |

Spaces left blank when data are not available; numbers in parentheses are percents

[a] Superobese excluded

outlet prosthetic restriction, and narrow pouches with outlet restriction. The mal-absorption category was divided into procedures in which restriction is created along the lesser curvature and procedures in which restriction is not limited to the lesser curvature of the stomach.

## Results

### Gastric Pouch Model

According to Laplace's Law as depicted in Fig. 1, cylinder Ba (2 cm diameter) will have twice as much wall tension as cylinder Aa (1 cm diameter). If the pressure and viscosity of the material going through the pouch is the same, the rate of flow is 48 times faster through cylinder Bb than cylinder Aa, according to Poiseulle's Law (Fig. 1).

### Restrictive Prostheses

Complications related to the restrictive band are depicted in Table 2. The three smooth restrictive implants (Gore-tex, silastic ring and silastic band) were associated with a higher incidence of stenosis and migration into the lumen. The Gore-tex band was used once and eroded into the lumen of the bowel. Smooth implants were found to create a capsule of unpredictable thickness that would reduce the size of the proposed lumen (Fig. 2d, e). The silastic band was found to create a very thick capsule; in 16% of these cases, band removal was required and in 47%, one or more endoscopic dilatations were needed. It is interesting that patients with silastic bands were completely asymptomatic in the first few weeks after surgery and developed symptoms of outlet obstruction 4 to 6 weeks post-operatively. We also noted that even when the band was removed at the time of revisional surgery, patients would continue to have symptoms of outlet obstruction for 3 to 6 weeks. An unexpected postoperative recovery in three patients brought this to our attention; one patient had a silastic non-adjustable band placed outside of the United States, and the other two patients had silastic tubing and a silastic band, respectively. These patients continued to present with symptoms of outlet obstruction even after removal of the bands and despite dilatation to 18 mm in two of them. Three weeks after removal of their prostheses, the patients began to improve and 6 weeks later were able to eat a normal diet. We also learned that the capsules of the silastic bands are very elastic and in some instances were dilated to 18 mm only to re-stenose a few weeks later. The capsule of a silastic ring dilates only slightly because of the threaded proline suture inside the tubing. Regarding polypropylene mesh, there were six cases where mesh removal was required. It appeared that mesh was too short and had been measured incorrectly in one case. In the other cases where the mesh was removed, the lumens were found to be adequate by endoscopy and contrast studies; the patients in these cases demonstrated their intolerance to the bands by recurrent vomiting; they included an individual with severe mental illness, an older patient with diabetes, and three other older patients with upper teeth prosthesis.

### Weight Loss Results

From November 1994 to April 2000, 652 consecutive patients were analyzed who underwent our current form of gastric bypass; these were primary cases in individuals with no history of previous bariatric surgery (Table 3) [1]. We also report 1–10 year follow-up weight loss data for 19 consecutive adolescent patients, ages 13–17, for cases performed between May 1990 and August 2001 [10]. We presented a review of 105 consecutive patients with a BMI of 70 or higher whose gastric bypasses were performed from 1994 to 2004 [11]. In Table 3, we summarize weight loss articles published in the bariatric literature. Publications have been chosen that report on purely restrictive procedures, roux-en-Y operations and mal-absorptive operations. Comparing the efficacy of different procedures is difficult because the lack of uniformity in methods of recording weights. Follow-up intervals and patient eligibility are often not clearly defined as recommended by the American Society for Bariatric Surgery [12]. Reports of weight loss at 5 years are few. Midterm reports for the superobese are not available after laparoscopic roux-en-Y gastric bypass, and the only one reported for the general obese population [13] is not suitable for comparison because of the low initial weight of the patients (BMI <55 in 99.4%, BMI <45 in 80%, BMI <40 in 37.5%) and the few patients (4 of 500) that qualified for the 5-year follow-up.

Despite the limitations in comparing weight loss data, it appears that long narrow pouches produce better weight loss. In the purely restrictive category, the two series analyzed [14, 15] are nearly identical in preoperative BMI and weight; patients with a lesser curvature pouch without restriction had greater weight loss than those with the adjustable laparoscopic band, 61 and 54% excess weight loss at 5 years, respectively. When assessing gastric bypass, Yale CE [16] and Pories WJ et al. [17] report an excess weight loss at 5 years of 60 and 58% respectively. The techniques in both of these studies utilize a transverse fundic pouch and the outlets are restricted with an 8- [16] and 12-mm [17] anastomosis. Balsiger BM et al. [18] report a weight loss of 66% at 3 years with their form of gastric bypass; their technique incorporates a small cardiac pouch and a side to side anastomosis with a circular stapler (the size of the stapler is not indicated). It should be noted that the average initial BMI and weight of the patient population in these last three studies is greater than for the above mentioned restrictive procedures. Higas KD et al., report an excess weight loss of 62% at 3 years with an initial average patient BMI of 46 [19]. The authors create a short vertical pouch; the diameter of the pouch is not described. The hand-sewn gastrojejunostomy is calibrated around a number 32–34 gastric tube. MacLean LD et al. [20] construct a narrow pouch along the lesser curvature using a number 28–32 gastric tube as a guide; the hand sewn anastomosis is not restricted. Their average initial patient BMI is relatively low (44) because they exclude the superobese from the study. The study has a follow-up of 88.6%; however, the patient eligibility at the 5-year interval and percentage follow-up are not included. Their reported follow-up at 5 years appears to include all patients contacted after 3 years. Although the study does not indicate the percentage excess weight loss, their patients attain a BMI of 29 and 93% lose more than 50% of their excess weight. Fobi M. et al. [21] report 75% excess weight loss at 4 years in two small (25 patients) relatively light groups of patients. In addition, they report that 100% of these patients lost more than 50% of their excess weight. With their technique, the pouch is formed by transecting the stomach longitudinally from a point 7 to 8 cm distal to the gastroesophageal (GE) junction along the lesser curvature to a point just lateral to the GE junction. A silastic ring 5.5- to 6.5-cm long is placed to restrict the pouch outlet. In later reports, the diameter of the silastic ring has been as long as 7 cm [22]. Our technique for pouch construction is described above; with an initial average BMI of 50, 112 patients in our study were eligible for 5-year follow-up. The average patient BMI was 29 at this interval and average percentage excess weight loss was 77%. Ninety-three percent of patients lost more than fifty percent of the excess weight [1].

Marceau et al. [22] compare their own series of bilio-pancreatic diversion (BPD) and duodenal switch procedures (DS). They found the DS procedure to be most effective. With an average initial patient BMI of 47, they report an excess weight loss of 73%. Eighty-seven percent of their DS patients lost more than fifty percent of the excess weight.

## Discussion

### Physical Laws Applied to Pouch Construction

The many complex anatomic and physiological variables encountered in gastric pouch construction make the precise application of physical principles difficult. Despite these variables, La Place's law suggests that a pouch with diameter of 1 cm will dilate only 50% as much as a pouch with a 2 cm diameter. As a pouch dilates, its restrictive capacity diminishes. Poiseuille was able to demonstrate that 16 tubes of 0.3-cm diameter are needed to deliver the same amount of water as a tube of 0.6 cm diameter. If we apply this law to our model, 48 pouches of 1-cm diameter and 13-cm length are needed to deliver the same amount of fluid as a pouch of 2-cm diameter and 3.25-cm length. The application of both of these principles suggests the importance of pouch anatomy on weight loss in bariatric surgery; nevertheless, the relevance of these laws to a clinical setting is probably limited. The pouches are not perfect cylinders; the walls are not rigid and are of variable distensibility. Peristalsis and possibly antiperistalsis are likely to play a significant role in the transport of materials. Despite these poorly understood variables, a pouch with a larger original diameter will very likely have a greater tendency to distend than a narrower pouch; furthermore, the transport of the material through a narrow pouch is likely to be slower and produce a longer sensation of fullness than a short and wide pouch. The studies of Deitel et al. [23] confirm these findings. Our feeling is that very small pouches [16] or micro-pouches [24] are not necessarily more effective. If this were the case, no pouch at all would theoretically be even more effective. Studies by Liedman B et al. [25] on non-obese gastrectomized patients ingested an average of 8,980 calories daily, and they had marginal weight loss at 1 year and 5 years.

### Restriction at the Pouch Outlet

Collective data from over 40 years of bariatric surgery suggest that some kind of outlet restriction is indicated. The ideal pouch outlet should probably have a diameter somewhere between 0.8 and 1.2 cm. With an outlet diameter less than 0.8 cm, some patients are likely to consume excessive amounts of high calorie liquids. Outlets larger than 1.2 cm are less effective because patients can ingest more food, especially if the dumping phenomenon has abated a common finding 2 years post-operatively. To prevent strictures laparoscopic surgeons have opted to use larger circular stapled anastomosis. When restriction is applied proximal to the anastomosis, the size of the gastrojejunostomy becomes irrelevant and can be made as wide as the size of the jejunum. Loss of dumping may explain why weight loss for un-banded gastric bypass patients is similar to weight loss in patients with an adjustable gastric band. It is unfortunate that there is such of dearth of weight loss studies available following laparoscopic gastric bypass despite the thousands of procedures that have already been performed. There is no published data available on midterm or long term weight loss in the laparoscopic treatment of the superobese.

Much has been discussed informally about the benefits and complications related to restrictive prostheses. Most of the objections to the use of these materials have been anecdotal; the data in this study support their use. Two restrictive prostheses have been extensively used and appear to be safe: the polypropylene band and silastic tubing. There appears to be a significant difference between silastic tubing and polypropylene mesh. Neither is reactive; however, the body's response to these implants is different. Like all smooth implants (smooth prosthetic breast implants, adjustable silastic gastric bands), they produce a capsule of unpredictable thickness [26]. From our small but significant experience of 49 cases in which silastic bands were placed as restrictive prostheses in gastric bypasses (January to June 2000), we acquired a better understanding of how the body reacts to smooth, silastic implants. Our series revealed that patients would not become symptomatic until four to six weeks post-operatively. This indicated that it took at least this long for a significant scar capsule to form. To our surprise, we also discovered that removal of the band without removing the capsule does not alleviate the symptoms or signs of obstruction immediately. It would usually take several weeks following removal of the prostheses for the remaining scar capsule to become clinically insignificant. We have noted the variable thickness of the capsule when removing adjustable gastric bands and smooth implants in revisional surgery (Fig. 2d and e). This unpredictability of the capsule may be the reason why proponents of the silastic ring have been increasing the diameter of the ring over the last 16 years. Fobi's group reported the circumference of the silastic ring to be 5.5 cm in 1991 [27], 6.5 cm in 1998 [28] and as long as 7 cm in the most recent study [29]. Stubbs RS et al. [30], using silastic rings, report a 14% ring removal with 5.5 cm, 5.1% with 6 cm ring and 2% with a 6.5 cm ring. This variation in size is probably secondary to the unpredictability of the thickness in the capsular formation.

The reaction of the body to polypropylene mesh is different; instead of forming a capsule, collagen fibers in growth through the interstices of the mesh stabilizing the diameter of the band. In all of our publications, we have described the use of a 5.5-cm polypropylene mesh [3, 10, 30]; this working circumference allows patients a wide choice of foods with a minimal incidence of strictures or intolerance, an indication that the intended lumen is maintained [25]. An interesting corollary to our findings in the use of polypropylene mesh in bariatric surgery is to the management capsular contracture following augmentation mammoplasty with smooth silicon prosthetic implants. Capsular contracture is a condition of which the exact cause is not known in which a thick scar forms around silicon breast prosthesis. The generally agreed upon treatment of this condition is to remove the scar capsule surrounding the implant and to then replaces the smooth implant with a textured implant.

### Weight Loss

Our data suggest that vertically oriented narrow pouches with outlet restriction produce better weight loss than wider pouches and those without annular, prosthetic restriction. This finding may be partly attributable to known physical laws. Narrow pouches should have fewer tendencies to dilate than pouches with a larger diameter despite similar volume (LaPlace's Law). If other physiological variables are not taken into consideration, patients with long, narrow pouches should have a longer emptying time than individuals with short and wide pouches (Poiseuilles' Law). If we accept these laws to be applicable to the anatomic changes created by bariatric procedures, pouches with less tendency to dilate and pouches that produce a longer sensation of fullness should be more effective in producing weight loss. The above concepts have been corroborated by two recent studies; O'Brien et al. [14] compiled 18 articles with weight loss data following laparoscopic adjustable gastric band (1–8 year follow-up) and compared that to standard gastric bypass (gastric bypass without prosthetic restriction). They concluded that after 2 years that there was no significant difference in weight loss between the two procedures. They also concluded that the BPD and banded gastric bypass produce better weight loss. For the first time, randomized studies have been carried out (Bessler et al. [31]) comparing banded and non-banded gastric bypasses in the superobese. Bessler et al. found a significant difference in excess weight loss at 3 years. The non-banded group lost 57.7% of their excess weight and the banded group 73%. The weight loss in the banded group is very similar to our results in the superobese. Again, the lack of uniformity in reporting the data makes comparisons difficult. According to information reported by Marceau et al. [32], narrow pouches with restriction or without restriction appear to be more effective than BPD and DS.

## Conclusions

Long narrow pouches should have less tendency to enlarge and should delay the transit of material to a greater degree than wider pouches, according to the Laplace's and Poiseuille's Laws. Strict application of these physical laws to the clinical biological setting will require further research. Our data suggest that the best currently used material to restrict and maintain the intended lumen of a gastric pouch outlet is polypropylene mesh. Polypropylene mesh has a lower incidence of erosion, migration and intolerance as compared to other materials used to control the outlet of the pouch. Our data and the data of others strongly suggest that long narrow pouches with a restrictive outlet are the most effective operations in bariatric surgery.

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