Influence of Jejunoileal and Common Limb Length on Weight Loss Following Roux-en-Y Gastric Bypass

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Received: 14 February 2008 / Accepted: 15 February 2008 / Published online: 6 May 2008
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Abstract
Background Capella surgery is one of the technical variations of Roux-en-Y gastric bypass. The method includes the preparation of an alimentary (Roux) limb with a standardized length (110 cm) in order to induce deficiencies in the absorption of macronutrients and thereby contribute to weight loss. The recognized variation in jejunoileal length in humans (approximately 4 to 9 m) is not considered, although this range correlates with the wide variation in the length of the common limb.
Methods In order to assess the influence of variations in jejunoileal and common limb lengths on weight loss, intraoperative measurements were made of these segments on 100 patients undergoing Capella surgery. Patients were followed for a period of 1 year. Statistical analysis included subdivisions of the population by gender and body mass index.
Results Average jejunoileal length was 671.4±115.7 cm (434–990 cm). Average common limb length was 505.3±113.3 cm (268–829 cm). No correlation was detected between jejunoileal length and weight loss at 6 months or 1 year following surgery. A weak negative correlation was detected between weight loss and common limb length at 1 year following surgery in male and super-obese patients.
Conclusions Jejunoileal and common limb length vary widely in gastric bypass patients. To make modifications in the alimentary and/or biliopancreatic limb length, surgeons must consider the variability of the jejunoileal and common limb length.

Keywords Obesity surgery · Malabsorption · Gastric bypass · Intestinal length

Introduction

Bariatric surgery has been proven more effective than other conservative treatments with regard to weight loss, the control of diseases associated with obesity, and improvements in quality of life [1, 2]. The most frequently employed method in Brazil and the world at large is the Roux-en-Y gastric bypass (RYGB), of which Capella surgery is a variation. The malabsorptive element of RYGB is the exclusion of the duodenum and the initial portion of the jejunum, as well as the preparation of a relatively long alimentary (Roux) limb. The degree of malabsorption can be modified by altering the length of the alimentary limb.
In Capella surgery, the alimentary limb has a standard length of 110 cm, which has been defined empirically [2, 3]. However, the method fails to take into consideration the recognized variation in jejunoileal length in humans (approximately 4 to 9 m) [4–7]. Due to this variation, the length of the common limb (segment with preserved function) can vary widely. The importance of this factor regarding weight loss is unknown.

Studies on the influence of intestinal length over weight loss following RYGB are fundamental in evaluating the real importance of the mal-absorptive element of this method.

**Method**

The present observational, prospective study was carried out at the Instituto Alfa de Gastroenterologia of the Clinical Hospital of the Federal University of Minas Gerais (UFMG), with the approval of the Research Ethics Committee of this institution. The population included patients of both genders with a BMI ≥40 kg/m², who had undergone surgical treatment for morbid obesity between June 2004 and September 2005.

Exclusion criteria are as follows:

- Patient refuses to participate
- Alteration in the gastrointestinal tract resulting from previous operations (resections, bypass, etc.)
- Technical impossibility of measuring the intestine (adherences, difficulties in exposing the intestine, etc.)
- Occurrence of complications influencing weight loss (digestive fistulas, etc.)
- Appearance of diseases or other conditions (pregnancy, drug use, etc.) with a potential influence over weight loss
- Lack of follow-up
- Death during the first year following surgery

All patients who underwent RYGB with the following standardizations:

- Supra-umbilical midline laparotomy (10 to 15 cm)
- Vertical gastric reservoir with 30 to 40 ml capacity
- Silicone band with circumference of 6.2 cm
- Alimentary limb with length of 110 cm
- Gastrojejunal anastomosis with a diameter of about 2 cm

The section point of the jejunum was defined by the identification of a favorable vascular arcade, which allowed the transposition of the alimentary limb to the supramesocolic compartment with little tension. The length of the biliopancreatic limb consequently presented some variation.

Intestine measurements were taken from the duodenojejunal flexure (Treitz angle) to the ileocecal junction. All measurements were performed by the principal author of this study. The procedure was carried out at the first manipulation of the intestinal limbs using a 45-cm length of 2.0 silk thread. The intestinal limbs were measured on the anti-mesenteric margin, applying the minimum tension necessary to obtain a straight measurement of the limbs. The alimentary limb and biliopancreatic limb were measured following the section of the jejunum for the preparation of the Roux Y. The length of the common limb was calculated by subtracting the lengths of these segments from the total length of the jejunoileal segment (JIS).

Data collection was carried out at 6 months and 1 year following surgery. Relationships between weight loss and jejunoileal and common limb length were assessed using simple linear regression (5% significance level). Additional statistical analyses were carried out for the following subdivisions:

- All patients (n=100), with and without outliers
- Female patients (n=76)
- Male patients (n=24)
- Patients with BMI<50 kg/m² (n=79)
- Patients with BMI≥50 kg/m² (n=21)
- Female patients with BMI<50 kg/m² (n=64)

The existence of correlations was also assessed between patient height and jejunoileal length. The Student’s t test was used to compare average jejunoileal length of male and female patients.

**Results**

JIS measurements were performed on 100 patients during the study period, including 76 (76%) female patients and 24 (24%) male patients. The population included 79 morbidly obese patients (average BMI=43.63±2.60 kg/m²) and 21 super-obese patients (average BMI=56.16±5.71 kg/m²). Table 1 displays other data on the population. The margin of error at a 95% confidence interval was ±1.58 kg.

The average time spent measuring the intestine was 8.7±2.1 min (5.0 to 15.0 min). Table 2 displays the variation in jejunoileal, biliopancreatic and common limb lengths among the population studied.

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographic variables of patients who underwent Roux-en-Y gastric bypass (n=100)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>Average±SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>36.0±10.5</td>
</tr>
<tr>
<td>Pre-operative weight (kg)</td>
<td>126.8±23.2</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.65±0.10</td>
</tr>
<tr>
<td>Pre-operative BMI (kg/m²)</td>
<td>46.29±6.20</td>
</tr>
</tbody>
</table>

SD standard deviations; BMI body mass index.
Average jejunoileal length was significantly greater \((p<0.005)\) in male patients \((739.67±132.31\text{ cm})\) than female patients \((649.86±101.65\text{ cm})\). A positive correlation was detected between patient height and jejunoileal length \((p=0.001)\). No statistically significant difference was found between the average jejunoileal length of morbidly obese patients \((672.04±119.42\text{ cm})\) and super-obese patients \((669.05±103.00\text{ cm})\).

Table 3 displays results regarding weight loss at 6 months after surgery.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Average±SD (cm)</th>
<th>Maximum (cm)</th>
<th>Minimum (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jejunoileal segment</td>
<td>671.4±115.7</td>
<td>990</td>
<td>434</td>
</tr>
<tr>
<td>Biliopancreatic limb</td>
<td>56.1±14.8</td>
<td>105</td>
<td>30</td>
</tr>
<tr>
<td>Common limb</td>
<td>505.3±113.3</td>
<td>829</td>
<td>268</td>
</tr>
</tbody>
</table>

\(JIS\) jejunoileal segment; \(SD\) standard deviation.

Table 4 displays results of weight loss at 1 year after surgery.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Average</th>
<th>Standard deviation</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight loss (kg)</td>
<td>45.5</td>
<td>12.1</td>
<td>44.5</td>
</tr>
<tr>
<td>Weight loss (%)</td>
<td>35.8</td>
<td>6.7</td>
<td>36.6</td>
</tr>
<tr>
<td>EWL (%)</td>
<td>71.3</td>
<td>14.3</td>
<td>69.9</td>
</tr>
<tr>
<td>Loss of BMI (kg/m²)</td>
<td>16.6</td>
<td>4.1</td>
<td>16.4</td>
</tr>
</tbody>
</table>

\(EWL\) excess weight loss; \(BMI\) body mass index.

(c) Length of common limb×excess weight loss (%)  
\((\text{patients with } BMI≥50 \text{ kg/m}^2/n=21)\)  
\(r = -0.445, r^2 = 19.8\% \ p = 0.043\)

The correlations detected were relatively weak: less than 25% of the variation in weight loss among these groups was explained by the variation in the length of the common limb. The remainder of the variation was due to other factors influencing weight loss. The other data intersections revealed no correlations between the variables analyzed.

### Discussion

In bariatric surgery, the Roux-en-Y was initially proposed to eliminate bile reflux, by making an alimentary limb with a length of 30 to 75 cm [8]. This length was later increased to about 1 m in order to create macronutrient malabsorption (especially fat) and increase weight loss. It should be stressed that this modification has been empirically made, as no studies have demonstrated the occurrence of
malabsorption of macronutrients (such as the detection of fecal fat content) following RYGB.

Different modifications in the length of the alimentary, biliopancreatic and common limbs have been proposed in order to optimize weight loss [9–16]. Studies comparing different methods perpetuate a similar bias by failing to consider the variation in lengths of the JIS. As with the length of the biliopancreatic limb, this measurement is a determinant of the length of the common limb (segment with preserved absorptive function). The problem becomes more evident when one considers the JIS measurements observed in the present study, which revealed variations of more than 100%. The ratio between the lengths of the alimentary limb and JIS displayed broad variation from one patient to the next.

The analysis of the length of the common limb also reveals discrepancies. In the present study, the minimum measurement observed was just over 2 m, which is nearly equivalent to the diagnostic reference of short bowel syndrome. This patient is possibly more susceptible to nutritional deficiencies. On the other hand, the maximum measurement was 829 cm, which is quite a bit longer than the average JIS length. In this case, it is unlikely that there was malabsorption of macronutrients.

Papadia [17] states that malabsorption following proximal RYGB only occurs with regard to micronutrients (iron, calcium, etc.), which have no caloric value. This is due to the exclusion of the duodenum and the initial portion of the jejunum, where the absorption of these elements predominately occurs. The author states that malabsorption does not contribute to weight loss, as the ingestion of macronutrients after RYGB is relatively low compared to the absorptive capacity of the common limb.

An overall analysis of the literature reveals that significant increases in weight loss can occur through different distal RYGB operations, in which the common limb is short (75 to 150 cm) [9]. The effect of moderate increases (100 to 200 cm) in the length of the alimentary and/or biliopancreatic limb remains controversial. Failing to consider the JIS length (and consequently the common limb length) is a serious methodological error that makes the results from the above-cited studies extremely questionable.

Hess [5] measured the JIS in patients undergoing bariatric surgery (duodenal switch) and found values ranging from 345 to 1140 cm (measurements performed with maximum stretching of the limbs). The author stresses the importance of knowing these variations and considers it more suitable to calculate the length of the common limb based on a percentage of the jejunoileal length in each patient. This measurements may therefore control for the risk of nutritional disorders (such as hypoproteinemia) among individuals with a short JIS and unsatisfactory weight loss among patients with a very long JIS.

The absence of a correlation between JIS length and weight loss found in this study can be explained by the relatively short length of the alimentary limb in Capella surgery. It is known that, in situations that require the resection of the corresponding jejunal segment (such as ischemia), the maintenance of full absorptive function is possible due to the adaptation of the remaining intestine.

As the use of a 110-cm alimentary limb may have an influence over weight loss among patients with a long JIS (greater than 8 m in length), this effect should be more pronounced in patients with a short JIS (4 to 5 m), which was not observed in the population studied. These results suggest that the malabsorptive element exercises little or no influence over weight loss following proximal RYGB. A number of authors report similar weight loss values following RYGB with the use of shorter alimentary limbs (40 to 60 cm), which reinforces this conclusion [10, 11, 14].

Admitting that the malabsorptive element exerts an influence over weight loss, the standardization of the length of the alimentary limb (110 cm) would be equally unjustifiable, considering the broad variation in jejunoileal length demonstrated in the population studied. In such a situation, this measurement should be individualized in a manner proportional to the length of the intestine in each case.

It becomes evident that there is no scientific argument for the conduct of making a 150-cm alimentary limb to achieve greater weight loss. This modification is likely insufficient for producing the intended effect, especially in patients with a long JIS.

A negative correlation was detected in the present study between the length of the common limb and weight loss in two groups of patients (males/BMI ≥ 50 kg/m²), which can be explainable. The length of the common limb is an important variable. This segment is responsible for the absorptive function after RYGB. A reduction in its length must cause an increase in weight loss, whereas a longer length would cause less weight loss. The weakness of this correlation probably reflects the very low degree of macronutrient malabsorption promoted by proximal RYGB.

The variable length of the biliopancreatic limb could be a problem in this study. However, standard deviation was small (14.8 cm). In the great majority of cases, the biliopancreatic limb length ranged from 50 to 80 cm. Besides that, the variation of biliopancreatic limb length ultimately affects the common limb length (segment with absorptive function), which has been analyzed.

From these analyses, it is supposed that other mechanisms are responsible for the greater weight loss observed following proximal RYGB when compared to purely restrictive methods, such as gastroplasty and gastric band. By modifying the secretion of peptides that influence appetite and the body energy balance, the influence of the
RYGB on the gut-brain axis may explain this difference in results [18, 19].

Conclusions

Jejunoileal and common limb length vary widely in gastric bypass patients. To make modifications in the alimentary (Roux) and/or biliopancreatic limb length, surgeons must consider the variability of the jejunoileal and common limb length.

References
