Jejunoileostomy for Extreme Obesity:

Rationale, Metabolic Observations, and Results in a Single Case

ALFRED P. MORGAN, M.D., FRANCIS D. MOORE, M.D.

From the Department of Surgery, Harvard Medical School and the Peter Bent Brigham Hospital, Boston, Massachusetts

SYMPTOMATIC obesity is notably difficult to treat successfully. Obesity clinics, offering near ideal medical, psychiatric, dietetic, and social support, report results no more than fair; relapse is the rule, and there is a wide gap between effort expended and results obtained.[14] Therapy by individual physicians is no more effective. This general problem has been reviewed recently by Mayer.[11]

Extreme obesity is defined as adiposity sufficient to cause socioeconomic, reproductive, or life-threatening disability in an otherwise normal person. Its treatment presents several special difficulties in addition to those encountered with the merely overweight. The orthopedic and cosmetic consequences of large weight losses are not all desirable, psychiatric difficulties are nearly universal in the hugely obese, and an unreasonably long time is needed for consumption of large adipose tissue reserves. For example, the energy content of 100 pounds of obesity tissue is about 400,000 calories, 6 months' or a year's expenditure without other intake.

Total fasting has been shown to have some advantages in treating obese patients. The recent history of therapeutic fasting began in 1959 with Bloom's account of nine persons who fasted from 4 to 9 days.[2] He reemphasized that patients receiving only acaloric fluids are not hungry, that when they are fed again less food is required for satiety than before fasting, and that demonstrated ability to lose weight is a worthwhile psychologic byproduct. All nine patients reported by Bloom maintained some weight loss (after 6 months). Intermittent, repeated fasting has also been reasonably successful; 60% of those treated maintain some weight loss or continue to lose weight on low calorie diets.[4] Others report longer fasts with consequently greater weight losses, but followup is short or not reported, and the long range results are not known.

Another approach to obesity has been creation of a reversible, short bowel syndrome by surgical bypass of part of the small intestine. Payne, *et al.*[13] reported ten cases in 1961. The operation was a jejunotransverse colostomy with 15 (or in one case 20) inches of jejunum left in continuity. The authors did not consider the operation a success: diarrhea was a problem, hypocalcemia and hypokalemia were threats, and although weight loss was produced (at rates similar to total fasting), it was not maintained.

Wood [16] reported discouraging results in a patient with a jejunoileostomy (18 in. of jejunum, 8 in. of ileum). The excluded bowel was allowed to empty into the transverse colon. Here steatorrhea seemed to

Supported in part by grants from the Hartford Fund, The National Institutes of Health, and the Surgeon General of the United States Army.

Submitted for publication February 6, 1967.

have been produced without weight loss on a 3,600 calorie diet. Concern over important electrolyte loss was reinforced by DeMuth's case, a patient in whom fatal hypocalcemic or hypomagnesemic tetany may have occurred.[3]

On the other hand, Lewis, Turnbull, and Page treated 11 patients with generally satisfactory outcome.[9] The operation was jejunocolostomy. All but 30 inches of jejunum were excluded in eight patients, all but 20 in three.

The place of small bowel bypass in obesity may be maintenance of weight reduction rather than actual weight loss, by creation of a caloric leak which allows relaxation of dietary restriction. This assumes there is a therapeutic zone between significant diarrhea on one hand and negligible loss of absorptive capacity on the other. Payne's experience is a guide to the choice of an operation for this purpose. Three of his reconstructive procedures were jejunoileal anastomoses, and in one, with 15 in. of jejunum and 10 in. of ileum in the circuit, weight was stabilized without disabling diarrhea.

With this as background, and with the cooperation of the Medical and Endocrinologic Services of the Peter Bent Brigham Hospital, we embarked on a program of applying surgical bypass as adjunctive therapy in obesity. A 3-year follow up is now available on one patient and allows an attitude of guarded optimism in further application of the operation.

Case Report

The patient (S. C., 3–14–51) was 33 when first admitted for intractable obesity. She was separated, and the mother of one child. She had been slender and active until age 14 when a tendency to obesity became apparent. Menarche was at age 13, uneventful pregnancy at age 19. Menses became scanty and irregular with increasing obesity. At 17, she weighed 180 pounds, and her weight steadily increased to the 458 pounds she weighed at the time of her first admission. She lost her job, and other employers were unwilling to hire her. She had undertaken medically supervised dieting three times and lost 50–70 pounds on each occasion, but rapidly regained it. Her sister, mother, and daughter were all greatly overweight.

She experienced all the discomforts of the hugely obese: dermatitis in intertriginous areas, inability to fully abduct her arms because of the great bulk of the trunk, and dyspnea from the effort of standing.

Physical examination showed only obesity. Blood pressure by conventional cuff measurement was 176/94, but with the cuff on the forearm, it was 130/80. Routine laboratory studies were normal. Oral glucose tolerance test was normal, PBI 5.2 mcg./100 ml., red cell T-3 uptake 11.3%, 24-hour 17-keto and 17-hydroxy steorid excretions were in the normal range.

For the next 8 months, as an inpatient, she was treated with intermittent 10-day total fasts interrupted by periods of 10 days to 2 weeks on a 1,000 calorie diet.* Generally, her course was predictable from published descriptions: hunger was not a problem, but adequate fluid intake was; occasionally a nasogastric tube was required to maintain 2 liters of daily intake. Calf tenderness and swelling developed during a diuresis and was treated with heparin. The expected hyperuricemia was seen; peak uric acid level was 11.8 mg./100 ml. Serum Na, K, and Cl remained normal, CO_2 combining power fell during fasting to 19 mM./L. The weight loss resulting from this regimen is shown in Figure 1.

Two days after her last planned fasting period ended, she had an attack of right upper quadrant pain, fever, and vomiting. A cholecystogram showed poor opacification and stones. The attack subsided in a few days. An elective cholecystectomy was planned, and the patient offered a small bowel bypass to be performed at the same time. The nature of the procedure was carefully explained.

On May 5, 1964, a routine cholecystectomy was done. The jejunum was then divided 15 inches from the ligament of Treitz, and the proximal jejunum anastomosed to the ileum, end-to-side, 10 inches from the ileocecal valve. The distal end of the divided jejunum was turned in. The measured length of the small bowel was 272 inches.

The postoperative period was not unusual. No respiratory or septic complications occurred. Stools were liquid, but not excessive in volume; there were usually 3 to 5 bowel movements, totaling an average 500 cc. daily. Radiographic transit time,

* As one of a series of patients studied by Dr. David Lauler, observations made during this period will be reported in greater detail in the future.

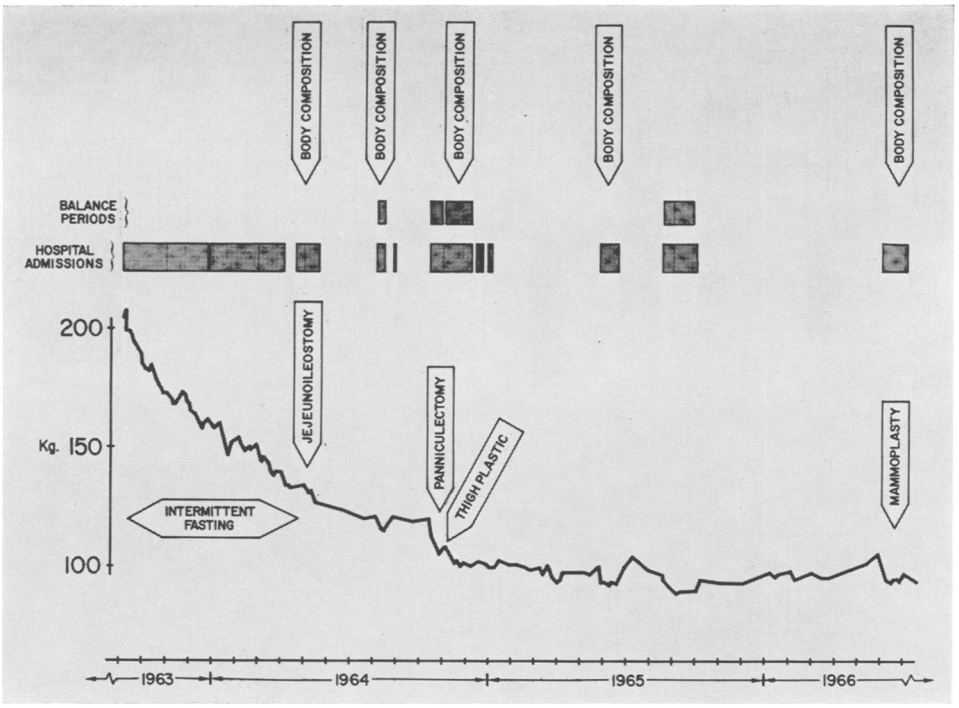

FIG. 1. Body weight and events during the 3-year period of observation.

mouth to cecum, was one half hour. It was found that the degree of diarrhea experience depended on activity and intake. A bout of gastroenteritis could result in significant fluid losses. Supplementary oral calcium, potassium, and magnesium were considered advisable. She was seen weekly as an outpatient and readmitted on several occasions for intravenous repletion (Fig. 1). After one year,

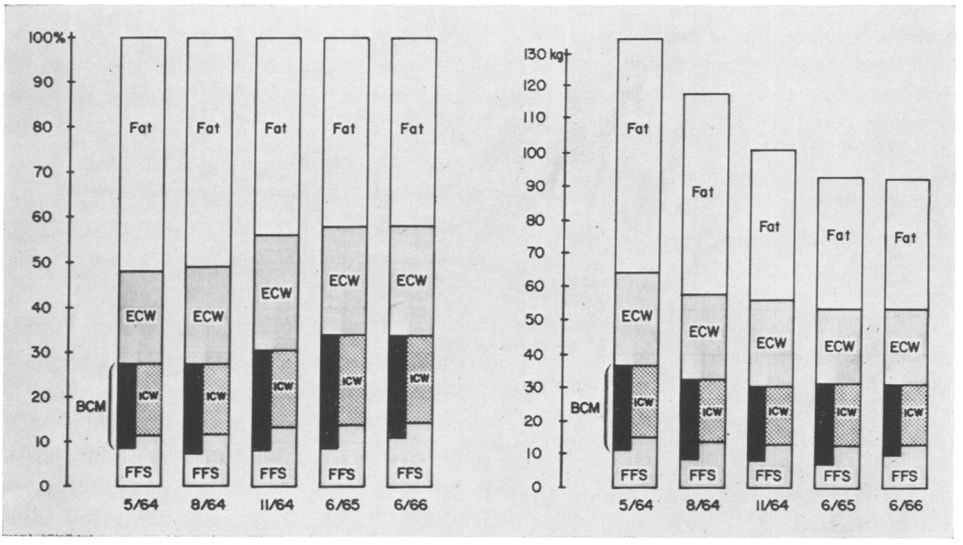

FIG. 2. Serial determinations of body composition by isotope dilution. Left: composition as percentage of total body weight. Right: absolute values. ECW: extracellular water; ICW: intracellular water; FFS: fat and free solids; BCM: body cell mass (exchangeable potassium ×8.33).

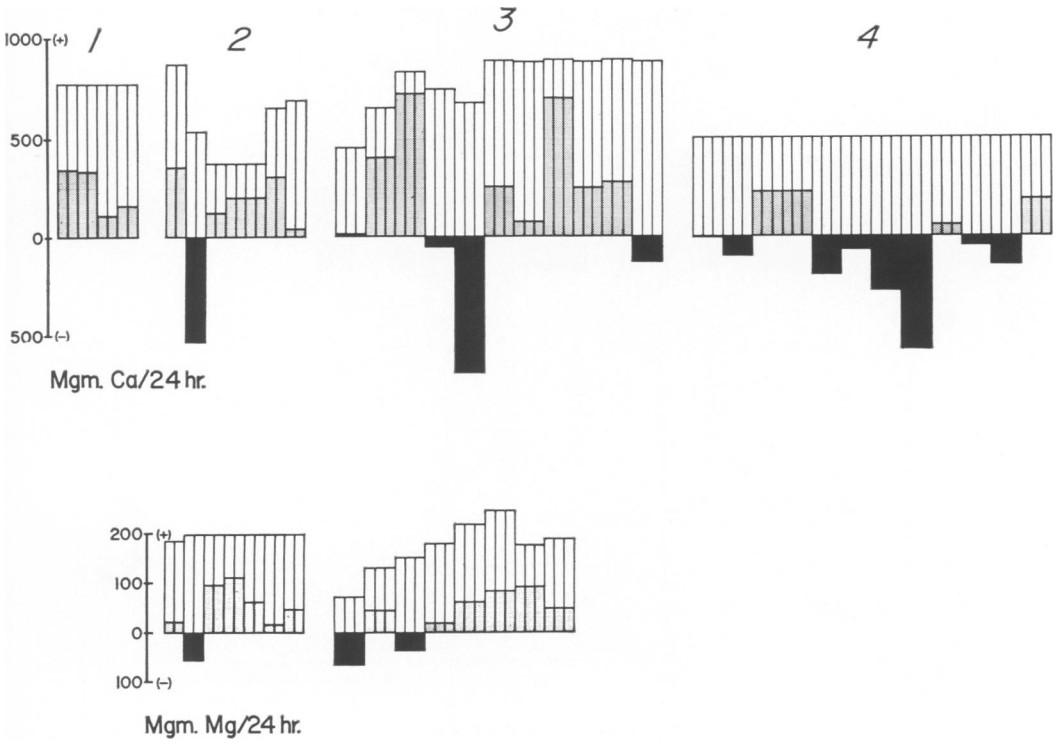

FIG. 3. Daily calcium and magnesium balance during the four balance periods shown in Figure 1.

diarrhea became less frequent and severe, and although her bowel pattern varied, in general she passed three semiformed stools daily. Supplementary electrolytes were continued until balance studies demonstrated they were not needed.

Weight loss continued, with intake restricted to 1,000 calories. As her diet was liberalized, her weight leveled off at 100–110 Kg. Several plastic procedures, including a panniculectomy, have been done to correct skin redundancy (Fig. 1).

Psychologically, there has been an apparent net improvement, although there was at first a period of marked dependency on the hospital and her physicians. This was followed by display of symptoms for which no anatomic basis could be found. The most dramatic use of these occurred after panniculectomy when she became suddenly paraplegic. The consulting neurologist found the patterns of sensory and motor loss neurologically inconsistent. Her symptoms cleared in three days, and have not recurred.

At present the patient's interests are centered outside the hospital; she is working, well groomed, sexually active, and proud of her appearance.

Laboratory Observations

The expected metabolic effects of bypass include induction of negative balance for nitrogen, potassium, calcium, magnesium, and energy, the latter principally by interference with fat absorption. Preoperatively, after three days on a diet containing 100 Gm. of fat, measurement of fecal fat showed 95% uptake. Postoperative uptakes have been 50–63% with no evidence of increasing absorptive capacity.

Electrolyte balance has been monitored for several periods during followup as a guide to her need for supplementary calcium, magnesium, and potassium. On these occasions, the patient was admitted to a metabolic ward, intake measured by standard technics—handbook values checked by analysis of diet aliquots—and output collected. Some collections were made in 2 and 3 day pools, pooled results are plotted

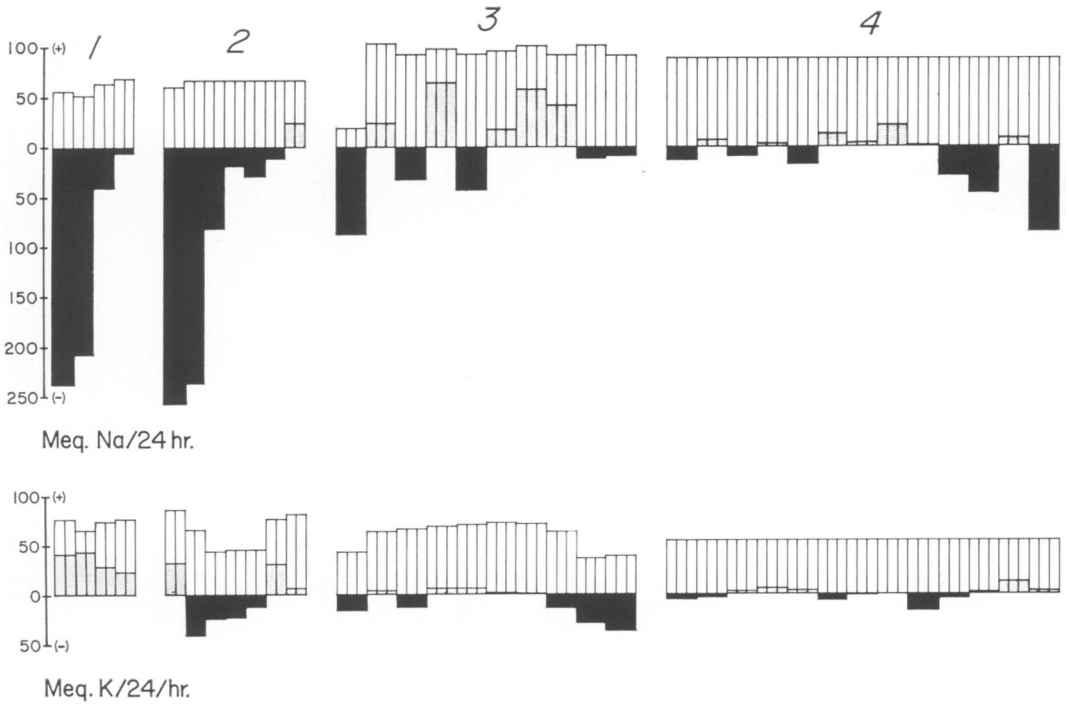

FIG. 4. Daily Na and K balance; same periods as Figure 3.

as daily averages in Figures 3 and 4. Stool markers were not used, and fluctuations in daily balance (Fig. 2), particularly for calcium, reflect the patient's irregular bowel pattern and emphasize that fecal losses predominate for calcium and magnesium. Fecal potassium loss was never excessive, always less than half the daily urinary excretion. The beginning of each period shows the sodium diuresis associated with decreased activity, (Fig. 3).

The simultaneous multiple-isotope method described earlier[12] was used to follow changing body composition (Fig. 4). When first examined, in addition to the obvious compositional deformity of having fat make up slightly more than half the body weight, the patient showed evidence of pathologic overhydration: her ratio of exchangeable sodium to exchangeable potassium was 1.48 and of intracellular to total body water 0.44. Her K_e/creatinine ratio was at the

TABLE 1.

Date	Weight	TBW	K_e	K_e/creatinine	Na_e/K_e	ICW/ TBW	Average ICK Conc.
5/ 1/64	134.2	49.3 L.	3024 mEq.	2.19 mEq./mg.	1.48	0.44	134 mEq./L.
8/ 7/64	118.0	44.3	2876	2.28	1.42	0.43	147
11/20/64	101.0	43.3	2700	2.39	1.58	0.40	149
6/ 3/65	93.0	41.0	2811	2.25	1.20	0.46	145
6/24/66	92.6	40.6	2551	2.41	1.41	0.45	136

* Magnesium determinations were done by Dr. Warren E. C. Wacker, Biophysics Laboratory, Peter Bent Brigham Hospital.

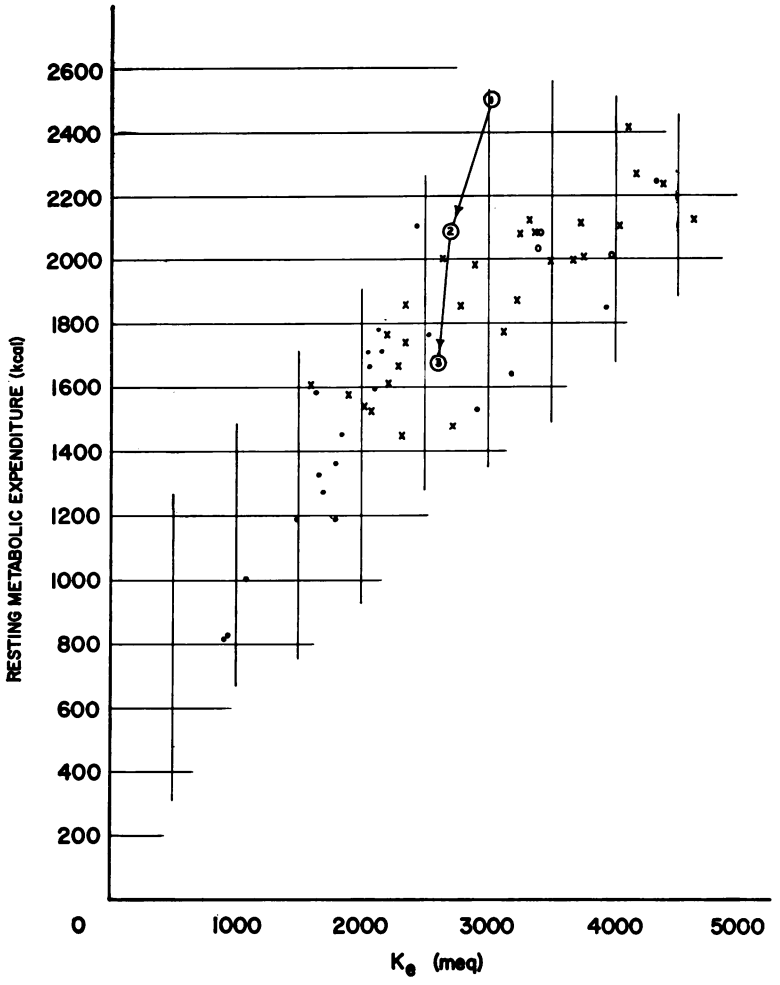

FIG. 5. RME vs. K_e; plotted with data from Kinney, Lister, and Moore. Ann. N. Y. Acad. Sci., 110:711, 1963. Circled, connected points show results on (1) 5/64, (2) 6/65, and (3) 6/66.

upper level of normal at 2.19 (normal 1.75–2.25 with higher values in the female), suggesting some wasting of skeletal muscle in relation to the visceral mass. This ratio rose slightly (about 10%) with further weight loss. The pertinent compositional ratios are shown in Table 1.

The relationship of exchangeable potassium to metabolic expenditure is plotted in Figure 5. Resting metabolic expenditure was estimated by indirect calorimetry, obtaining 12 five-minute expired air samples daily for three days. Results of the analyses are integrated over each 24-hour period as described by Kinney [6] and expressed as kilocalories per 24 hours, using the constants assumed in the Zunst-Shumberg-Lusk tables.

Discussion

For this patient the surgical procedure has proven to be a satistifactory compromise between excessive absorption and excessive diarrhea. Retention of the ileocecal valve and right colon in continuity have probably contributed to her ability to reabsorb gastrointestinal water; it is also possible that her initially large doses of oral calcium lactate played a role in preventing diarrhea by saponification of the fatty acids of small bowel contents.[8]

It was gratifying that exclusion of 90% of the small bowel produced neither dis-

abling symptoms nor uncontrollable losses of cation, but individual response to a given configuration of small intestine is certain to vary. Close observation and balance studies were helpful guides to electrolyte replacement.

Obese patients previously studied tend to fall into two groups, constitutionally speaking.[12] This patient is one of the unhealthy obese, characterized by expansion of ECF, with low ICW/TBW, and high Na_e/K_e ratios, reduced BCM in proportion to skeletal weight, and a high incidence of hypertension. The opposite type, often male, with more muscle and more normal compositional ratios, tends to be less disabled by obesity.

This patient's compositional deformity was not corrected by either 41 Kg. of weight loss (occurring between 5/64 and 6/65) or a year of relatively stable weight (6/65–6/66). Further, she is still a wasted individual: at 200 pounds her mantle of remaining fat conceals atrophy of her body cell mass, as evidenced by ICW/TBW still at 0.45 and Na_e/K_e at 1.41. The lost body cell mass includes an unknown fraction of that part of adipose tissue which contains potassium and nitrogen. This component includes protoplasm of fat cells and the potassium poor extracellular solids of the stroma. Analysis of fat from this patient's panniculectomy specimen shows that 1 mg. of nitrogen is presented in support of each 88 mg. of triglyceride; the K/N ratio of human adipose tissue averages 1.2 mEq./Gm.,[15] so the loss of 15 Kg. of fat is *potentially* associated with loss of 170 Gm. nitrogen and 217 mEq. of potassium or a fat:K ratio of 69 Gm./mEq. The extent to which this potential loss is actually realized is the subject of current studies. Between her first two body compositional measurements, she lost 9.9 Kg. of fat and with this 148 mEq. of potassium, for a triglyceride:K ratio of 67 Gm./mEq.

A relationship between resting metabolic expenditure and the size of the metabolic core, expressed as K_e, would be expected and has been described.[7] Expenditure increases less rapidly than K_e (Fig. 5) as K_e increases; the nonlinearity is explained by the increasing contribution of resting muscle to the total cell mass in larger individuals.

Our patient's high energy expenditure per unit K_e was an unanticipated finding, but has since been reproduced in studies of other obese patients by our group and by others.[10] Three explanations may be offered: first, that there is a major increase in work of breathing in obesity. In fact, work of breathing, though increased, is still a small fraction of total energy expenditure in resting obese subjects.[5] Second, increased metabolic expenditure in extreme obesity could be due to the energy required for maintenance of posture, but these measurements were made at rest, which would underestimate rather than overestimate expenditure. The final possibility is that the excess oxygen consumption by adipose is similar to other tissues, if the comparison is made on a lipid-free dry weight basis. Oxygen consumption is increased as much as ten times with lipolysis.[1] The measurements in this patient were done during active lipolysis.

With accomplished weight loss, energy expenditure then falls, and its relation to K_e becomes more normal, one of the factors making weight reduction progressively more difficult to accomplish.

Summary

1. Jejunoileostomy, with 25 inches of bowel remaining in continuity, and with the ileocecal valve not bypassed, has been an acceptable procedure in this patient, allowing weight loss with moderate caloric restriction and weight stability with a liberal diet without disabling diarrhea.

2. Fecal loss of calcium, magnesium, and potassium was not excessive.

3. Compositional studies show that adipose tissue loss takes place only with con-

current potassium loss in a setting of extracellular fluid expansion.

4. Energy expenditure, estimated by indirect calorimetry was significantly increased over that predicted from exchangeable potassium; after further loss of weight, this returned toward normal.

5. Small bowel bypass may be useful as an adjunctive therapy in obesity, rather than as a primary treatment.

References

1. Ball, E. G. and Jungas, R. L.: In Adipose Tissue, ed. Reynold, A. E. and Cahill, G. F., Jr. Washington, D. C., American Physiological Society, 1965.
2. Bloom, W. L.: Fasting as an Introduction to the Treatment of Obesity. Metabolism, **8**: 214, 1959.
3. DeMuth, W. E., Jr. and Rottenstein, H. S.: Death Associated with Hypocalcemia after Small Bowel Short Circuiting. New Eng. J. Med., **270**:1239, 1964.
4. Duncan, G. G., Jenson, W. K., Christofori, F. C. and Schless, G. L.: Intermittent Fasts in the Correction and Control of Intractable Obesity. Amer. J. Med. Sci., **245**:515, 1963.
5. Gilbert, R., Sipple, J. H. and Auchincloss, J. H.: Respiratory Control and Work of Breathing in Obese Subjects. J. Appl. Physiol., **16**:21, 1961.
6. Kinney, J. M.: A Consideration of Energy Exchange in Human Trauma. Bull. N. Y. Acad. Med., **36**:617, 1960.
7. Kinney, J. M., Lister, J. and Moore, F. D.: Relationship of Energy Expenditure to Total Exchangeable Potassium. Ann. N. Y. Acad. Sci., **110**:711, 1963.
8. LeVeen, H. H.: Communication at 52nd Clinical Congress, American College of Surgeons, San Francisco, 1966.
9. Lewis, L. A., Turnbull, R. B., Jr. and Page, I. H.: Effects of Jejunocolic Shunt on Obesity, Serum Lipoproteins, Lipids, and Electrolytes. Arch. Int. Med., **117**:4, 1966.
10. Lister, J.: Personal Communication.
11. Mayer, J.: Some Aspects of the Problem of Regulation of Food Intake and Obesity. New Eng. J. Med., **274**:610–616, 662–673, 722–731, 1966.
12. Moore, F. D., Olesen, K. H., McMurrey, J. D., Parker, H. V., Ball, M. R. and Boyden, C. M.: The Body Cell Mass and Its Supporting Environment, Ch. 1. Philadelphia, W. B. Saunders Co., 1963.
13. Payne, J. H., DeWind, L. T. and Commons, R. R.: Metabolic Observations in Patients with Jejunocolic Shunts. Amer. J. Surg., **106**:273, 1963.
14. Stunkard, A. and McLaren-Hume, M.: The Results of Treatment for Obesity. Arch. Int. Med., **103**:79, 1959.
15. Thomas, L. W.: The Chemical Composition of Adipose Tissue of Man and Mice. Quart. J. Exper. Physiol., **47**:170, 1962.
16. Wood, L. C. and Chremos, A. N.: Treating Obesity by "Short-Circuiting" the Small Intestine. JAMA, **186**:63, 1963.