EXTENSIVE RESECTIONS OF THE SMALL INTESTINE *

By Addison G. Brenizer, M.D.
of Charlotte, N. C.

The term "Extensive" as applied to resections of the small intestine has arbitrarily been accepted to embrace only those lengths, measuring 200 centimetres (6 ft. 7 in.) or more. This measurement is accepted on the basis of clinical records, which prove that resections beyond 200 centimetres may give rise to various metabolic disturbances.

Various authors give the length of the small intestine between fifteen feet, six inches and thirty-one feet, ten inches. The summary of opinion would place the average length at twenty-two and one-half feet. Brenizer found that the small intestine not only varied, within wide limits of length in the dog, but also in man and varied with the height and weight of the individual, usually the larger the individual, that is the taller and fatter, the longer the intestine. Beneke states that for every 100 centimetres (3 ft. 3½ in.) of body length there is 387.5 centimetres (12 ft. 9 in.) of small intestine, and Flint claims that there is a definite ratio between the size of the individual and the epithelial surface of the intestine.

In the work of Evans and Brenizer it was also observed that the intestine measured *in situ,* that is, attached to the mesentery, was much shorter than when measured detached from the mesentery; that a variable of several feet might be gained through stretching the length. Due to the natural variability in length, that due to detachment and stretching, they made their reports more accurately in percentage.

Again, in children, the intestine, though relatively to size longer, is actually shorter than in adults, allowing, length for length, a shorter resection to equal or excel the percentage resected in the adult.

The important question is not so much the extent removed as that left behind, either measured directly, which is frequently difficult or impossible, or estimated by that removed.

RECORDED CASES

Up to June, 1923, Pirie Watson, using the tables of all authors to date, collected seventy-three cases, including his own, in a most exhausting search of the literature.

Doerflor reports a case six and one-quarter years after removal of 560 centimetres (18 ft. 8 in.) of the small intestine, leaving only twelve centimetres (4 and 4/5 in.) of jejunum and twenty centimetres (8 in.) of terminal ileum, and claims the patient to be in good health, no complaint, takes regular meals, has two stools a day, gets up at 5 A.M. and does his whole work at the age of fifty-eight. He raises the question: "Is the small intestine essential for life?"

Sohn resected the entire jejunum and part of the ileum, 275 centimetres (9 ft.

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2 in.), and reports the case again four and one-half years later as subjectively well and strong, but further examinations of metabolism refused by patient.

SARNOFF resected fifteen feet of the small intestine and did a hysterectomy, recovering the patient after a stormy course and fæcal fistula. The patient presented the typical symptoms credited to such extensive resection, namely, thirst, hunger, diarrhœa, loss of weight and sensitive intestines, all of which occurred during the first few weeks of her illness. The patient, six months later, is in good condition; appetite undiminished, has two bowel movements daily instead of being constipated as before operation.

HOFMANN reported two cases, 385 centimetres (12 ft. 6 in.) and 300 centimetres (10 ft.), after five and one-quarter and four years respectively. The former case, a woman, tolerated a resection of twelve feet, six inches of small intestine and cæcum, lived three years complaining of dyspepsia; on finding two callous gastric ulcers, the size of a small apple, a posterior gastro-enterostomy was done with recovery; experienced two and one-quarter more years of relative comfort, except for a ravenous appetite and diarrhœa, and died of basilar meningitis (tuberculous). Hofmann failed to find any histological difference between the intestine removed and preserved five and one-quarter years previously and that recovered at autopsy. The latter case, a man, bore a resection of ten feet of the small intestine, continued to complain with symptoms typical of ulcer of the stomach, experienced, likewise, a gastro-enterostomy for ulcer of the stomach and is living after four years and doing fairly well on a restricted diet. Hofmann explains the ulcers, likely due to a retrograde infected embolus, slipped at the time of the resection operations, and quotes Eiselberg, that ulcers of the stomach and duodenum are not infrequent after massive procedures in the abdomen.

JACKSON resected 142 centimetres (4 ft. 8 in.) and left twelve inches of the ileum in a child two years old. This resection he calculated to be two-fifths of the entire small intestine and exceeding the arbitrary extensive resection in the average adult. For the first year the bowel movements were almost continuous, but gradually improved for five years and after seven years still has some "stomach trouble" and diarrhœa on account of a ravenous appetite and indiscretions in diet.

PALMER'S case, 327 centimetres (10 ft. 1 in.) resected and about 80–90 centimetres (2 ft. 6 in.) left behind was operated on for so-called "knot formation". This case made an excellent recovery and was used by Tuomikoski for his experiments in metabolism, where he found fats and proteins are poorly utilized but that carbohydrates are well borne. This author stressed the importance of a well-developed colon favoring his nutritional results.

SCHUGT reports, on April 11, 1925, a case of perforation of the uterus with gross injury and extensive resection of a case operated by Professor Dietrich March 30, 1924, when, according to Beneke's estimations, 580 centimetres (19 ft. 4 in.) of the small intestine was removed, likely 95 per cent. of the whole small intestine. By January 26, 1925, she had gained five and one-half pounds over her usual weight and complained only of gas after potatoes and vegetables, and of some weakness.

FLOSDORF resected 200 centimetres (6 ft. 7 in.) of small intestine and reports the case after three years. During the last year there are marked digestive disturbances, loss of weight, and patient is a chronic invalid, getting worse and not expected to live.

BRENIZER.—Mr. W. M., age twenty-one years, entered the hospital November 22, 1927, abdomen distended, painful, vomiting, fæcal fistula. He was operated on in another town for puss appendix in December, 1926, and drained. Remained in the hospital for nineteen days and drained for a month and half after leaving the hospital, wound finally healing March 16, 1927, vomited, and had difficulty getting bowels to move. September 1, 1927, reëntered same hospital, vomiting and no bowel movements. Was operated on for the second time and loop of bowel opened. Shortly after this operation, wound split open and another loop of bowel came out of wound. Attempt to replace the loop was futile and it was cut off. Remained in hospital forty-two days. Four days

after leaving, the flow from the intestine stopped and he returned to hospital, when a forceps was put into the wound and spread, on October 16, 1927. This opening continued to drain fæcal matter irregularly until November 21, when it stopped again, and since then he has been vomiting and having no bowel movement. Has steadily lost weight, from 168 down to 102 pounds; is pale and weak.

Temperature, 99-4; pulse, 110; respiration, 20; blood pressure, 95/60.

Abdomen: Distended, firm, tympanitic, McBurney scar; right rectus scar; two fistulous openings, from one pus can be pressed from hard mass on left side below navel. Small amount of fæcal matter from other.

Operation, November 22, 1927. Excision of old right rectus scar with fistulæ, liberation of massive adhesions to abdominal wall and between intestinal loops; considerable pus between loops on lower left side. Intestine severed in several places. Due to several separate segments of severed intestine shredding on liberating, nine and a half feet of ileum was resected, leaving about six feet of ileum and jejunum behind. A lateral anastomosis was done between the ileum and much damaged cæcum. Patient, already weak, was very much collapsed from rough handling, and blood ooze, was given 500 cubic centimetres of blood on the table. Picked up markedly.

The after course was surprisingly uneventful. Proctoclysis and liquids for first four days, then semi-soft diet for six days and soft diet for remainder of three weeks in the hospital. The wound scarcely drained at all for five days, the drains were removed and wound healed. At first there were five or six stools a day and two or three stools a day for six weeks. Patient returned for examination in three months, having eaten, after six weeks, practically a full diet. He had gained from 102 to 172 pounds, felt well, and had three stools a day. Urine was negative.

X-ray: Stomach emptied in one and one-half hours; small intestine visible in streaks; colon filled in three hours.

Patient returned November 16, 1928, looking well, feeling strong, doing his work and eating what he wants; is very hungry for his meals; has two stools a day; weighs 168 pounds, his regular weight.

X-ray: Examination one hour after the ingestion of barium meal showed about an 80 per cent. residual in the stomach and the head of the barium column in the ileum. The two hour examination showed about a 40 per cent. residual in the stomach, the barium to be scattered throughout a few loops of small intestine. The loops of the small intestine well filled are few. The head of the barium column is in the ascending colon near the hepatic flexure, the colon distal to this being well filled. The enterostomy stoma is low in the pelvis, consequently cannot be manipulated. The five hour examination showed the stomach to be empty and the barium to be scattered from terminal ileum well down into the descending colon.

Fæces: Normal, no blood, no mucus, no excess of fat and nitrogen. White blood cells 11,000; red blood cells 5,500,000; hæmoglobin (Sahli) 95 per cent.

Including my own case the total number of cases published to date, where the resection of the small intestine exceeds 200 centimetres (6 ft. 7 in.) is eighty-three, with seventy-one operative recoveries. The natural tendency has been to report only successful cases where the recovery lasted for several months or years. This accounts for the surprisingly low death rate in the published cases—14.3 per cent. There have been recently deaths reported after two to five and one-half years. The percentage of recovery from operation equals 85.7 per cent. and the percentage of good functional recoveries is 65.5 per cent.

The series includes cases of small intestine resections ranging from that of Flosdorf, six feet seven inches, with death from digestive disturbances

and inanition in three years; that of Brenner, seventeen feet nine inches, with death from marasmus in two and a half years; up to that of Schugt, nineteen feet four inches, and that of Doerflor, eighteen feet eight inches, in excellent condition after one year and six and one-quarter years respectively.

We must conclude from the clinical evidence drawn from these cases that the minimum extreme resection may fail in time and the maximum offer excellent results and that there are always possibilities for good or bad between the two extremes.

The ages between eleven months and sixty-five years have been reported but most of the cases occurred between twenty to forty years; and the sex has been fairly equally distributed in these cases where it was mentioned.

Extreme resection of the small intestine is almost always an emergency procedure, in a bad risk case, where the surgeon is caught between the two alternatives of resection or letting the patient die. The morbid condition is mentioned in sixty-four out of the eighty-three cases reported:

Twenty-one cases were strangulated herniæ: 7, variety not stated; 7, inguinal; 2, femoral; 3, umbilical; 2, ventral.

Nine cases were for strangulation from omental and other bands and adhesions.

Eleven cases were for trauma: 3, rupture of mesentery and intestine; 6, rupture of uterus with protrusion of intestine; 2, gangrene after intestinal prolapse through a punctured wound.

Seven cases were for abdominal tumors: 5 of the mesentery, fibroma, myxofibroma, myxosarcoma, sarcoma; 1, ovarian, 1, carcinoma of cæcum, with metastases in meso-colon and mesentery.

Four cases were for multiple strictures (tuberculous).

Three cases for mesenteric thrombosis.

Four cases for volvulus.

Two cases for intussusception.

One case, so-called "knot formation".

One case of gangrene of bowel following appendicitis.

The method of restoring the continuity of the bowel is recorded in forty-four of the eighty-three cases. About 75 per cent. were a lateral anastomosis and 25 per cent. end-to-end (a larger opening and greater security has been sought).

In eight of the cases between 1901 and 1909 the Murphy button was used with success, but the unsuccessful cases, where it was used, are not reported. The part of the intestine resected is mentioned in thirty-four out of the eighty-three cases, the jejunum was included in five of these cases. From a physiological standpoint, resection of the jejunum should cause more digestive disturbances than resection of the ileum, but this fact has not been proven either from the recorded cases, nor the contradictory experiments on animals.

The average of good functional recoveries is 65.5 per cent. (thirty-seven out of fifty-seven cases). Diarrhœa is the most disturbing disorder of metabolism, coupled with a ravenous appetite and therefore a morbid tendency on the part of the patient to break the diet. Almost all authors are agreed that

foodstuffs are most disturbing in the following order: Fats, proteins, bulk of cellulose material, and carbohydrates. The painstaking experiments of Tuomikoski on Palmer's case (327 cm. resected, 80–90 cm. of jejunum left behind—75 per cent. to 80 per cent. removed) would confirm and establish the fact that fats and proteins are poorly utilized, while carbohydrates are well borne. This author, as well as several others, have been impressed with the idea that a well-developed colon favored their nutritional results. This is undoubtedly true, the longer, the less irritable the colon, the longer the delay in the colon, favoring a longer continued digestion of material squirted into the colon and its more complete absorption. Where X-ray reports after resection are recorded, as in my own case, the emptying of stomach and small intestine, and consequently the colon, is at first very rapid, followed in the course of time, a year or more, by delay in emptying of the stomach and remaining small intestine, as well as delay in the colon. In my own case two months after operation the stomach was completely empty in two hours, the coils of the small intestine could scarcely be pictured, but, after one year, the stomach was not completely emptied up to five hours and the intestinal coils were easily pictured with accumulation in the terminal ileum.

The reports on the urine have been recorded only in a few cases, using an excess of indican and ethereal sulphates to indicate increase in intestinal putrefaction. An excess was commonly found in dogs subjected to extreme resections. In all reports except five the urine has been reported normal. There have been no satisfactory reports on the blood picture and blood chemistry, nor on the metabolic rate.

The combined work of experiments on dogs initiated by Senn in 1892, Trzebicki in 1894, Monari in 1896, Diliberti-Herbin in 1904, culminated in the work of Evans and Brenizer in 1907, and Flint in 1912. Evans and Brenizer, in 1907, resected one-third to one-half of the combined jejunum and ileum on four animals which recovered. They noted a compensatory hypertrophy localized to the anastomosis. In two animals resections of 76 per cent. and 85 per cent. of the small intestine were followed by recovery, but in three animals resections of 86 to 92 per cent. resulted in death from inanition. In these animals the limit had been exceeded beyond which compensation could be established, and as no hypertrophy was noted at their autopsies, Evans and Brenizer concluded that in animals one-third to one-half of the combined jejunum and ileum can be resected with safety, but that beyond this limit compensation may fail to be established and death from inanition results. This limit of resection with safety corresponds with the arbitrary limit accepted in man, that of 2 metres (6 ft. 7 in.).

Flint in 1912 carried his work on beyond that of Evans and Brenizer, but arrived at about the same limit of resection. He concluded: "Dogs from which about 80 per cent. of the combined ileum and jejunum have been removed or short circuited may live indefinitely after the operation. The first effects of the operation give a profuse diarrhœa and loss of weight, from both of which the animal slowly recovers. At the same time the resec-

tion of a smaller amount, *e.g.,* 65 per cent. of the entire intestine may lead, notwithstanding a ravenous appetite and an unlimited diet, to changes which prevent the dog from recovering its well nourished condition. In these animals the nutrition may be apparently normal, but they are nevertheless so sensitive to dietetic disturbances that a diet or conditions of any severity may introduce a fatal marasmus or enteritis. Flint found that young, growing animals did not stand the operation as well as older dogs. Still, his case of an infant, eleven months old, in whom a resection of 100 centimetres, more than one-third of the entire intestine at this age and equal to the arbitrary limit of 2 metres in the adult, was done made an excellent recovery, although, at first, there were severe digestive disturbances.

Flint's investigations into the metabolism of these animals showed an excess of nitrogen and fat in the fæces as a direct result of diminution, of the absorbing surface of the gut. Profuse diarrhœa invariably occurred after the operation and the animals lost weight, being forced to consume the nitrogen and fat of their own tissues. Gradually, however, the excessive excretion of nitrogen and fats diminished through a restoration of the power of absorption in the remaining gut and the animals return to normal nutrition. They remain, however, susceptible to changes in diet, so that diets rich in proteins, fats or indigestible substances may again produce diarrhœa with excess of nitrogen and fat in the fæces.

Finally, the most important question: Does functional recovery depend on compensatory hypertrophy of the remaining small intestine? According to Flint, there is an increase in the transverse dimensions of the bowel, no increase in the number of villi, but an increase in their size, which equals 400 per cent. increase of surface. The crypts were enlarged in proportion to the enlargement of the villi. The epithelial cells of the hypertrophied villi were increased in size and the goblet cells were numerous. He found this anatomical compensation present and complete, or partial, or absent, with a corresponding recovery or not of the animal. Brenizer and Evans noted a compensatory hypertrophy localized to the anastomosis alone.

The clinical course in man, in many cases, corresponds with these anatomical findings of Flint, although no compensatory hypertrophy has been reported in humans as yet. On the other hand, as already referred to, Hofmann failed to find any histological difference between intestine removed five and one-quarter years previously and that recovered at autopsy. Was this a case where compensatory hypertrophy was incomplete and finally failed?

CONCLUSIONS

1. The arbitrary limit of assured safety, two metres (6 ft. 7 in.), applied to resections of the small intestine, is embraced in the term extensive.

2. Resections up to and beyond the arbitrary limit have become necessary as a life-saving measure and have yielded 85.7 per cent. recoveries from operation and 65.5 per cent. good functional results.

3. Functional recoveries in man, as in dogs, are likely dependent upon compensatory hypertrophy.

4. Metabolic studies both in animals and man establish a diet rich in carbohydrates, less of proteins, but poor in fats.

In the preparation of this paper, though I have read all references in their original, I have, of a necessity, drawn abundantly on the paper of Pirie Watson, a veritable statistical compilation up to that date, June, 1923, and wish to credit him and thank him for any material or expression I may have borrowed from him.

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