Obesity Surgery, 6, 38–43

Measurement of Functional Pouch Volume following the Gastric Bypass Procedure

Latham Flanagan, Jr, MD, FACS

Private Practice, Eugene, Oregon, USA

Background: The cottage cheese test was developed in an attempt to find a simple way to measure functional pouch volume and to better understand the fate of the tiny proximal pouch following the gastric bypass procedure.

Methods: Our patients were asked to eat cottage cheese in a structured fashion before their return visits from 3 months to 2 years postoperatively.

Results: We found there was a step-wise progression of increase in functional pouch volume with statistical significance between each time interval. Also, we compared the patients' excess weight loss at 1, 2, and 3 years postoperatively to their pouch size at 1 year postoperatively. Although there is a wide range (2.5–9.0 oz) of pouch sizes at 1 year, there is no significant difference in excess weight loss between the smaller and larger pouches.

Conclusions: The pouches enlarge by the orderly process of hyperplasia. Within the 2.5–9 oz volume variation, the pouch volume alone is not a predictor of weight loss. Rather, how the patient uses the pouch/tool, in addition to the other behavior modifications, determines the degree of weight loss. This data strongly suggests that the surgeon's understanding of and teaching of the optimal use of the pouch/tool may be more important than previously thought.

Key words: Morbid obesity, gastric bypass procedure, gastric pouch enlargement, gastric hyperplasia, cottage cheese test

Introduction

The fate of the tiny proximal gastric pouch created at the initial gastric bypass operation is the source of much interest and widely divergent opinions by bariatric surgeons, but, as yet, little data have been developed. Opinions about the cause of the observed pouch enlargement vary from 'passive stretching' due to over-eating, to the process of hyperplasia, similar to that which occurs in other areas of the gastrointestinal tract when functional capacity of an organ system is sharply curtailed.

Reprint requests to: Latham Flanagan Jr, MD, 655 East Eleventh Avenue, Suite 8, Eugene, OR 97401, USA. Tel: 503-687-1445; fax: 503-687-6816.

The difference between these two views is important to the way we view our patients and their management. On the one hand, viewing pouch enlargement as passive stretch due to over-filling the pouch by uncontrolled eating places the responsibility for increasing meal capacity squarely on the patient and his/her 'lack of compliance'. This view can lead to passivity on the part of the surgeon when approaching the bariatric patients' postoperative management, and even to negativity if weight loss is not satisfactory. On the other hand, establishing that the postoperative pouch enlargement is primarily due to the inevitable physiologic change of hyperplasia should promote an attitude on the part of the bariatric surgical team of continued involvement in the patient's progress and should stimulate further understanding of pouch hyperplasia and how it affects the satiety mechanisms. Finally, better understanding should lead to the development of better methods of teaching patients how to use their 'pouch/tool', and thus in turn better success in weight loss and maintenance.

Materials and Methods

Heeding the suggestion of our pioneer, E. E. Mason, in 1991[1] we began asking our postoperative patients to eat as much cottage cheese as they could comfortably hold on 3–4 occasions during the week before their postoperative visits at 3, 6, 9, 12, 18 and 24 months. They were asked to fast for 60 min before the test and do the test but once a day at a meal which is their 'prime time' for best appetite. They were asked to eat from the side of a standard carton of cottage cheese until they felt 'comfortably satisfied'. They should take no more than 5 min to complete the meal. They then gently filled the resulting space in the cottage cheese carton with milk or water, then poured off the liquid and measured it to the nearest $\frac{1}{4}$ oz. Further, the patient was asked to assess the degree of satiety 20 min after each test meal. Finally, they were asked to compare the volume of their

cottage cheese test (CCT) to their usual meal volume. About one of 20 patients disliked cottage cheese sufficiently to not be able to do the test. These people were asked to substitute thick oat meal for the cottage cheese and there appeared to be no difference in the outcome between using cottage cheese and oat meal.

As one might expect of this request, compliance was not uniform. Of our patients, 95% performed the first CCT at 3 months, but thereafter compliance fell off. In the first year, 50 patients completed all four tests, 99 patients completed three or more tests, and 145 patients completed two or more tests. The data of patients were included in this study if they reported two or more test results in the first year. At each visit the three to four cottage cheese meal volumes were noted to be quite close, usually varying by not more than $\frac{1}{2}$ oz. The patient's assessment of the degree of filling or satisfaction helped to choose the weighted average that was used as **THE** test result on that visit. The patients were asked to continue doing the tests at the 18- and 24-month postoperative visits, but, as expected, both compliance and follow-up fell off even further in the second year.

The data was collected over a 10-year period from June of 1982 through February 1992. The same gastric bypass procedure was performed by the same surgeon over the entire test period. The procedure uses a 30 cc pouch measured at 75–90 cm of water pressure, a 10 mm outlet, and a vertical, lesser curve orientation of the pouch. The method of creating the outlet was described previously.[2] We used a retro-colic 45 cm Roux-en-Y limb. The overall series results revealed a mean excess weight loss (EWL) of 67% at 6 years and 10 years, with a success rate of 85%/93% weight loss when 50%/40% of EWL and maintenance was used as criteria for success.

As the patients' weights were measured at each follow-up visit, correlations were able to be made between pouch size and weight loss, expressed as per cent excess weight loss (%EWL). Correlations could also be made between patient compliance to instructions and wishes of the medical team, as reflected in their doing or failing to do the cottage cheese test and 'success' as measured by weight loss.

Results

The results of the CCT using all the tests performed and reported by those patients reporting two or more tests in the first postoperative year revealed that there is a step-wise, orderly, increase of functional pouch volume (FPV) at each interval, with a high level of statistical significance between intervals using the unpaired T-test (Figure 1). The pouches average 4.9 oz in size at 1 year, enlarging to 6.0 oz in the second year. At 1 year the range is 2.5–9 oz with a SD of 1.5 oz. For ease of communication, 'functional pouch volume' and 'pouch size' will be used interchangeably below with the understanding that the two are not necessarily identical.

Over 90% of the patients stated that their best estimate of their usual meal volume was the same as the results of their CCTs.

Figure 2 depicts the results for the smaller group of 50 patients who completed all four tests in the first year or five of the six tests in 2 years. The data was analysed in this group by the paired *t*-test and reveals results indistinguishable from that in Figure 1.

Figure 3 demonstrates the relationship between the patients' pouch sizes at 1 year and the %EWL at 1 year. There is no significant difference, in fact, no difference at all between the various pouch sizes and the %EWL. Comparison of the %EWL of the larger one-half to the smaller one-half of pouch sizes and, further, comparison of the largest tertile to the smallest tertile of pouch sizes confirms the lack of any significant difference in weight loss compared to pouch sizes at one year.

We went on to compare the pouch sizes at 1 year to the %EWL at 2, 3, and 4 years. There is a trend towards better weight maintenance in the smallest tertile of pouch sizes vs the largest tertile at the longer time intervals, but this trend does not reach statistical significance.

Discussion

The progressive step-wise increase in FPV with a declining rate in time, as defined by the CCT, suggests that pouch enlargement is caused by the orderly process of hyperplasia, rather than by some more erratic phenomenon of excess 'stretch' due to some highly variable and poorly predictable process such as 'non-compliance' with dietary instructions. That the pouch enlargement may be secondary to gastric hyperplasia is consistent with observations made about the hyperplastic response seen in the liver, kidney and small bowel when there is an abrupt reduction in the functional capacity of these organs. A bariatric surgeon is quite familiar with the extraordinary hyperplasia that occurs in the functional segment of the small bowel following a jejunoileal bypass procedure.

We performed random biopsies of the pouch wall during a few revision procedures and found the microscopic characteristics of gastric fundus rather than of cardia from which the pouch was originally constructed. Systematic biopsies of the original pouch

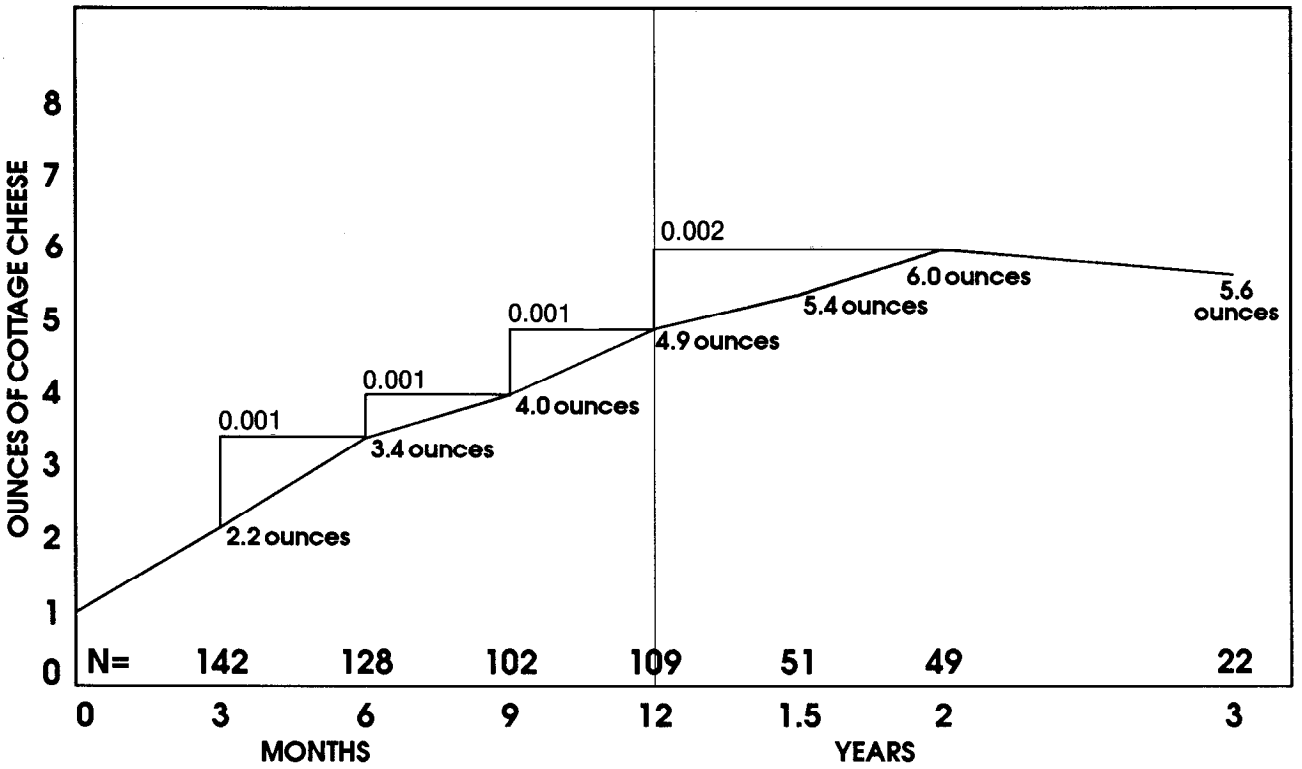

Figure 1. Cottage cheese test. All tests – unpaired *t*-test.

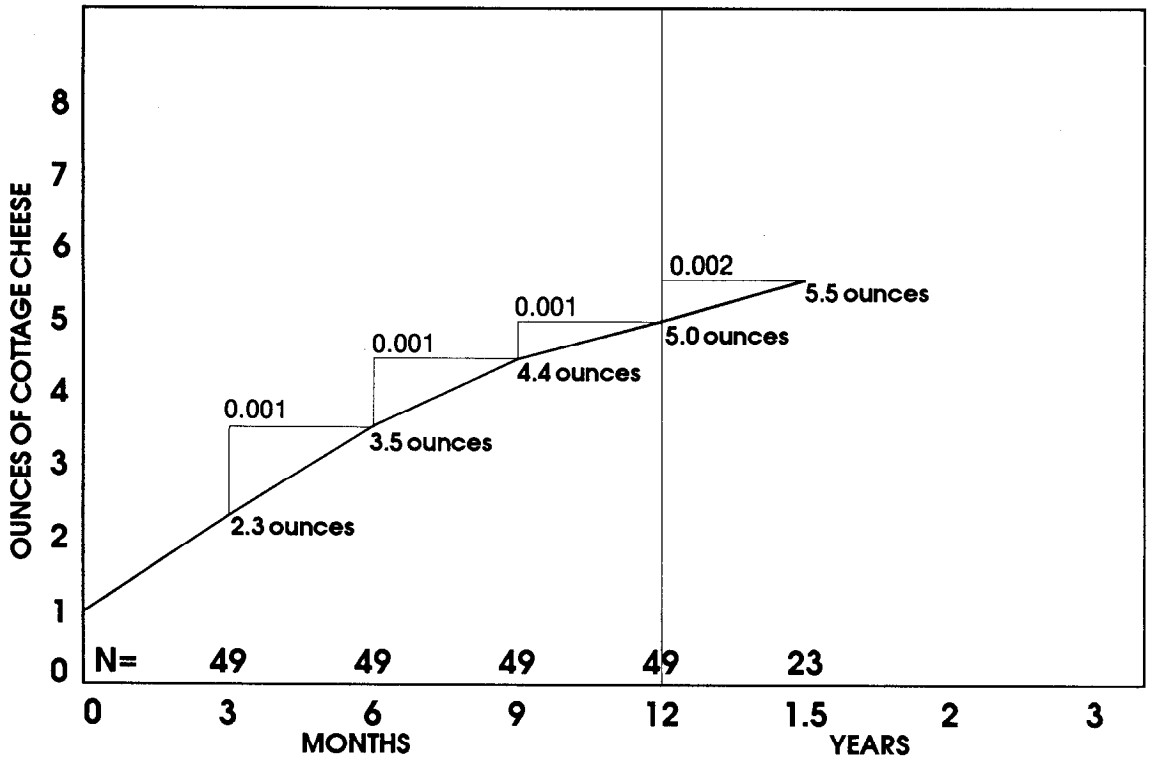

Figure 2. Cottage cheese test. Paired *t*-test (patients who performed all four tests in first year).

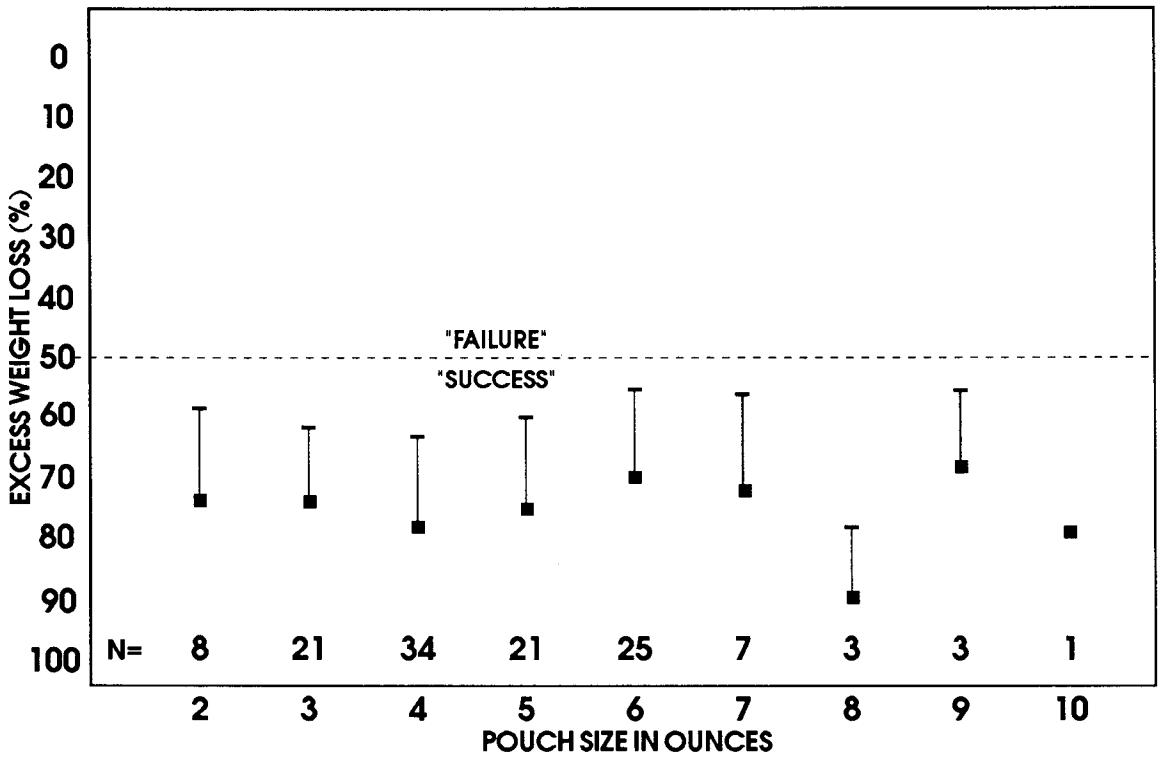

Figure 3. Excess weight loss at 1 year postoperation for each pouch size at 1 year post-GBP.

and mature pouch would further clarify this issue.

It is interesting that the paired *t*-test results on the more cooperative patients (the ones who provided test results at each follow-up interval) were indistinguishable from the unpaired *t*-tests on the 'less cooperative' patients, some of whom performed two of six test results over 2 years. Certainly, compliance or cooperativeness in responding to our requests for CCTs did not influence the rate or degree of growth during the first 18 months postoperatively.

The wide variation in pouch sizes at 1 year, ranging between 2.5 and 9 oz remains unexplained. In light of this, perhaps the common reference to 'pouch stretch' and 'noncompliance' and eating habits bears further investigation to see if over-filling at many or most meals, vis-a-vis some sort of 'norm', might cause an increase in gastric hyperplasia. Further, it might be of interest to correlate pouch size to a history of preoperative gorging behavior. On the other hand, our assumption that the basic 'disease' process of morbid obesity is not uniform but follows some sort of skewed curve distribution suggests that some patients might need more pouch wall stretch per filling to achieve a satisfactory degree of satiety.

The finding that the amount of %EWL is not correlated to pouch size at 1 year and beyond should not be surprising to the experienced bariatric surgeon. Although we were searching for a correlation between FPV and %EWL, it would have been difficult to believe the data should we have found the correlation to exist. Observation of our patients' behavior during their postoperative courses strongly suggests a cause and effect relationship between their behaviors and the degree of %EWL. Obtaining good quantities of regular exercise, eating solid foods at meal-times, avoiding liquids with meals and for 1.5 h afterwards, fluid loading, and eating adequate protein at each meal seems empirically to be behaviors that result in success in weight loss and weight maintenance. If this is true, then the proper use of the pouch/tool, rather than meal size *per se*, appears to be the significant variable. The proper use of the pouch/tool needs to be taught, as some techniques would seem to be counter-intuitive, such as separating solid and fluid intake. Modification of eating behavior after Bariatric Surgery is primarily achieved by the satiety gained from the pouch wall distention. However, other behavior modification techniques, especially exercise, are still important for optimum results. Clearly, behavior modification is important in weight loss and whatever weight maintenance that can be achieved in non-surgically treated morbidly obese patients.[3]

We have just noted that there is no correlation

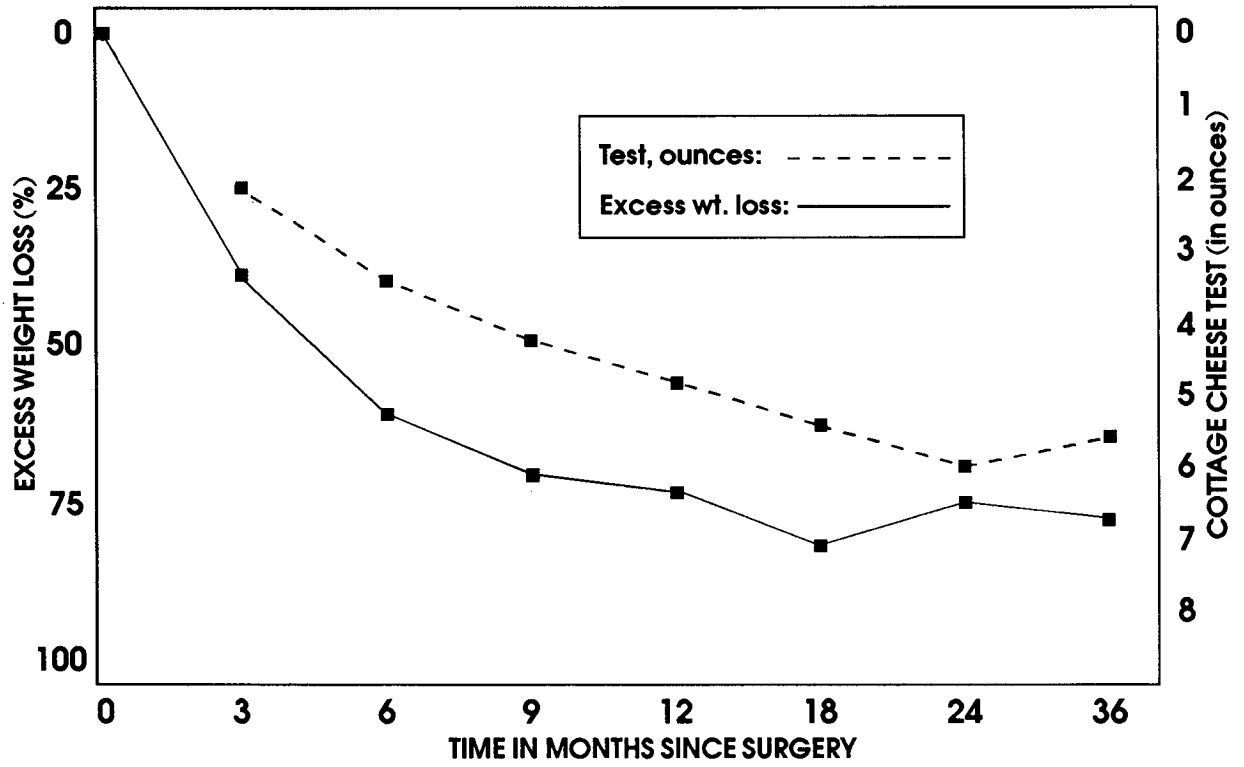

Figure 4. Curve of per cent of excess weight loss compared to inverted curve of pouch size growth.

between %EWL and pouch size at 1 year and beyond. Yet, Figure 4 reveals an apparently good relationship between the curves of pouch growth and EWL. How can we reconcile these seemingly disparate pieces of information? These curves suggest that the *rate* of pouch growth may define the *rate* of excess weight lost by the group or individual, but that the total amount of excess weight lost is related to factors other than the pouch size alone –at least when the pouch size at 1 year is not greater than 8–9 oz.

In our practice this CCT has become a useful, additional piece of data in assessing patient progress. If the pouch size is smaller than average, increased emphasis is placed on protein consumption as a percent of meal volume. If the size is larger than average, warnings are given concerning constant 'stuffing' vs eating until 'comfortably satisfied'. A sudden increase in FPV associated with decelerating weight loss suggests need for evaluation of the staple-line and/or outlet by upper GI series. The CCT is also helpful in assessing patients for loss of weight maintenance. It is especially helpful in evaluating a patient who is new to us with weight regain from a previous bariatric surgical procedure, although in this instance, baseline values for FPV are missing.

Others have attempted to measure FPV using various techniques. Kral[4] attempted to measure FPV by observing an actual meal eaten by patients under controlled conditions. He did not feel this method was successful. Others at the American Society for Bariatric Surgery meetings have anecdotally reported using endoscopy with balloon inflation in the pouch to effectively measure pouch volume in reference to pressure, and thereby obtain a more valid comparison to the original pouch size. I am not aware of any significant numbers reported and this approach is, obviously, expensive, difficult to repeat and entails some risk. It may or may not correlate to functional meal capacity.

Kuzmak[5] and others have attempted to define pouch size using radiographic techniques and complex mathematical formulas. Kuzmak came to the conclusion that there is only a very small increase in pouch size when evaluated by this method. However, it would appear that the upper GI series technique using liquid barium is not a valid method by which to measure FPV, as liquid barium drops through the fixed sized outlet without distending the pouch sufficiently to measure its actual volume. Bechtold[6] measured vertical banded gastroplasty pouch volume by upper GI radiographic techniques preoperatively in 16 patients whose pouches were to be revised for inadequate weight loss. When remeasured at operation the pouch volumes ranged from 90 to 1550 cc with a

mean of 468 cc, although the preoperative X-ray volume measurements ranged from 54 to 302 cc. He concluded that "the hypothesis that upper GI series measurements accurately reflect pouch size is erroneous and that no such correlation exists".

Indeed, liquid barium would seem to correlate only with a liquid meal, and it is becoming fairly well established that liquid meals do not maintain sufficient satiety.[7] A similar criticism can be made for the CCT in that cottage cheese is a softer substance than meat and vegetables. Nevertheless, the CCT would seem to be a reasonable compromise in light of the invasiveness, risk, expense and difficulty of repeatability of the endoscopy and upper GI series techniques.

Finally, could the CCT findings of increasing volumes over time be due to an increasing rate of gastric emptying over time? Miskowiak *et al.* in 1985[8] measured gastric emptying of a liquid meal following the Pace horizontal gastroplasty before, 1 week and 3 and 12 months postoperatively in 11 patients by a radionuclide method. They found markedly increased gastric emptying over time to the point that it actually exceeded preoperative emptying. The failure of outlet control in the Pace horizontal gastroplasty, the small sample size and the almost universal experience of our patients that they can drink a much greater volume of fluid than of solids and, further, that they can repeat the drinking in a short period of time invalidates a comparison to the CCT in the gastric bypass patient.

Another radionuclide gastric emptying study in 27 patients by Andersen *et al.* in 1985[9] used a semi-solid meal of mashed potatoes and minced meat, not unlike cottage cheese. They were unable to demonstrate any change in gastric emptying between their 6-, 12-, 18- and 24-month test times following Gomez gastroplasty. There was only a significant change from their first (and only other) test time at 7–10 days postoperatively. They probably accurately attributed that difference to "recovered motility".

The rate of gastric emptying seems unlikely to account for the step-wise increase in CCT results, or cottage cheese meal capacity, for another reason. The almost universal observation of our patients is that when they approach feeling full after a meal, "one more bite" will cause nausea and/or pain. This would suggest that the gastric emptying of even a semi-solid such as cottage cheese is too slow to significantly alter these volumes in the short duration of the meal, most of which last 5 min or less.

Summary

The CCT is a safe, inexpensive, easily repeatable and relatively simple procedure to assess the functional pouch volume in a postoperative gastric bypass patient. The CCT results strongly imply that increase in FPV is a function of gastric hyperplasia, rather than 'stretch'. The rate of increase in FPV correlates with the *rate* of weight loss but not with the total *amount* of weight lost.

The CCT in our practice has also become a useful, empirical, clinical tool for assessing patient progress following the gastric bypass procedure. The CCT data, thus, by default, emphasize the importance of patient behavior in achieving and maintaining success in weight loss which, in turn, emphasizes the important role of the bariatric surgeon, and/or his/her team, in teaching and training patients in how to optimally use their 'pouch/tool'.

Acknowledgement

I would like to especially thank Professor E.E. Mason for presenting the idea of the CCT in 1980 and for his encouragement in this as in many other bariatric surgical endeavors.

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(Received 10 April 1995; accepted 31 August 1995)