METABOLIC STUDIES OF AN UNUSUAL CASE OF SURVIVAL FOLLOWING RESECTION OF ALL BUT EIGHTEEN INCHES OF SMALL INTESTINE

COMPLICATED BY COMBINED ABDOMINOPERINEAL RESECTION FOR CARCINOMA OF THE RECTUM PERFORMED NINE YEARS PREVIOUSLY*

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INTRODUCTION

THERE HAVE BEEN occasional isolated case reports of survival after extensive intestinal resection since Koeberle's first report in 1881 (Haymond[17]). However, the emphasis has been on the surgical aspects of these cases, and surprisingly few metabolic studies have been performed on patients who have survived beyond a six-month period. It is generally accepted for purpose of discussion that a massive resection consists of removal of more than 200 cm. of small bowel. More important from a physiologic standpoint would be the length of remaining bowel; and the emphasis should not be so much on the measurement of the excised specimen as on the length of remaining absorptive surface, as this will more accurately reflect the metabolic deficiency.

HISTORICAL

An excellent and detailed review of the literature up to 1912 was first presented by Flint.[13] Again, in 1935, H. E. Haymond critically analyzed and collected 257 cases up to that date.[17] For those interested in the historical background and for detailed protocols, these references will suffice. Since 1935 there have been 13 additional case reports of massive intestinal resection, only one of which had an adequate metabolic investigation.[2, 3, 5-8, 11, 13-16] E. S. West, Todd, *et al.*[27, 28] did repeat nutritional surveys in 1938 and 1940 on a patient with only three feet of remaining small intestine. Their findings were that carbohydrates were utilized normally, proteins were not absorbed well (only 70 to 75 per cent being utilized), and that fat absorption was poor (45 per cent being lost in feces). Also, there was excessive loss of calcium when a large amount of fat was included in the diet. This work represents the sum total of metabolic investigation to date in patients with massive small intestinal resection.

CASE REPORT

On August 1, 1948, Mrs. E. G., a 55-year-old woman, was brought to the University Hospital in a state of shock. Two days before admission she noted the onset of mid-abdominal, cramping pain which radiated to the back and both shoulders. She developed

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progressive anorexia, nausea, vomiting and obstipation. Within a few hours of admission her abdomen became severely distended and she went into circulatory collapse.

Nine years before, an abdominoperineal resection with permanent colostomy was performed for cancer of the rectum. She was re-admitted 3 years ago for profuse bleeding from the colostomy. An exploratory laparotomy was then performed without discovering the source of the bleeding, and aside from the development of a ventral hernia in this wound, her subsequent course was uneventful and she had no recurrence of the bleeding. She maintained weight and remained in fairly good health up to the time of the present illness.

On physical examination she appeared acutely ill, toxic and dehydrated, and was complaining bitterly of abdominal pain. Her temperature was 97, pulse 160, feeble and thready, her blood pressure 90/50 and her respiration 28. There was evidence of severe dehydration, with inelastic dry skin and a dry, coated tongue. There was no icterus. The heart and lungs were negative. The abdomen was markedly distended and tympanitic, and a melon-sized, tense mass protruded through the upper two-thirds of the left rectus scar above a partially prolapsed and edematous end-colostomy. There was diffuse, exquisite, direct and rebound abdominal tenderness and muscle spasm; no peristaltic sounds were audible. Digital examination of the colostomy was negative. Pelvic examination revealed bulging in the cul-de-sac but normal uterus and adnexae. The perineal scar was soft and showed no evidence of recurrence of carcinoma.

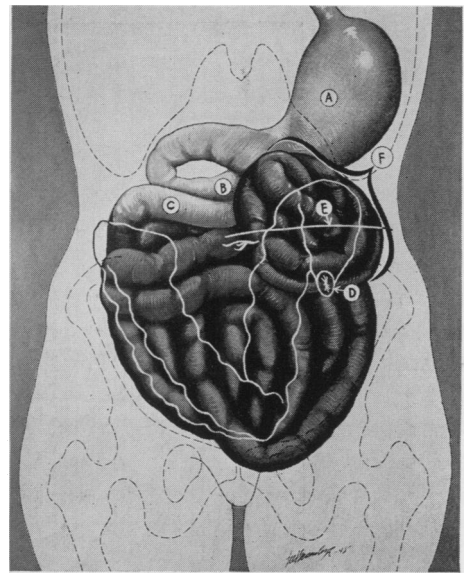

FIG. 1.—Artist's drawing of operative findings, (gangrene of entire small intestine except for first 18" of uninvolved jejunum). A. Stomach. B. Duodenum. C. Intact jejunum. D. Permanent colostomy. (Status nine years past combined abdominal perineal resection for carcinoma of the rectum). E. Transverse operative incision. F. Gangrenous small bowel in ventral hernia sac (in bracket).

Laboratory findings on admission were as follows: Flat plate of the abdomen revealed moderately severe ileus, with dilatation of both small and large intestine and a suggestion of peritoneal fluid. Hemoglobin was 16.5 Gm. with 5.6 million red cells and 18,500 white blood cells, with 88 per cent polymorphonuclear leukocytes, 80 per cent nonfilamented. Urine was negative except for a 2-plus acetone and a 1-plus albumin. The hematocrit was 47 volumes per 100; blood carbon dioxide combining power was 33 volumes per 100; blood plasma chloride 102 milliequivalents per liter; blood non-protein nitrogen 29 mg. per 100 cc.; blood sugar 100 mg. per 100 cc. and total protein, 5.7 Gm. per 100 cc.

On admission she received vigorous supportive therapy, including plasma, whole blood and oxygen. Wangensteen drainage obtained several liters of dark brown, malodorous "fecal" fluid. Both penicillin and streptomycin were given preoperatively in adequate doses. After seven hours of this intensive therapy, blood pressure rose to 120/70, pulse slowed to 120 and the patient was considered a suitable risk for laparotomy.

Anesthesia was induced with sodium pentothal followed by nitrous oxide and oxygen, and local infiltration of the wound with one per cent procaine. Her condition was poor throughout the procedure. A long transverse incision was used to gain access to the

ventral hernia sac just above the umbilicus. The wall of the sac was completely necrotic and contained about a liter of foul smelling, brownish fluid. Six feet of completely gangrenous small intestine was strangulated in a ring of fascia 3 inches wide, in which the root of the mesentery had twisted twice on itself as a volvulus (Fig. 1). After division of the fascial ring, and opening into the true peritoneal cavity, a huge amount of similar fluid poured out. The twist of the mesentery had completely infarcted almost the entire remaining small intestine, extending from 18 inches below the ligament of Treitz to 6 inches above the cecum. The proximal 18 inches of jejunum and the entire large intestine up to the colostomy were viable. The mesentery was greatly engorged and hemor-

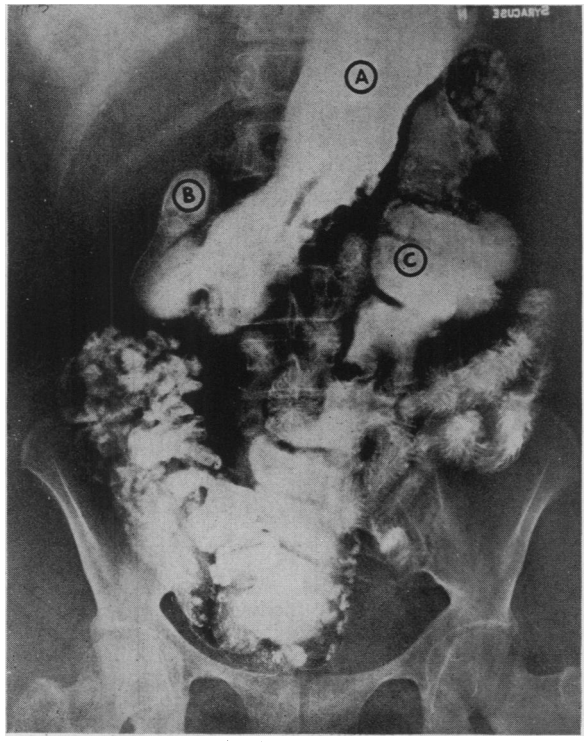

FIG. 2.—Barium meal four months following operation revealing 18 in. of residual jejunum by actual measurement. A. Stomach. B. Duodenum. C. Ligament of Treitz.

rhagic and all of the vessels appeared to be thrombosed. There was no gross perforation of the infarcted gangrenous intestine, although its wall was paper-thin and necrotic.

In the face of this seemingly hopeless situation no lesser procedure than resection seemed practical. Accordingly, the root of the entire mesentery was quickly divided between clamps and ligated with multiple cotton ties and the entire gangrenous area was resected, using Payr clamps, leaving 18 inches of viable proximal jejunum and 6 inches of distal ileum. The distal end of the ileum was closed in two layers and the end of the jejunum anastomosed to the side of the cecum, using interrupted fine cotton for serosa, and Connell closure with ooo chromic to complete the anastomosis. The entire cavity was then sucked dry and the abdominal wall defect was repaired, using interrupted No. 30

stainless steel wire through fascia and peritoneum after the excess sac was excised. The patient received 1500 cc. of whole blood during the 90 minutes of operating time and left the table in poor condition, her blood pressure 80/40, pulse 140 and showing marked cyanosis. She was immediately placed in an oxygen tent. In the first 36 hours her sole intake consisted of continuous plasma and whole blood infusion, a total of 1000 cc. of plasma and 2500 cc. of whole blood. Other measures included continuous Wangensteen drainage and adequate doses of streptomycin and penicillin. She excreted 900 cc. of urine the first 24 hours, and her general condition slowly responded. Blood pressure rose to 100, pulse slowed to around 100 and her color improved. She had moderate febrile response up to 101 degrees for the first week. Her abdomen never became distended. Her colostomy did not function until the eighth postoperative day, at which time the Wangensteen was first removed. Electrolyte balance was maintained with parenteral fluids for the first week, after which oral feedings were started. Her blood N.P.N. ranged between 25 to 35 mg. per 100 cc.; serum protein 6.2 to 6.8; blood chlorides 95 to 102 milliequivalents per liter; carbon dioxide combining power 40 volumes per 100; prothrombin 95 to 100 per 100.

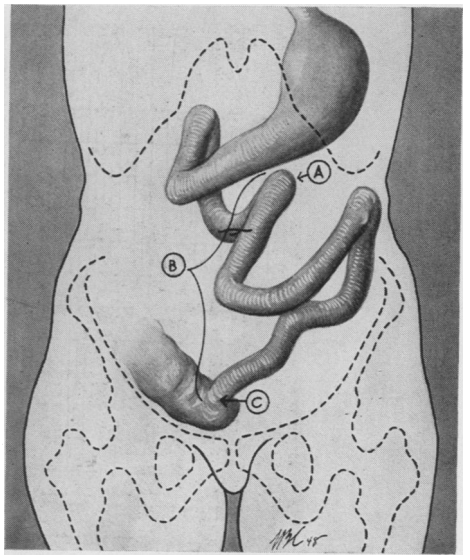

FIG. 3.—Artist's drawing from barium meal roentgenogram. A. Ligament of Treitz. B. Residual 18" of jejunum. C. Jejuno-caecal end-to-side anastomosis.

Despite a moderately severe fascial infection which required irrigation she had fairly good wound healing. On the twelfth and eighteenth postoperative days there were episodes of chest pain with roentgen ray evidence of pulmonary infarction despite absence of clinical evidence of phlebitis in either extremity. Because of the wound complication, ambulation was delayed until the thirty-fourth postoperative day. She was discharged 6 weeks after admission.

The pathologic report was as follows: The specimen consists of approximately 540 cm. of small bowel attached to practically the entire mesentery. The small bowel appears grossly hemorrhagic and necrotic. Cross section of the mesentery reveals thrombosis of nearly every large vessel.

The problem in the hospital once the immediate postoperative critical stage had subsided was the management of the almost continuous liquid discharges from the colostomy. Following any intake of fluid or food by mouth, the patient complained of rather severe but transient cramps, followed by a profuse discharge from the colostomy, varying from a brownish green liquid to a semi-fluid, tape-like stool which kept oozing forth. Drugs to control this and to thicken the stool were for the most part ineffective. They included deodorized tincture of opium, paregoric, bismuth, atropine, belladonna, *Dreft*, psyllium seed derivatives, aluminum hydroxide gel, apple powder and other pectin compounds. A saving grace was the Rutzen bag, which held the liquid discharges quite well (Fig. 4).

When she began oral feedings, the main problem in nutrition was to provide easily assimilated foods, namely glucose and protein hydrolysates fortified with vitamins in adequate doses. The question of volume of food was important, for she tolerated small volumes of food at frequent intervals, but no large meals. Since her return home, she

averages 6 to 8 small feedings a day, with supplements such as glucose, milk, Proteinal,* vitamins and calcium, but she does not require parenteral medication. Fats, apparently being poorly tolerated and absorbed, are held to a minimum. On this regimen her caloric intake is maintained at about 2000 to 2500 calories a day.

Aside from a smooth, somewhat shiny, red tongue, she never demonstrated evidence of gross vitamin deficiency, and her blood counts never showed significant anemia or abnormality in the blood cells. Repeated blood studies at monthly intervals show normal blood count and blood protein level. A gastro-intestinal series performed several months after discharge revealed a very small residual segment of small intestine (measured on the film as 18 inches) with only moderate dilatation of this loop. The site of anastomosis was open. The barium very rapidly progressed to its exit at the colostomy (Figs. 2 and 3).

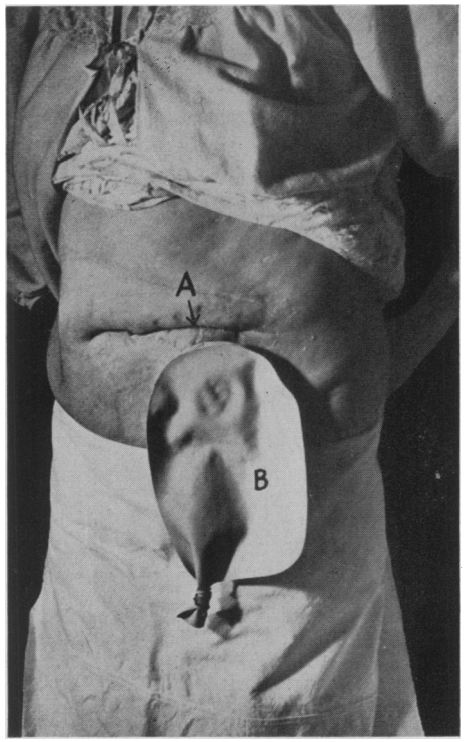

FIG. 4.—Photograph of patient—present status. A. Transverse incision at site of exploration. B. Rutzen bag over colostomy.

Despite an anticipated sharp weight loss and progressive cachexia, the patient did not deteriorate seriously. Her weight slowly fell from her usual 120 pounds prior to this admission to the present 100 pounds, which she maintains. Since her return to her home the patient has been able to do light household duties. Her chief disability lies in the almost continuous colostomy discharge, as many as 15 to 20 movements a day. Her skin and muscle turgor remain good and her general appearance belies the fact that she has only 18 inches of residual small intestine. At the outset it was inconceivable to us that she could obtain sufficient absorption in this segment to sustain life, let alone nutrition.

In an effort to explain the maintenance of an adequate nutritional state in the face of this gross intestinal deficiency, the patient was admitted to University Hospital in January, 1949, for special studies to determine the absorption and excretion of nitrogen and fat and to determine sugar tolerance.

PROCEDURE

To avoid any marked variation from day to day, the metabolic study period lasted three days, and an average daily value was obtained. The diet used for the study was made to approximate, in so far as possible, the patient's own diet. An attempt was made by the dietitian to follow as closely as possible the

* Proteinal supplied by National Drug Co., Philadelphia, Pa.

eating habits and food desires of the patient. A sample of a 24-hour diet given her is shown below.

SAMPLE DIET FOR A 24-HOUR PERIOD.

Item	Grams	Calories
Eggs (4)	...	316
Butter	30	292
Bread (4 slices)	80	216
Sugar, white	45	180
Cream, light	120	241
Cream of wheat	20	71
Grapefruit juice (sweetened)	100	67
Baked potato	100	85
Beef, ground	85	137
Cottage cheese	100	101
Canned salmon	50	138
Canned pears	100	75
Boiled milk	540	369
Chocolate milk	180	66
Hershey bar	43	239
Whiskey	84	258
Coffee	150	...
Tea	300	...
Total	2127	2851

The patient was encouraged to eat as much of her diet as possible. A sample control diet was prepared with each meal served, and one-half of each item in each meal was preserved for analysis. (This included one-half of all supplementary foods also.) All food left uneaten at each meal was also saved. In the laboratory, all these specimens, the control diet, the uneaten food and the stools (which were marked at the beginning and end of the metabolic period with charcoal ingested with the first and last meal) were emulsified in a Waring blender, using distilled water for quantitative transfer from special collection pots used for this study. They were then placed in separate, known-weight containers, refrigerated and stored for analysis at the completion of the metabolic period.

All urine specimens during this same period were also collected, preserved with hydrochloric acid to prevent loss of ammonia and refrigerated for Kjeldahl analysis.

Upon calculation from food tables (5, 18), the diet served (Table I) contained 224 Gm. of carbohydrates, 105 Gm. of protein (16.8 Gm. of N) and 108 Gm. of fat, with a calculated caloric value of 2633 calories as a daily average.

METHODS

Nitrogen of the dietary elements, stools and urine specimens was determined by the Kjeldahl procedure, using the digestion method of Campbell and Hanna[7] and the titration method of Meeker and Wagner.[20] Every precaution was followed to avoid loss of nitrogen from the stool and urine specimens, as

well as the food specimens. These were immediately analyzed for nitrogen on completion of the collection.

To determine the total solids or dry matter of the specimens—the control diet, the uneaten diet, and the stools—a conversion factor was determined. Quadruplicate 10 cc. samples of the well mixed semi-liquid, emulsified media

TABLE I.—*Control Diet Calculated and Analyzed.*

	Calculated		Analyzed		Per Cent of
	72 Hr.	Ave. 24 Hr.	72 Hr.	Ave. 24 Hr.	Calculated
Carbohydrates.....	671 Gm.	224 Gm.	(671)*	(224)*	.....
Proteins.....	315 Gm.	105 Gm.	295.8 Gm.	98.6 Gm.	93.9%
As nitrogen.....	50.4 Gm.	16.8 Gm.	47.3 Gm.	15.8 Gm.	.....
Fats.....	325 Gm.	108 Gm.	296.6 Gm.	98.9 Gm.	91.3%
Calories.....	7900	2633	6541.5	2180.5	82.8%

*Calculated.

were weighed in weighing bottles in the wet state and then dried to constant weight. The conversion factor (dry weight/wet weight) was then applied to the known total wet weight of each specimen.

Fowweather's[15] modification of Saxon's[26] method, a wet extraction method,[24] was then used on aliquots of known volume (10 cc.) and weight of the food specimens and the feces. This method gave, by fractionation, a measure of the total lipoid concentrations and the relative proportions of the

TABLE II.—*Nitrogen Metabolism—Detailed.*

	72 Hour		Ave. 24 Hours		Per Cent of
	As Protein	As Nitrogen	As Protein	As Nitrogen	N—Intake
Intake:					
Diet eaten.....	207.1 Gm.	33.1 Gm.	69.0 Gm.	11.1 Gm.	.....
Output:					
Stools.....	90.1 Gm.	14.4 Gm.	30.0 Gm.	4.8 Gm.	43.2%
Urine.....	115.0 Gm.	18.4 Gm.	38.3 Gm.	6.2 Gm.	55.9%
Total.....	205.1 Gm.	32.8 Gm.	68.3 Gm.	11.0 Gm.	99.1%
Balance:					
Intake.....					
Output.....	+2.0 Gm.	+.3 Gm.	+.7 Gm.	+.1 Gm.	.....

free fatty acid, the soaps and the neutral fats in these specimens. The method was standardized by running recoveries on oleic acid.

The oral glucose tolerance test consisted of giving the patient orally a dose of 100 Gm. of glucose in 400 cc. of water flavored with lemon juice. The blood specimens were drawn at fasting, one-half, one, two, three, and four-hour intervals. The blood sugar concentrations were determined by the method of Folin and Wu.[14] Her carbohydrate intake prior to the test was not excessive.

* Normal fecal nitrogen output equals approximately one-tenth of the daily ingested N on a normal intake; 1 to 2 Gm. N with an average of 1.3 Gm.[23]

RESULTS

Nitrogen Metabolism: *Nitrogen intake:* Detailed data for the total nitrogen intake is summarized in Table II. The average daily value was found to be 69.0 Gm. of protein or 11.1 Gm. of nitrogen. *Nitrogen output:* In Table II the total average daily output was found to be equivalent to 68.3 Gm. of protein or 11.0 Gm. of nitrogen, of which 4.8 Gm. of N (43.2 per cent of the total N intake), occurred in the stools and 6.2 Gm. of N (55.9 per cent) occurred in the urine. As a rule, fecal nitrogen output will approximate 10 per cent on normal intake or an average of 1.3 Gm. of N of the total nitrogen ingested.[23]* *Nitrogen balance:* The total output of N came to 99.1 per cent of the intake. The patient is probably in nitrogen equilibrium on this diet, rather than in slightly positive balance (Table II and Fig. 5).

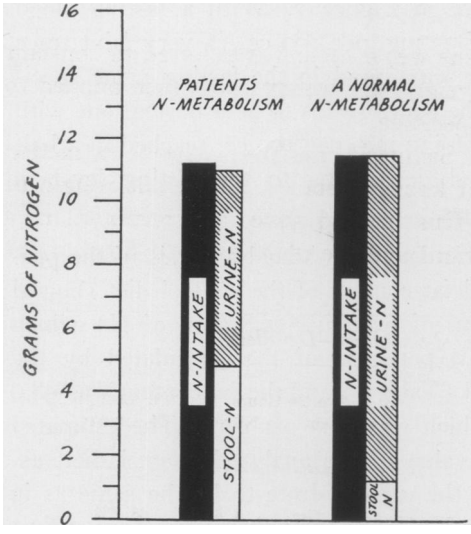

FIG. 5.—Nitrogen Metabolism (as Protein)

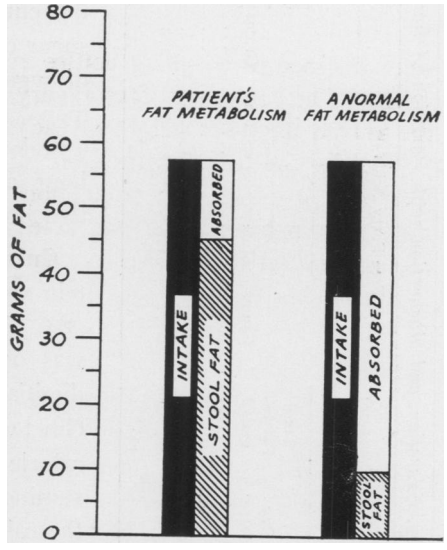

FIG. 6.—Fat Metabolism

Fat Metabolism: An inspection of Table III, which gives summarized detailed data on the fat study results, shows that with a daily fat intake of 58.5 Gm. daily fat absorption was 13.2 Gm., or 22.5 per cent of that ingested; while 77.5 per cent, or 45.3 Gm., was lost in the stools (Fig. 6). It has been found that a normal adult on an ordinary mixed diet utilizes approximately 90 per cent of the fat ingested, losing in the feces, from 5 to 10 per cent.[23]

Partition of the total fats of the specimens analyzed are also shown in Table III. The daily total dry matter of the feces was 106 Gm., of which 42.8 per cent, or 45.3 Gm., was total fat, and free fatty acids were 31.3 per cent, or 33.2 Gm. of the dry matter. It is readily apparent that the daily excretion of free fatty acids is very high, amounting to 73.3 per cent of the total fat output of the stools. The relative proportions of fats as soaps and neutral fat

TABLE III.—*Fat Metabolism—Intake, Excretion, and Absorption with Partition of Fats—24-Hour Average Values.*

Analyzed Specimens	Total Dry Weight	Total Fats			Free Fatty Acids			Soaps			Neutral Fats		
			Per Cent			Per Cent			Per Cent			Per Cent	
	Grams	Grams	Dry Matter	Total Fat Ingested	Grams	Dry Matter	Total Fat of Specimen	Grams	Dry Matter	Total Fat of Specimen	Grams	Dry Matter	Total Fat of Specimen
Control diet	459.6	98.9	21.5%	.....	3.7	.8%	.....	...	.....	.....	95.1	20.7%	.....
Diet uneaten	156.2	40.4	25.9%	.....	1.6	1.0%	.....	...	.....	.....	38.8	24.8%	.....
Intake diet eaten	303.4	58.5	19.3%	.....	2.1	.7%	3.6%	...	.....	.....	56.3	18.6%	96.2%
Output stools (excreted)	106.0	45.3	42.8%	77.5%	33.2	31.3%	73.3%	3.3	3.1%	7.3%	8.8	8.3%	19.4%
Balance intake—output (absorbed)		13.2		22.5%									

and their percentage of the dry matter and of the total fat output are shown in this table. These fall into a normal range, as shown by comparison with Table IV, a study by Fowweather[15, 23] of fat partition in the stools of normal adults (84 cases). This patient, with only 18 inches of small intestine, demonstrates abnormal excretion of total fat and free fatty acids, whereas excretion of combined fatty acids as soaps and neutral fat fall within a normal range.

Oral Glucose Tolerance: The results of the oral glucose tolerance test are shown by the curve in Figure 7. With a fasting blood sugar of 95 mg. per 100 cc. (a very faint trace of sugar was found in the fasting urine specimen), the curve seems to be a normal one with a peak of 130 mg. per 100 cc. reached in a half hour and descending to the fasting level in two hours.

Caloric Intake: Actual analysis of the protein and fat content of the control diet showed 98.6 Gm. of protein (15.8 Gm. of N) which was 93.9 per cent of that calculated by the dietitian (Table I) and the fat content was 98.9 Gm., which was 91.3 per cent. The estimated caloric value of the analyzed control diet, assuming the carbohydrate to be the same as in the calculated diet, was therefore about 2180.5 calories (82.8 per cent) instead of 2633 calories, as originally calculated (Table I).

However, actual intake, when the uneaten food was analyzed, and proper subtractions made from the control diet, was 69.0 Gm. of protein (11.1 Gm. of N) and 58.5 Gm. of fat as a daily average. Her daily caloric intake was about 1506 calories (Table V).

DISCUSSION

In evaluating the physiologic effect of extensive resection of the small intestine, one must keep in mind the difference between marginal survival and a nearly normal nutri-

tional status. With certain other organs, such as the kidney, liver and pancreas, the minimum necessary for survival has been fairly well established. Yet as concerns the small intestine, despite probably inaccurate estimates (such as 50 per cent being necessary for normal survival),[13] no critical evaluation has been made. Again, it must be stressed that an underlying disease process which had necessitated a massive resection, *i.e.*, regional ileitis, cancer, etc., would compound the deficiency of the resection *per se*.

The absorption of all the essential nutrients is practically completed in the small intestine. The single chief problem posed by massive small intestinal

TABLE IV.—*Partition of Fat in Normal Human Stools.*[15, 23]
Dry Matter 4.6 to 38 Per Cent (Average 20 Per Cent) of Total Weight of Stool.

Of This	Per Cent of Total Dry Matter		
	Minimum	Maximum	Average
Total fat	7.3	28	17.5
Soaps	0.5	11	4.6
Free fatty acid	1.0	10	5.5
Neutral fat	2.5	12	7.3

resection is, therefore, that of absorption, not only as regards surface for absorption but also as regards what might be called time-contact relationships between food, mucosa and ferments. The presence of intact, normal gastric and duodenal secretions, including pancreatic and hepatic enzymes, should assure a normal digestion potential. This has been shown to be the case both experimentally (Grey, *et al.*,[16]) and clinically (Todd, Elman, *et al.*,[27, 11]).

As far back as 1896 Monari[13] postulated from experimental work on dogs that hypertrophy of remaining small intestine occurs in cases of massive re-

TABLE V.—*Determination of Caloric Intake Average 24-Hour Values.*

Control Diet		Diet Uneaten	Intake
Total Dry Weight*, grams	459.6	156.2	303.4
Total fats*, Grams	98.9	40.4	58.5
Per cent of dry weight	21.5%	25.9%	19.3%
Total protein*, Grams	98.6	29.6	69.0
Per cent of dry weight	21.4%	18.9%	22.7%
Carbohydrates, Grams	262.1	86.2	175.9
Per cent of dry weight	57.0%	55.2%	58.0%
Total calories	2332.9	826.8	1506.1

* All analyzed except carbohydrates and calories, which were estimated on the basis of dry weight. Factors used for obtaining calories were fats—9, proteins—4, and carbohydrates—4.

section. This was supported by microscopic evidence of thickening of the mucosa and by actual increase in the number and size of the villi. This important observation was later confirmed by Evans and Brenizier[12] and Flint.[13] However, there has been no comparable demonstration in the human being, as shown by autopsy findings.[6] This whole subject of compensatory phenomena in the intestinal tract following massive resections is in need of investigation, and better postmortem follow-up.

Despite the very rapid progress of food through this patient's abbreviated intestinal tract, she has maintained a nitrogen balance, even though she absorbs only slightly over half of the nitrogen ingested. With digestion accomplished by the intact enzyme system, she apparently absorbs enough protein from 18 inches of jejunum to maintain balance.

The fat studies in this case agree with previous work[13, 27, 28] demonstrating that these patients are unable to absorb fat to any great degree. The fat partition studies show a normal ability to hydrolyze fats, the key defect being in absorption. A striking observation in this case was the high percentage of free fatty acids, amounting to 73 per cent of the total fat output of the stools, while soaps and neutral fats were normal. This might explain the maintenance in this case of normal serum calcium level and the absence of tetany, since there was no undue excretion of calcium as soaps.

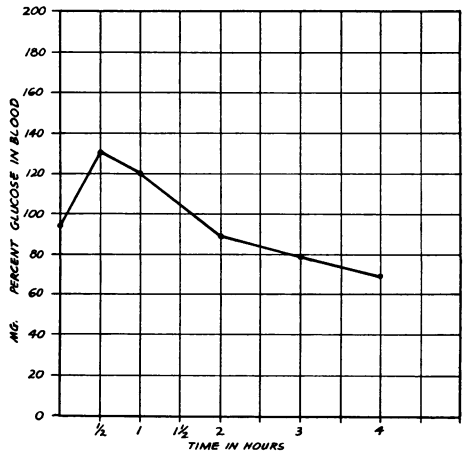

FIG. 7.—Oral glucose tolerance test curve of patient.

The glucose tolerance test, which was surprisingly normal (Fig. 7), substantiates the concept of Peters and Van Slyke[23] in interpretation of a sugar tolerance curve. According to them, it is only the initial part of the ascending limb of the curve which is attributable directly to the absorption of sugar from the alimentary canal. For less than 30 minutes the speed with which the blood sugar of a normal person rises parallels the rate at which glucose is absorbed in the intestine, and after this, utilization is so greatly accelerated that it dominates all other influences in the determination of the form of the curve. Hence, the sensitivity of the oral glucose tolerance test depends only on normal functioning of the upper portion of the digestive system, which this patient has.

Thus, the studies bear out previous concepts in relation to the feeding of patients with massive intestinal resection; *i.e.*, fat is poorly tolerated and absorbed and should be restricted; proteins should be given in easily absorbable form and in adequate amounts. Carbohydrates should be given at frequent intervals. The feeding process must be almost a continuous one throughout the day to utilize the absorptive capacity of the remaining segment of small intestine to its fullest.

SUMMARY AND CONCLUSIONS

1. A metabolic study has been carried out involving determinations of total dry matter, nitrogen and fat intake, nitrogen and fat output and a glucose tolerance curve on a 55-year-old woman surviving 12 months in fair nutrition

following resection of all but 18 inches of her small intestine (a status further complicated by a previous abdominoperineal resection for cancer of the rectum). The case report is included.

2. Hydrolysis of fat is within normal limits, but absorption is limited.

3. This patient maintained nitrogen equilibrium, although only little more than half of the nitrogen intake was absorbed.

4. A normal glucose tolerance curve was obtained and interpreted in the light of present knowledge.

5. An optimal diet in cases of massive small intestine resection should be high in carbohydrate and easily assimilated protein, low in fat, and low in residue. It should be given in small, frequent feedings with adequate supplementary vitamins.

6. Intractable diarrhea unresponsive to all therapy with drugs, as indicated in this report, presents the single, most distressing problem in these cases.

7. Further metabolic and postmortem studies are indicated to determine the compensatory phenomena which might account for survival following massive intestinal resection.

Appreciation is expressed for invaluable interest and advice given by Dr. Richard H. Lyons, Professor of Medicine, Syracuse University.

ADDENDUM

In May, 1949, the patient was admitted to Mt. Sinai Hospital, New York City, for further metabolic study under the direction of Drs. I. Snapper and Adlersberg, who will publish their results at a later date.

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