Reversed Intestinal Segments in the Management of Anenteric Malabsorption Syndrome *

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Introduction

It has been repeatedly observed that massive resection of small bowel both in experimental animals and man leads to either severe weight loss with readjustment of metabolism at a new physiologic level [2, 8, 10] or death.[15, 17] Numerous attempts, both medical and surgical, have been made to overcome these problems based on the theory that decreased intestinal motility would allow an increased absorption time which leads naturally to vagotomy [32] and the utilization of methscopolamine bromide (Pamine) [16] as a parasympatholytic agent. Neither attempt has proved very successful since the effect of vagotomy on intestinal motility is transient [32] while the side-effects from prolonged high dosage of methscopolamine tend to obscure any benefit.[16]

It has been proposed [28] that some form of physiologic partial obstruction might be introduced into the small gut to increase transit time permanently, thereby allowing an increased absorption from the luminal content. The most obvious way to achieve this was thought to be direct reversal of a segment of small bowel, re-anastomosed end-to-end. The idea of reversal is a very old one, apparently first suggested by Nicoldani in 1887 [24] which formed a basis for much later experimentation by many authors [3, 9, 11, 13, 19, 22, 23, 33] including Halsted [14] and Mall [21] but its utilization in the present context is relatively new.[12]

It is self evident that any form of reversed segment should be inserted into the small bowel distal to the region of maximal absorption; however, the question of where each of the three major food materials is taken up in the gut is by no means settled [1, 4, 5, 6, 7, 20, 30] but it is slowly becoming clearer that the absorptive "importance" of the human intestine decreases distally. It is equally evident that any reversed segment should be small because of the high rate of obstruction with longer loops.[9, 11, 13, 22, 23]

It is relatively well accepted that such segments will maintain their original direction of peristalsis or "polarity" [3, 25, 27] which should theoretically allow them to function as partial mechanical obstructions of the type we are seeking.[33]

Material

It was elected to employ fat absorption as an index of effect following massive small gut resection, since this faculty is considerably easier to study than protein or carbohydrate mechanisms. Radioactive iodine^{131}-labelled trioleic acid (Triolein) was therefore utilized to measure changes in the amounts of fat removed from the intestinal lumen. The reliability of this technic has been documented on a number of occasions.[18, 26, 31]

Method

Twenty-five mongrel dogs were employed, varying in weight from 10 to 26 Kg. An average fat absorption level was established for each animal using I^{131}-labelled

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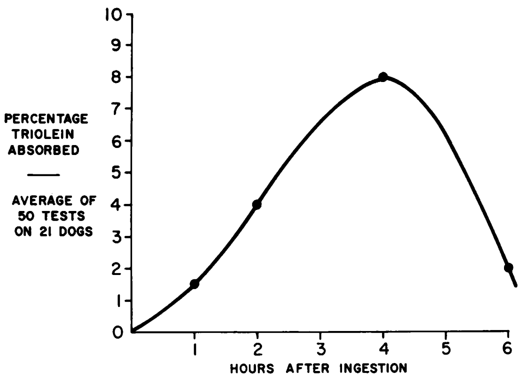

FIG. 1. Fasting absorption of oral trioleic acid[131].

trioleic acid in a capsule with a predetermined count which was then fed to the dogs. Blood samples were withdrawn at 1, 2, 4 and 6 hours after the original dose and the residual plasma radioactivity measured in a well-type counter at sufficient length to allow 95 per cent confidence with 5 per cent error. The quantity of absorption was calculated by allowing 8 per cent body weight as blood volume, from which the plasma volume was deduced by utilizing a microhematocrit determination with every individual test. Four dogs were promptly rejected as unsuitable because two comparable, successive absorption curves could not be obtained in these animals.

One month later under intravenous Nembutal anesthesia 66 to 70 per cent of the small bowel was resected. The distal 66 to 70 per cent was resected in the first ten animals but the terminal 15 cm. of ileum was left while the proximal bowel was removed in the second ten, i.e., from just below the pancreatic and bile ducts. This was all that was done on six animals; three from each group of ten being kept as controls. Weekly absorption studies were continued postoperatively for 1 month at which time the abdominal cavity was re-entered where a 4 to 6 cm. segment of distal ileum was reversed upon a single vascular pedicle followed by end-to-end two-layer anastomosis as close to the ileocecal valve as possible.

Weekly studies with trioleic acid[131] were carried out for 1 month after the second operation, and thereafter monthly studies were conducted for 2 years. The results at 1 year are presented. It is hoped to present a 2-year follow up at a later date.

Results

Twenty-one animals yielded an average fasting trioleic acid[131] absorption curve as shown in Figure 1. One animal died by an anesthetic accident leaving 20 dogs that actually came to operation.

After the resection there was an immediate fall in both weight and absorptive capacity in all animals which was, however, much more severe in the case of the ten proximal resections. The latter lost an average of 30 per cent of body weight within 1 month compared to a 15 per cent loss in the distal resections; alterations of fat absorption capacity correlated with this fairly well. Steatorrhea was a more marked accompaniment of proximal enterectomy (Fig. 2, 3).

One month after the resection the average 4-hour peak absorption was 4 per cent in the distal and 1 per cent in the proximal resections, compared with their original preoperative value of 8 per cent. Two weeks after reversal of a distal ileal segment, the animals with a distal resection began to gain weight and were back to preoperative levels within 6 months—compared to the unreversed controls who gained no weight for 6 weeks, then slowly returned to their original weight by 9 months. The recovery of absorptive ability appeared to lag a little behind weight gain although the two curves were comparable within time limits. The lowest peak absorption recorded was 3.5 per cent in the reversals and 3 per cent in the controls, while in both groups the maximal weight loss was 15 per cent.

The response of the group subjected to high enterectomy was quite different. Weight loss was rapid and catastrophic;

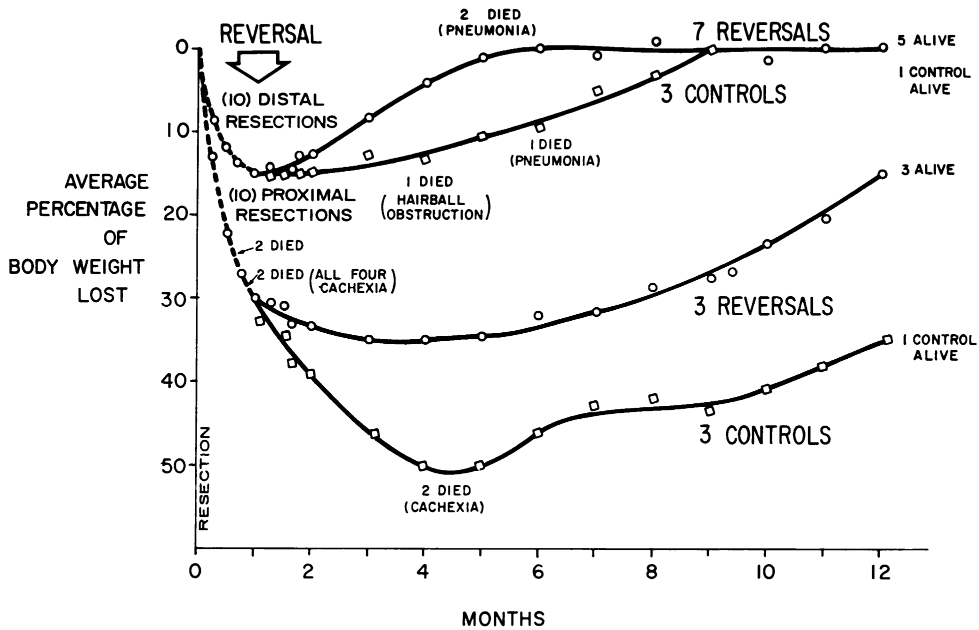

FIG. 2. Changes in body weight after 66–70% small bowel resection and reversal compared with controls.

two dogs succumbed in the third week followed by two more in the fourth week postoperatively. Autopsy revealed only cachexia while the anastomoses appeared well healed. After reversal weight loss continued for 2 months until loss represented about 35 per cent of the original weight with a minimum peak absorption of 0.5 per cent.

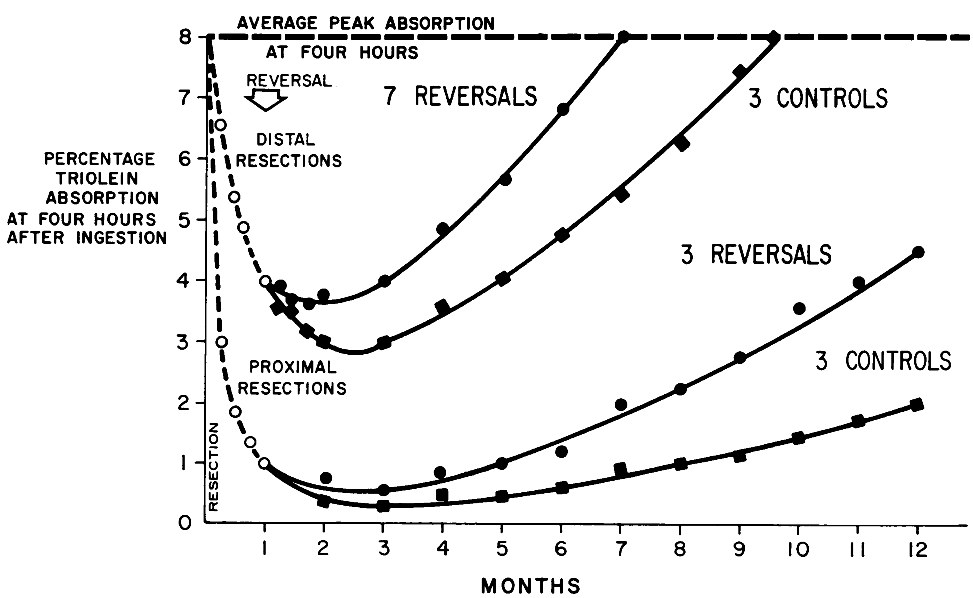

FIG. 3. Alterations in trioleic acid^{131} peak uptake following resection and reversal compared with controls.

TABLE 1. *General Analysis of Results*

	Resected					Reversed					Controls				
	No.	Deaths	Cause of Death	Max. Weight Loss at One Month	Min. Peak Absorption at One Month	No.	Deaths	Cause of Death	Max. Weight Loss	Min. Peak Absorption	No.	Deaths	Cause of Death	Max. Weight Loss	Min. Peak Absorption
Distal resections	10	0		15%	4%	7	2	pneumonia	15% regained pre-op weight at six months	3.6% regained pre-op absorption capacity at seven months	3	2	1 hairball 1 pneumonia	15% regained pre-op weight at nine months	3% regained pre-op absorption capacity at nine and one half months
Proximal resections	10	4	cachexia	30%	1%	3	0		35% gained until only 15% deficient at one year	0.5% increased until 4.5% at one year	3	2	cachexia	>50% gained until 35% deficient at one year	0.3% increased until 2% at one year

At this point however a long, slow period of weight gain began which was reflected in an equally slow increase of absorptive capacity.

The control group (unreversed with high resection) continued a downhill course until two of three died at 4½ months from apparent starvation, having lost 50 per cent of preoperative weight with a maximum 4-hour uptake of about 0.3 per cent. The third control dog survived and slowly began to gain weight with absorptive ability—apparently stabilizing weight loss at about 35 per cent of preoperative value with a concomitant peak absorption of 2 per cent. This compares with the three surviving animals with high resections combined with reversal, who at 1 year have stabilized loss of preoperative weight at only 15 per cent while having a peak absorption of 4.5 per cent.

These results are analyzed in Table 1.

Discussion

It is manifest that reversed segments will have an optimal length at which the maximum absorption increase with minimal obstruction is produced. If this optimum is exceeded clinical obstruction will result and conversely, if the optimum is shortened, decreasing benefit will be obtained. In these experiments the shortest length of gut that could be manipulated with facility was reversed. This was done because failure of older experiments was due almost entirely to obstruction following use of segments from 18 in. or longer combined with the fact that, as yet, we have no means of determining optimal length.

It is stressed that these maneuvers were merely pilot experiments designed to test the theory that reversal would increase material uptake from the gut lumen in animals suffering from massive resection. It is worthy of note that reversal has already been attempted with success in man utilizing a 15-cm. segment,[29] which with our results suggests that the procedure might be employed in individuals who suffer cachexia and diarrhea because of lack of absorptive bowel. It is possible that 15 to 20 cm. for a reversed segment will prove optimal in *man*, but before this can be accepted we need proof of increased absorption of protein and carbohydrate as well as of fat. Such an undertaking is difficult, since not only is this type of lesion rare but those undergoing this operation are rarer still. We may become resolute however when we view the unfortunate, cachectic patient who has suffered loss of a large segment of small bowel.

Conclusions

1. Resection of the proximal small bowel produces far more serious deterioration than removal of the distal part. The reason for this is not known, but perhaps it suggests that the proximal area possesses more "absorptive power" with decreasing "power" distally. The result raises the interesting problem, lying more within the physiologist's realm than the surgeon's, of whether the small gut functions as an absorptive with decreasing power from above downwards or whether there are definitive absorptive zones for specific food materials or whether mucosal cells are specialized or generalized in absorptive capacity.

2. Reversal of a short segment of bowel in animals shortened convalescence after massive resection and preserved the lives of animals undergoing a high resection.

Summary

A group of mongrel dogs were subjected to massive small bowel resection with resulting anenteric absorption deficiency. A distal segment of small bowel was then reversed end-to-end with greater weight gain and recovery of absorptive capacity compared with unreversed controls.

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