Nutrition Following Gastric Operations for Morbid Obesity

LLOYD D. MACLEAN, M.D., BARBARA M. RHODE, P.DT., M.SC.(NUTR.), HARRY M. SHIZGAL, M.D.

From the Departments of Surgery, Royal Victoria Hospital, and McGill University, Montreal, Canada

Nutritional status after 238 gastric operations designed to reduce caloric intake and body weight to within 30% of ideal was assessed by measuring body composition using the multiple isotope dilution technique. Body cell mass (BCM) and body fat were quantitated before and at 24 months after operation. Malnutrition was defined as a total exchangeable sodium (Na_e) to total exchangeable potassium (K_e) ratio greater than 1.22. Data were collected on 96 patients. All had lost a mean of 26% of preoperative weight by 24 months. Significant malnutrition occurred in 47 patients whose Na_e/K_e ratio ranged from 1.23 to 2.17 (1.45 ± 0.03). There was a 34% reduction in body fat. The malnourished patients lost 10% more BCM by 24 months than did the normally nourished group. Malnutrition resolved as the stoma enlarged in 19 patients, and dietary counselling helped eight patients. Eighteen patients required reoperation to establish a larger orifice, and endoscopic dilatation was successful in two patients. Administration of a liquid diet via the gastrostomy was required for prolonged periods in some malnourished patients. Seventeen patients who had lost weight rapidly over a short time had low vitamin B_{12}, thiamine, and serum and RBC folate levels. One patient had a markedly decreased serum thiamine level with neuropathy. Symptoms of weakness, easy fatigability, and lassitude were found in the malnourished patients. Low thiamine and serum folate levels were also seen in patients ingesting a liquid diet of 750 kcal with a standard multivitamin supplement. Malnutrition was not seen in these patients. In the 49 patients who remained well nourished, BCM decreased by 19%, but the Na_e/K_e remained normal. Weight loss was well tolerated, and no patients required reoperation or supplemental liquid diet to increase caloric or protein intake. The degree of malnutrition in patients after gastric operations is as great as following intestinal bypass but is not associated with liver failure. Malnutrition with vitamin deficiency is a great potential hazard in patients who undergo intake-limiting operations, especially if the goal of the operation is to restore near-normal weight. Current operations are successfully designed to maintain a small orifice size, so that the risks of malnutrition are likely to increase in the future.

THE SURGICAL TREATMENT of morbid obesity is based on the dual premise that this degree of obesity is of life-threatening severity and that long-term nonoperative treatment usually fails. The most startling evidence of the risk of mortality has been reported by Drenick et al.,[1] who followed 200 morbidly obese patients for a mean of 7.5 years. The mortality rate during that time for patients aged 25 to 34 years was 12-fold that of individuals of the same age who were of normal weight. In fact, 50 of the 200 morbidly obese died during this follow-up period.

It is now over 30 years since Viktor Henrikson[2] of Sweden resected a large segment of small intestine in two obese patients with an early favorable response. During the interval since 1952, more than 450 reports have appeared of over 10,500 patients who underwent intestinal bypass. Articles have documented more than 5000 instances where a gastric operation for morbid obesity was performed. Certain conclusions have been reached by most surgeons involved in this work. Intestinal bypass is unsuitable because of the risk of malnutrition frequently associated with liver failure. Other metabolic disturbances have also been reported.[3] An unpredictable weight loss and troublesome persistent diarrhea are additional reasons for abandoning this procedure. An intake-limiting operation is preferable, and certain surgeons favor gastroplasty with its greater ease of performance and relative freedom from operative complications. Others prefer gastric bypass with the ability to make a larger stoma, even though higher complication and operative mortality rates may ensue. If gastroplasty is chosen, a small supported stoma is essential if significant weight loss is to be achieved and maintained. The difference in the diameter of the stoma between patients who achieved a good result and those who fail is small—a few millimeters. The difference in pouch volume cannot usually account for an unsuccessful result. The chance for stenosis and malnutrition is greater now than at the time of the first favorable reports[4,5] on body composition after gastroplasty or gastric bypass, because the follow-up time is longer and external support, especially after the gastroplasty now being performed, can prevent stomal dilatation.

The goals of the present study were to determine the

Presented at the Annual meeting of The American Surgical Association, May 12–14, 1983, Boca Raton, Florida.

Reprint requests: Lloyd D. MacLean, M.D., Department of Surgery, Royal Victoria Hospital, 687 Pine Avenue West, Montreal, Quebec, H3A 1A1, Canada.

Submitted for publication: May 16, 1983.

0003-4932/83/0900/0347 $01.25 © J. B. Lippincott Company

state of nutrition in morbidly obese patients prior to and at intervals following current gastric operations. We wished also to document the change in weight and nutrition in patients totally obstructed after gastroplasty. Additionally, we determined the vitamin status of patients who were losing weight rapidly or who were malnourished.

Materials and Methods

Patient Selection

All patients who were chosen for either gastroplasty or gastric bypass surgery were at least 200% above ideal weight and were considered capable of participating in an exacting follow-up program after surgery, as determined with the aid of a psychiatric consultation. All patients were seen on several occasions by a trained dietician, and a detailed assessment of oral intake was recorded. Full-length photographs were taken, and weight, height and ideal weight[6] were recorded for each patient.

Operative Procedures

Seven types of gastroplasty and one type of gastric bypass operation were performed. In the type 1 gastroplasty, a single application of a TA90 stapler with three staples removed from the midportion of the 4.8-mm cartridge was used. Pouch size was between 30 ml and 100 ml in all patients. The type 2 gastroplasty was performed identically, except that two applications of the stapler were used. The type 3 gastroplasty was created in two ways—either by placing a TA55 stapler from the lesser to the greater gastric curve, impinging on a 14F catheter or by placing a TA90 stapler from the lesser to the greater curve, having removed two staples from the lateral end of the staple cartridge. Each device was fired twice. The orifice was reinforced with 000 polyethylene sutures and with pledgets of Teflon® (polytetrafluoroethylene). The polyethylene sutures circumvented the 14F tube and were tied down firmly on this tube after passing through the Teflon. The type 4 gastroplasty was created by removing three staples from each cartridge and placing the two rows 1 cm apart. The orifice was created 2.5 cm from the greater curvature, and at least one short gastric vessel was preserved. An 18F nasogastric tube was advanced through the orifice, and each side of the interrupted staple line was reinforced with a 000 polyethylene suture tied over a Teflon pledget at the orifice site. These procedures have been described previously in greater detail elsewhere.[5]

The type 5 gastroplasty is a gastrogastrostomy performed with a single continuous polyethylene suture tied over an 18F nasogastric tube passed through the anastomosis. A double application of the TA90 was used to create a small upper gastric pouch.

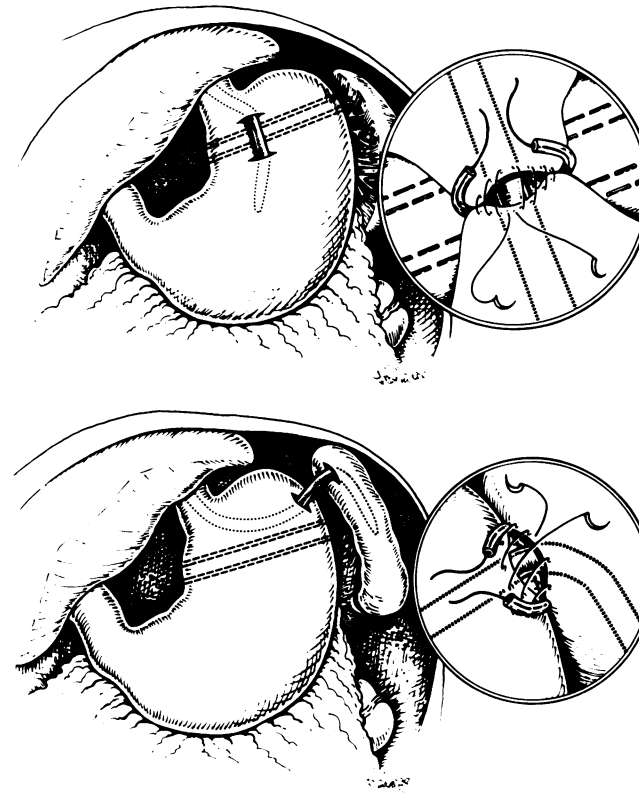

FIG. 1. Gastrogastrostomy with external support using a 10F silicone tubing. A polyethylene suture passed via the lumen of the silicone tubing permits securing the support tubing permanently and without tension (a). The same technique is illustrated for Roux-en-Y gastric bypass (b).

The type 6 operation was either a gastrogastrostomy or a Roux-en-Y gastrojejunostomy performed with a single, nonabsorbable suture, as in Type 5, but surrounded by a 10F silicon tubing (Dow Corning, Midland, MI). This tubing was tied loosely around the anastomosis using a 0 polyethylene suture passed via the lumen of the tubing (Fig. 1.). The type 7 operation is the vertical banded gastroplasty of Mason,[7] in which the Marlex mesh wrap was 15 mm in width and either 45 mm or 50 mm in length.

Postoperative Management

Patients were started on a clear liquid diet on the second day after surgery. Food intake was advanced daily to full liquids and soft diet, and patients were discharged on a 1000-kcal soft diet (60 g protein, 30 g fat, 100 g carbohydrate). Patients were instructed to ingest a multiple vitamin supplement daily. Those who could not tolerate oral intake were discharged on tube feedings administered via a gastrostomy or gastroduodenal tube inserted at the time of surgery. The tube feeding preparation consisted of 100 g Sustagen (Mead Johnson) and

TABLE 1. *Status of Patients Following Gastroplasty or Gastric Bypass Surgery*

No. of patients	167
No. of operations	238
Follow-up time	
Mean	28.5 ± 1.3 months
Range	1–59 months
Results	
Good	48 (29%)
Satisfactory	52 (31%)
Unsatisfactory	44 (26%)
Too early	23 (14%)
Mortality	1 (late)

* Mean ± SEM.

1 L skim milk. This mixture provided 750 kcal, all essential trace minerals and vitamins with the exception of iron, and contained 60 g protein, 4 g fat, and 119 g carbohydrate. In addition to the tube feeding, patients were instructed to take two L water daily.

Evaluation

Most patients were seen weekly for 1 month, monthly for 6 months, and every 3 months thereafter following discharge from the hospital. At each visit, patients were weighed and food intake was assessed for nutritional quality. A medical evaluation and a record of well being and ability of the patient, as well as actual return to work, were also made. Esophagogastroscopy was performed on most patients at 6 weeks, 6 months, and at 1 year after operation in order to assess orifice size.

Body composition measurements were performed in selected patients before and at 3 months, six months, 12 months, and 24 months after surgery using the multiple isotope dilution technique.[8] Simultaneous intravenous injections of 8 μCi of sodium-22 and 500 μCi of tritiated water were given. Blood samples were obtained prior to and following isotope injection at 4 and 24 hours. All urine excreted during the initial 24 hours was collected to correct for isotope loss. Total exchangeable sodium (Na_e) was determined from the equilibrated plasma sodium-22-specific activity at 24 hours. Total body water (TBW) was calculated from the plasma tritium concentration at 24 hours. Total exchangeable potassium (K_e) was calculated from TBW, Na_e, and the ratio in whole blood of the sodium plus potassium content divided by its water concentration. Lean body mass, body fat, and body cell mass were also calculated from equations previously published.[8] Assessment of nutritional state was reported as the Na_e/K_e ratio. The Na_e/K_e ratio is normally 1.00. Malnutrition was defined as a Na_e/K_e ratio greater than 1.22.[9]

Blood samples for vitamin determinations were drawn from fasting subjects admitted for malnutrition or those having lost weight rapidly during the initial period following surgery. Serum or whole blood samples were sent for analyses of vitamin B12,[10] folic acid,[11,12] vitamins A and C,[13] riboflavin (B2),[14] vitamin B6,[15] vitamin D (25-hydroxy D),[16] and thiamine (B1).[17]

Statistical Analysis

Paired and unpaired Student's t tests were used to determine significance. Differences with a p value of less than 0.05 were considered to be significant. In all instances, the mean value was listed with the corresponding standard error of the mean (SEM).[18]

Results

Over a period of 59 months, 238 intake-limiting operations were performed in 167 patients (Table 1). No patient was lost to follow-up. Variations of the gastroplasty surgery were used in 129 patients. Thirty-eight patients had gastric bypass using the Roux-en-Y technique. The mean follow-up was 28.5 ± 1.3 months for all patients. There were 126 women and 41 men. Their mean age was 39.2 ± 0.7 years, with a range from 20 to 62 years. Results based on weight loss in all patients are shown in Table 1.

A good result was defined as a weight loss of at least 25% of the preoperative weight, with weight within 30% of ideal for height and body build.[6] A satisfactory result was defined as a loss of 25%, but not less than 30% above the ideal weight. An unsatisfactory result was defined as a loss of less than 25% of the preoperative weight. Sixty per cent of the patients had either a good or satisfactory result, and in 14% it was too early to evaluate (less than 6 months). There was one late death.

Evaluation of patient status based on the seven variations of gastroplasty surgery is illustrated in Table 2. Gastroplasty types 1 and 2 produced an inadequate weight loss due to a large orifice size. There was devascularization of the orifice site in the type 3, with either dilatation or stenosis of the orifice. Perforation of the upper gastric pouch was found exclusively in this group. Fifty-one per cent of results were unsatisfactory with the type 4. There was migration of foreign bodies sutured to the stomach wall, with enlargement of the orifice. Type 5 achieved acceptable results in 63% of patients. One patient was reoperated on. A weight loss of 29.8% was associated with the Type 6 gastroplasty, with 80% of the results being either good or satisfactory. Malnutrition and stenosis or obstruction of the gastric orifice were the two major complications seen in all seven operations. Malnutrition appeared in 25% of patients following type 6 gastroplasty. Twenty-nine per cent of cases were stenosed or obstructed.

Of the 238 operations performed, 43 operations were

TABLE 2. *Clinical Information*

	Type 1	Type 2	Type 3	Type 4	Type 5	Type 6	Type 7
No. of patients	16	5	34	37	16	79	21
No. of operations	16	6	34	38	17	106	21
Preoperative wt. (lbs.) (Mean ± SEM)	315 ± 14	323 ± 38	291 ± 8	305 ± 11	247 ± 23	276 ± 6	291 ± 9
Follow-up (mos.) (Mean ± SEM)	31.2 ± 5.4	52.8 ± 2.4	33.8 ± 2.9	29.2 ± 1.8	23.1 ± 2.5	16.2 ± 0.9	2.8 ± 0.3
Per cent wt. loss	11.9 ± 2.2	20.2 ± 5.8	22.0 ± 2.3	26.4 ± 2.6	16.3 ± 4.4	29.8 ± 1.5	10.9 ± 1.0
Results							
Good	0	0	6 (18%)	7 (19%)	4 (25%)	32 (41%)	—
Satisfactory	1 (6%)	2 (40%)	11 (32%)	11 (30%)	6 (38%)	31 (39%)	—
Unsatisfactory	15 (94%)	3 (60%)	17 (50%)	19 (51%)	6 (37%)	14 (18%)	—
Too early	—	—	—	—	—	2 (2%)	21 (100%)
Complications							
Malnutrition	3	2	9	10	3	20	0
Stenosis/obstruction	0	1	4	6	6	23	1
Splenectomy	0	0	0	0	0	0	0
Deaths	0	0	1	0	0	0	0

Roux-en-Y and 195 were a variation of the gastroplasty surgery. Of these 43 Roux-en-Y operations, seven (16%) became obstructed. Twenty-nine operations (15%) of the gastroplasty form became obstructed. Obstruction occurred most frequently in operations that produced ischemia of the greater curvature of the stomach or with silicone tubing reinforcement of the anastomosis, even though this was not fixed to the stomach or small intestine.

A total of 71 reoperations were required. Thirty of these reoperations were performed for failure to lose sufficient weight, and 41 were done because of obstruction with demonstrated or potential malnutrition. The latter group of patients responded infrequently to dilatation by endoscopic techniques.

The effect of orifice size on weight loss in 117 patients evaluated endoscopically 9 to 12 months after surgery is shown in Table 3. Weight loss of greater than 25% was associated with an orifice size of less than 10 mm in diameter in 70 of 74 (95%) patients. Only 14 of 43 patients (33%) who had an orifice size larger than 10 mm lost more than 25% of preoperative weight. These represented good or satisfactory results.

Body Composition in Normal and Malnourished States

Changes in body composition parameters in 96 normally nourished and malnourished patients are illustrated in Figure 2. Forty-seven patients were defined as normally nourished before operation and 49 patients were normal after operation on the basis of the Na_e/K_e ratio[9] (preop:1.00 ± 0.02; postop: 1.10 ± 0.02). Two patients had an abnormally elevated Na_e/K_e prior to surgery. The mean body weight of the 49 normally nourished patients prior to surgery was 138 ± 4 kg, of which body fat accounted for 50%, or 69 ± 2 kg. In 25 normal volunteers, body fat comprised 29% of the body weight. The mean body weight of these normally nourished obese patients was 96% greater than the mean weight of the normal volunteers, while the lean body mass was only 37% greater.

Following gastroplasty, malnutrition developed in 47 of 96 morbidly obese patients. In the other 49 patients, body composition remained normal 24 months after gastroplasty. A body composition characteristic of malnutrition was present prior to gastroplasty in five of the 47 patients with postgastroplasty malnutrition. The body cell mass decreased significantly ($p < 0.0001$) in both groups after gastroplasty. In the 49 with normal body composition following gastroplasty, body weight decreased by 25.7%, while the body cell mass decreased by 18.8%. There was a 36.2% decrease in body fat ($p < 0.0001$). In the 47 patients with malnutrition after gastroplasty, weight loss was 25.9%, while the body cell mass had decreased by 29.4%. The malnourished patients lost 10.6% more body cell mass over a similar time period and developed a Na_e/K_e that was distinctly abnormal. Fat decreased by 34.4% ($p < 0.0001$).

Malnutrition was associated with lassitude, easy fatigability, difficulty to attain full employment, and hair loss. Comparison of weight loss on the basis of preoperative weight in the normally nourished and malnourished patients did not reveal significant differences. Seventy-five per cent of the malnourished patients attained

TABLE 3. *Weight Loss in Patients with Orifice Size Evaluated 9 to 12 Months after Surgery*

Orifice Size Diameter (mm)	Wt. Loss < 25%	Wt. Loss > 25%
<10	4	70
>10	29	14

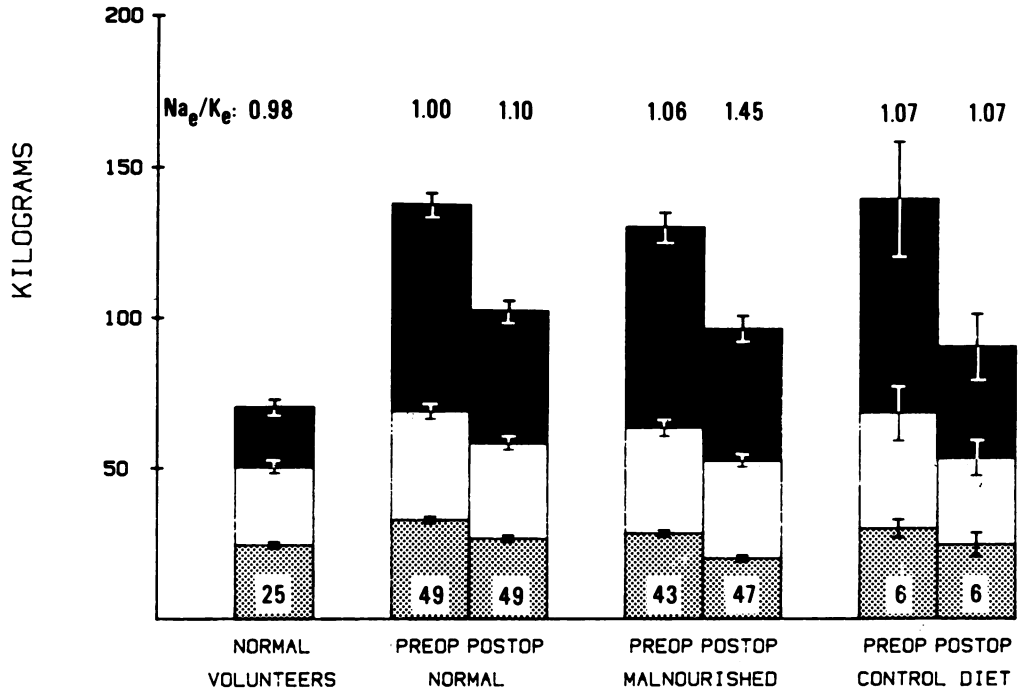

FIG. 2. The body composition before and following gastroplasty and gastric bypass in 47 patients with and in 49 patients without malnutrition after surgery. The body composition in six patients who remained on the control diet of 750 kcal daily is also illustrated. The body composition of 25 normal volunteers is included. Black shading represents fat; white is extracellular mass; stipled shading is the body cell mass.

a good or satisfactory result. Seventy per cent of the normally nourished patients achieved acceptable results. Malnutrition was resolved as the stoma enlarged spontaneously in 19 patients. Eight patients were treated through dietary counselling. Eighteen patients required reoperation to establish a larger orifice. Endoscopic dilatation was successful in only two patients.

Body Composition after Control Diet

Body composition studies were performed also in six patients who took a liquid diet for 7.2 ± 1.4 months (Fig. 2). The diet in these patients was controlled strictly and monitored closely. Each patient consumed 750 kcal/day consisting of 60 g protein, 119 g carbohydrate, and 4 g fat. This was given as 100 g Sustagen diluted in 1 L skim milk and 2 L water with supplemental vitamins.

There was a 33.4 ± 7.8% decrease in body weight ($p < 0.025$) and a 43.8 ± 11.3% reduction in body fat ($p < 0.025$). Body fat was lost at a rate of 4.24 ± 1.1 kg/month. The body cell mass decreased from 30.3 ± 3.1 to 24.8 ± 4.1 kg (19.7 ± 4.9%; $p < 0.01$). Malnutrition

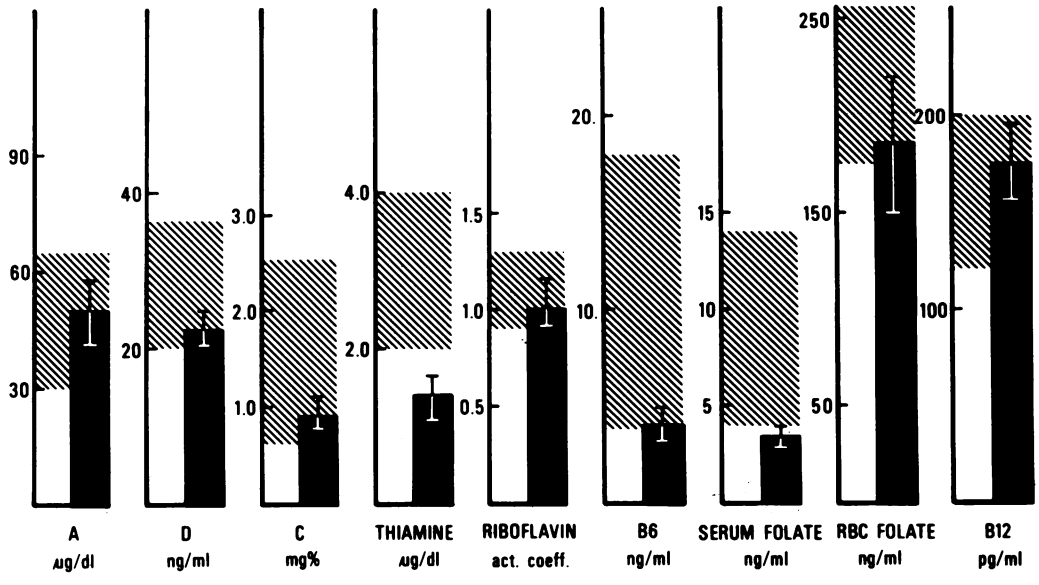

FIG. 3. Serum and whole blood vitamin concentrations in patients consuming the control diet of 750 kcal/day with supplemental vitamins. Shaded areas represent normal ranges. Note significant decrease in thiamine and serum folate.

did not develop. The Na_e/K_e remained normal and unchanged (1.07 ± 0.06 to 1.07 ± 0.11).

The serum and whole blood levels of several vitamins were quantitated in these six patients consuming the liquid control diet (Fig. 3). Vitamin concentrations remained normal, except for a low thiamine and serum folate. Vitamin B6 levels were borderline. No clinical deficiencies of these vitamins were observed.

Vitamin Concentrations During Excessive Weight Loss

Thiamine, serum folate, RBC folate, and vitamin B12 concentrations are depicted in 17 selected patients who were either admitted for malnutrition or who lost weight more rapidly than normal after surgery (Fig. 4). Deficiencies in all four vitamins were noted, based on reference values.[10,17,19] Supplemental vitamins were not ingested by all patients at the time of evaluation. Thiamine levels were below normal range in 50% of patients, serum folate in 65%, RBC folate in 18%, and vitamin B12 in 24% of patients. Thiamine deficiencies were observed clinically. No anaemia associated with folic acid or vitamin B12 was noted.

No. of Patients	8	17	17	17
Mean ± SEM	2.1 ± 0.5	4.7 ± 1.1	365 ± 53	164 ± 10

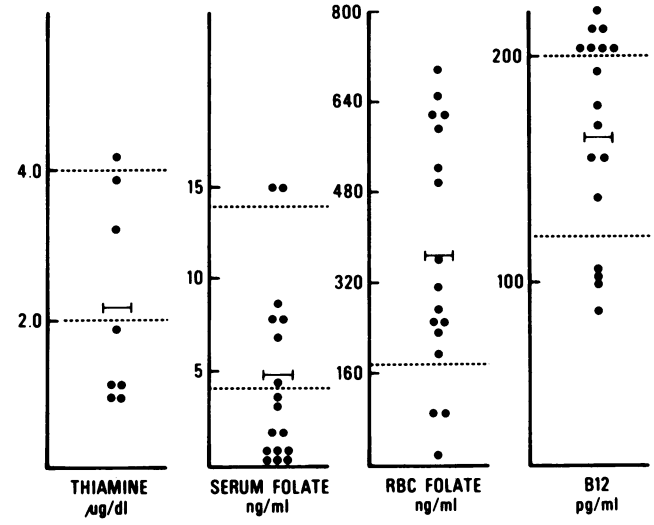

FIG. 4. Distribution of thiamine, serum and RBC folate, and vitamin B12 concentrations in 17 patients with malnutrition or excessive weight loss. Broken lines outline normal ranges. Mean is indicated. Note significant deficiency in all vitamins.

Discussion

The goal of this program of gastric operations for morbid obesity is to return all patients to within 30% of ideal weight. This was achieved in 29% of all patients and was considered a good result. A lesser weight loss, which exceeded 25% of preoperative weight, was designated as satisfactory. This was achieved in 31% of all patients (good and satisfactory in 60%). A weight loss at this time of evaluation of less than 25% was designated as unsatisfactory and was found in 26% of patients 6 months and longer from the time of operation. This method of reporting permits evaluation of each patient separately. Mean weight loss for a given operation is frequently used and may appear good, but can include patients with a good as well as many patients with an unsatisfactory result. The physical risks of obesity become significant when weight exceeds 30% of ideal,[20] and this is the reason we chose this goal for our weight-loss program.

In this study which comprised some form of gastroplasty in 76% of the patients, an orifice size of less than 10 mm in diameter was required over the initial 12 months for patients to have a reasonable chance of achieving a good result. A small orifice led to complete obstruction or severe stenosis requiring reoperations 41 times (17% of all operations), and was associated with significant malnutrition on the basis of body composition and/or vitamin deficiencies in over 50 patients. A good result depends on a small orifice that does not enlarge over long periods of time and a cooperative patient who will ingest high grade protein (especially important is milk protein). Patients who were completely obstructed and were fed via gastrostomy maintained their body cell mass on the control diet of 750 kcal daily, but even these patients have developed significant thiamine deficiency while receiving prophylactic replacement which exceeded theoretical requirements.[21] Patients lose approximately 50% of body weight in one year on this regimen and maintain a normal Na_e/K_e.[5] Patients who vomit because of rapid eating, poor choice of protein, or aversion to milk can become seriously malnourished with vitamin deficiency (especially thiamine), in spite of a caloric intake that is larger than that provided by the control diet. Patients who become malnourished do not necessarily lose more weight than those who remain normal. Those ingesting the control diet lost their body weight rapidly in the form of fat. Body cell mass also decreased significantly in these patients, but they remained nutritionally normal with a normal body composition. The decline in body cell mass reflects the smaller muscle mass required with the new decreased body weight. Malnutrition developed in the majority of patients not on some form of controlled intake. It was characterised by an excessive loss of body cell mass with an abnormal Na_e/K_e ratio. Weight loss is very well tolerated by patients who remain normally nourished, in contrast to those who become malnourished. The malnourished patients develop lassitude and easy fatigabil-

ity. Therefore, weight loss alone or rapidity of weight loss is not an accurate method to detect malnutrition.

Thiamine Deficiency

We have encountered thiamine deficiency in six patients (proven by blood levels in five and by clinical response in one). This was extremely severe in one patient who had high-grade stenosis of the gastroplasty orifice. This patient was admitted to the hospital with severe weakness of the lower extremities and inability to stand. Prompt parenteral treatment with thiamine reversed this symptom in several days, and no suggestion of encephalopathy appeared.

Wernicke-Korsakoff encephalopathy has been reported after gastric plication.[22-24] This is characterized by ataxia, ophthalmoplegia, nystagmus, and mental confusion and is due to thiamine deficiency and can, if untreated, be lethal or result in irreversible nervous system defects.[25,26] In retrospect, we have encountered several patients who complained of "unsteadiness" during periods of rapid weight loss, which may have represented periods of transient thiamine deficiency and incipient Wernicke's disease. Vitamin supplements highly rich in thiamine (over 10 mg per day) should be given to patients losing weight rapidly after gastric-limiting operations. Parenteral therapy may be necessary for some patients. One of Wernicke's first case descriptions involved a young woman with pyloric stenosis and pernicious vomiting.[28] The disease is not limited to alcoholics and has been encountered following prolonged starvation for obesity.[27] Thiamine requirements are normally about 1 mg daily in the healthy adult, but paradoxically increase with decreased oral intake. Stores of thiamine are limited, so that total body thiamine depletion can occur within 18 days following dietary restriction in healthy adults.[21]

Despite low levels of serum and RBC folate and serum vitamin B12 in the patients with rapid weight loss, no clinical detectable anaemia or neuropathy was encountered. Additional vitamin supplements are indicated in these individuals. As many as 50% of patients who lose weight rapidly can have deficiencies of these vitamins. Even those six patients who were on standard vitamin supplements and controlled liquid diet developed diminished thiamine and serum folate levels. It is important that all patients undergoing gastric surgery for weight loss receive supplemental vitamins at high dosage.

A firm recommendation cannot be made of the best operation for obesity on the basis of this study or a review of the literature. Most series do not report patients individually, so that an operation may appear acceptable on the basis of mean weight loss after 1 year or even 2 years, but be unsuccessful in over one-third of the patients studied. Patients lost to follow-up should be classified as unsuccessful.[29] Very few reports indicate how many patients have achieved a weight loss which leaves the patient stable and within 30% of ideal. Reports which compare gastric bypass and gastroplasty frequently show gastroplasty as inferior but also show incredibly small weight losses for gastroplasty which would not be acceptable to surgeons interested in this operation. These comparisons fail to show if either group achieved a good result, as herein defined. The fact remains that a greater than 25% weight loss can be achieved with greater regularity when using gastric bypass without external support of the anastomosis. Gastroplasty requires external support. If silicone tubing is used for external support as described, this will migrate into the lumen in at least one-third of patients, and reoperation due to stenosis may be required (Table 2). In type 6 gastroplasty (silicone support), 35 patients had a Roux-en-Y bypass and 43% achieved a good result. This was our best overall result. However, 20% did require reoperation for obstruction. Patients who have had vertical banded gastroplasty have not been followed long enough for evaluation but are not losing as rapidly as the type 6 gastroplasty patients in our own experience.

Vomiting on a daily basis, not always admitted to by the patients, is an excellent indicator of nutritional depletion and can result in both malnutrition and diminished vitamin status. These same patients may not necessarily lose weight most rapidly, and should therefore be carefully followed.

In a similar study of patients after intestinal bypass for morbid obesity, Shizgal et al.[30] found protein malnutrition in 11 of 44 patients. In addition to malaise, debilitating weakness requiring multiple admissions to hospital, the intestinal bypass patients frequently developed life-threatening liver failure. This represents protein malnutrition more characteristic of kwashiorkor. In the gastric-limiting operations, the malnutrition appears to involve both protein and calories and more closely mimics marasmus in which liver failure is not common and was never seen in this follow-up study.

Conclusions

Reports on surgery for obesity should include the number of patients and follow-up time; the number lost to follow-up, which should be classed as failures; weight loss as a per cent of preoperative weight; and a classification of results such as good, satisfactory, or unsatisfactory, so that each patient is distinguishable and listed as stable, gaining, or losing at 2 to 4 years.

This study shows that weight loss classified as a good result (within 30 per cent of ideal) can be achieved in

about 30% of patients, but requires external support of the orifice if some form of gastroplasty is performed.

The orifice size must be initially and remain less than 10 mm in diameter in order to ensure a satisfactory result after gastroplasty. This small orifice can lead to stenosis or complete obstruction in a significant number of patients requiring reoperation.

Malnutrition occurs frequently after gastric operations for obesity. Enlargement of the stoma resolves the problem in many. Dietary counselling can be successful, but the majority of patients require reoperation or endoscopic dilatation.

Deficiencies of thiamine, folic acid, and vitamin B12 occurred frequently in patients with good weight loss. Thiamine stores are limited and, especially in patients who are prone to vomiting, these stores may become quickly depleted and cause Wernicke's disease with irreversible neuropathy or death. Supplementation of patients undergoing gastric surgery for obesity with vitamins and high quality protein is mandatory in order to prevent malnutrition and clinical vitamin deficiencies. We suggest the daily use of a vitamin supplement (administered either enterally or parenterally) which contains at least 10 mg thiamine during periods of rapid weight loss.

References

1. Drenick EJ, Bale GS, Seltzer F, Johnson DG. Excessive mortality and causes of death in morbidly obese men. JAMA 1980; 243:443–445.
2. Henrikson V. Kan tunntarmsresektion forsvaras som terapi mot fettsot. Nordisk Medicin 1952; 47:744.
3. Halverson JD, Wise L, Wazna MF, Ballinger WF. Jejunoileal bypass for morbid obesity. A critical appraisal. Am J Med 1978; 64:461–475.
4. Bothe A Jr, Bistrian BR, Greenberg I, Blackburn GL. Energy regulation in morbid obesity by multidisciplinary therapy. Surg Clin North Am 1979; 59:1017–1031.
5. MacLean LD, Rhode BM, Shizgal HM. Gastroplasty for obesity. Surg Gynecol Obstet 1981; 153:200–208.
6. Society of Actuaries and Association of Life Insurance Medical Directors of America. 1979 Build and blood pressure study. 1980. Chicago, Illinois.
7. Mason EE. Vertical banded gastroplasty for obesity. Arch Surg 1982; 117:701–706.
8. Shizgal HM. Body composition. *in* Fischer JE, ed. Surgical Nutrition. Boston: Little, Brown and Company, 1983; 3–17.
9. Shizgal HM. The effect of malnutrition on body composition. Surg Gynecol Obstet 1981; 152:22–26.
10. Hutner SH, Bach MK, Ross GIM. A sugar-containing assay medium for vitamin B12-assay with euglena: application to body fluids. J Protozool 1956; 3:101–112.
11. Cooper BA, Jonas E. Superiority of simplified assay for folate with *Lactobacillus casei* ATCC 7469 over assay with chloramphenicol-adapted strain. J Clin Pathol 1973; 26:963–967.
12. Herbert V. Aseptic addition method for *Lactobacillus casei* assay of folate activity in human serum. J Clin Pathol 1966; 19:12–16.
13. Nino HV, Shaw W. Vitamins. *in* Tietz NW, ed. Fundamentals of Clinical Chemistry. 2nd ed., Philadelphia: WB Saunders, 1976; 547–551.
14. Nichoalds GE. Assessment of status of riboflavin nutriture by assay of erythrocyte glutathione reductase activity. Clin Chem 1974; 20:624–628.
15. Rose DR. Plasma pyridoxal phosphate assay. *in* Curry AS, Hewitt JV, eds. Biochemistry of Women: Methods for Clinical Investigation. Cleveland: CRC Press, 1974; 334–338.
16. Delvin EE, Dussault M, Glorieux FH. A simplified assay for serum 25-hydroxycalciferol. Clin Biochem 1980; 13:106–108.
17. Schultz AL, Natelson S. Studies on the distribution and concentration of thiamine in blood and urine. Microchem J 1972; 17:109–118.
18. Armitage P. Statistical Methods in Medical Research. New York: John Wiley & Sons, 1971.
19. Cooper BA, Lowenstein L. Relative folate deficiency of erythrocytes in pernicious anemia and its correction with cyanocobalamin. Blood 1964; 24:502–521.
20. Seltzer CC. Some re-evaluations of the build and blood pressure study, 1959 as related to ponderal index, somatotype and mortality. N Engl J Med 1966; 274:254–259.
21. Ziporin ZZ, Nunes WT, Powell RC, et al. Thiamine requirement in the adult human as measured by urinary excretion of thiamine metabolites. J Nutr 1965; 85:297–304.
22. Haid RW, Gutmann L, Crosby TW. Wernicke-Korsakoff encephalopathy after gastric plication. JAMA 1982; 247:2566–2567.
23. MacLean JB. Wernicke's encephalopathy after gastric plication. JAMA 1982; 248:1311.
24. Gardner TW, Rao K, Poticha S, Wertz R. Acute visual loss after gastroplasty. Am J Ophthalmol 1982; 93:658–660.
25. Feit H, Glasberg M, Ireton C, et al. Peripheral neuropathy and starvation after gastric partitioning for morbid obesity. Ann Intern Med 1982; 96:453–455.
26. Rothrock JF, Smith MS. Wernicke's disease complicating surgical therapy for morbid obesity. J Clin Neuroophthalmol 1981; 1:195–198.
27. Drenick EJ, Joven CB, Swendseid ME. Occurrence of acute Wernicke's encephalopathy during prolonged starvation for the treatment of obesity. N Engl J Med 1966; 274:937–939.
28. Wernicke C. Lehrbuch der Gehirnkrankeiten fuer Aertzte und Studierende. Theodore Fischer Kassel 1881; 2:229–242.
29. Freeman JB, Burchett H. Failure rate with gastric partitioning for morbid obesity. Am J Surg 1983; 145:113–119.
30. Shizgal HM, Forse RA, Spanier AH, MacLean LD. Protein malnutrition following intestinal bypass for morbid obesity. Surgery 1979; 86:60–68.

DISCUSSION

DR. WARD O. GRIFFEN, JR. (Lexington, Kentucky): We have seen significant nutritional and vitamin depletion in the early days and months following gastric reduction procedure. We have looked at this problem in another fashion and less sophisticated way. With the help of one of our medical students, Ms. Katie Coughlin, we looked at the caloric intake of a group of 25 patients who underwent the procedure, depicted on this first slide.

(Slide) This is the gastric bypass that we currently do, just putting a staple line across the upper part of the stomach, to create a 50 ml pouch, and then bringing up a Roux-Y loop of jejunum to drain the pouch into the intestine. We taught these patients how to take a dietary history—a dietary diary—and had them do a 1-day diary preoperatively, and then had them do a diary each week for a year following their operative procedure. Ms. Coughlin then collated the information in terms of calories, and we were able to show the caloric intake of