Generation of Small Bowel Mucosa

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SUMMARY

Following massive bowel resection, the characteristic features of a 'short bowel' syndrome develop. Some patients respond to medical treatment but may succumb later to the effects of deficient absorption. Some surgical procedures devised for delaying transit through the bowel, are mentioned.

The patient lacks absorptive surface of the bowel. Experiments performed on mongrel dogs to produce generation of mucosa and the results obtained, are described. Further experiments were carried out to show that this generated mucosa has absorptive capacity.

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The average length of small bowel in an adult is 6·1 m and the length of colon 155 cm, whereas the average length of small bowel at birth in an infant of 50 cm body length is 300 cm and the large bowel 52 cm.[1]

Massive bowel resection has been defined as resection of all but 75 cm of the small bowel in neonates[2] and all but 90 cm in the adult.[3] In the newborn a minimum of 30 cm of small bowel with an intact ileocaecal valve is regarded as necessary for adequate nutrition and growth.[4] When less than 30 cm of small bowel remains or when the ileocaecal valve is resected in addition to a large part of the small bowel, the patient's nutritional status becomes precarious. The characteristic features of a 'short bowel' or 'massive bowel resection syndrome' develop, namely, diarrhoea, steatorrhoea, hypovolaemia, metabolic acidosis, impaired absorption of fat and protein, and magnesium and calcium deficiency. The metabolic upset and nutritional disturbance following massive resection, and the medical management of such patients, have been discussed in a number of excellent publications.[2,4-6] Some patients respond to medical treatment but many succumb later to the effects of deficient absorption.

In the medical management of these babies intravenous hyperalimentation has proved itself most valuable, in that concentrated feeds with high calories can be given for weeks or months, maintaining a positive nitrogen balance and actual gain in weight.[7] This method of treatment, added to the other known medical measures, proved itself of great benefit in one of our cases.

A newborn baby weighing 2 kg had a massive resection of small bowel for multiple atretic segments, leaving him with 17 cm of small bowel. The immediate postoperative course was uncomplicated but he soon developed the characteristic features of short bowel syndrome as described above. Mouth to anus transit time was 3 - 4 minutes. With parenteral hyperalimentation and intravenous supplementation, we were able to manage him for 9 months with a steady gain in weight, before he was able to maintain himself on oral diet alone. He is now 18 months old, weighing 8 kg. and still thriving. The mouth to anus time has increased to 5 - 6 hours. Although he still has some malabsorption, he does not require supplementation for excessive fluid loss. Thus, with energetic medical management and hyperalimentation, we were able to tide this baby over until the compensatory mechanisms in the remaining small bowel and large bowel could eventually correct the massive fluid loss.

In those in whom all the medical measures have failed, several surgical procedures have been tried—all aimed at delaying the transit through the remaining bowel and so allowing a longer period for contact and absorption.[8-11] These procedures include: (*a*) vagotomy and pyloroplasty, (*b*) recirculating small bowel loops, (*c*) antiperistaltic gastric tubes, (*d*) reversed small bowel segments (single or paired), and (*e*) formation of a pouch (Fig. 1).[12,13] A recirculating loop has been shown to be inadequate.[14,15]

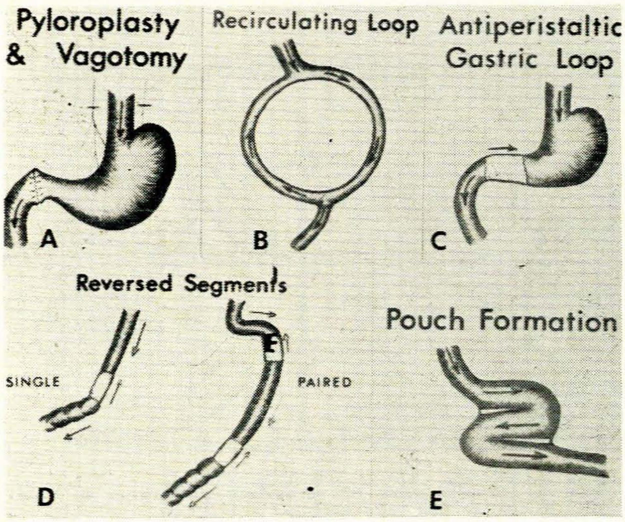

Fig. 1. Surgical procedures for delaying transit through bowel.

The objections to these surgical procedures are the risks of stasis with superinfection, with aggravation of a malabsorption already caused by the short length of bowel. These procedures should thus be carried out only when medical treatment has failed, and not at the initial resection. Medical treatment and intravenous hyperalimentation should be continued with for as long as possible.

The pathological changes noticed in cases with massive bowel resections are: an increase in the diameter of the bowel and prolongation of the villi of the mucosa, rather than any appreciable increase in the length of the bowel.[2,16,17] What the patient lacks is absorptive surface of the bowel. In an attempt to produce such an increase in the absorptive surface, the following experiments were carried out in dogs and puppies.

EXPERIMENTAL PROCEDURE

The dogs were operated upon under pentobarbital anaesthesia. The abdomen was entered through a midline incision and a segment of small bowel was selected. The lumen of the bowel was occluded with bulldog clamps and a longitudinal incision of variable lengths in different dogs was made on the ante-mesenteric border of the segment between the clamps (Fig. 2). The edges of the incised bowel were sutured to the serosal surface of the adjacent loop of bowel, widening the gap in the incised bowel as far as possible. A two-layered anastomosis was effected with interrupted silk sutures. A cross-section of this procedure is depicted in Fig. 3.

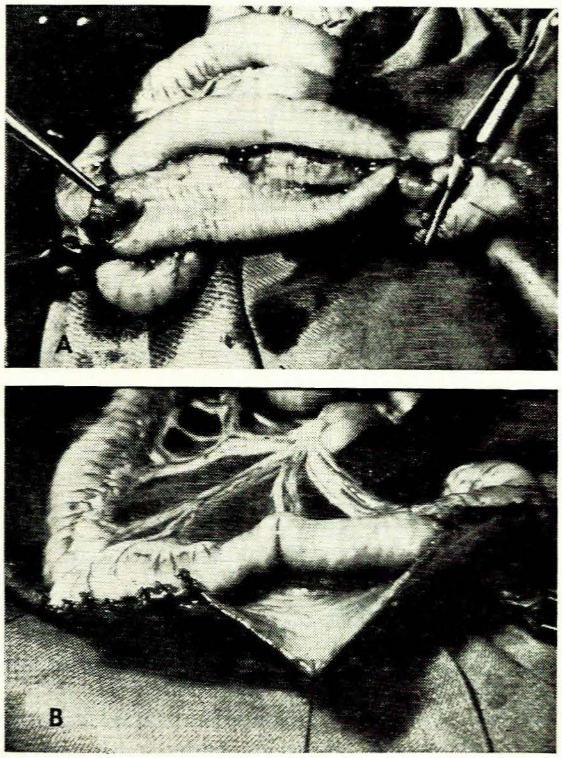

Fig. 2. Experimental procedure for generation of mucosa.
A: Longitudinal incision on antemesenteric border of bowel.
B: Edges of incised bowel sutured to serosa of adjacent loop of bowel.

The dogs were fed intravenously for 24 hours before starting oral fluids, and gradually over the next 3 days a more solid diet was introduced. Penicillin and streptomycin were given intramuscularly for the first 3 days.

After periods of 1 - 3 months, the dogs were again anaesthetized and the anastomosed segments were resected. Continuity of the bowel was restored by end-to-end anastomosis. The excised bowel was inspected and submitted for histological study.

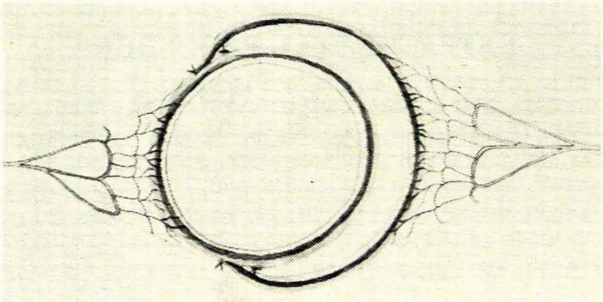

Fig. 3. Cross-section of procedure.

RESULTS

We have found that during the first 6 weeks the exposed serosal surface undergoes peptic digestion and at the same time there is a slow creeping in of the mucosa all along the edges (Fig. 4). After 10 - 12 weeks a defect of 3·5 cm × 2 cm is covered by generated mucosa (Fig. 5).

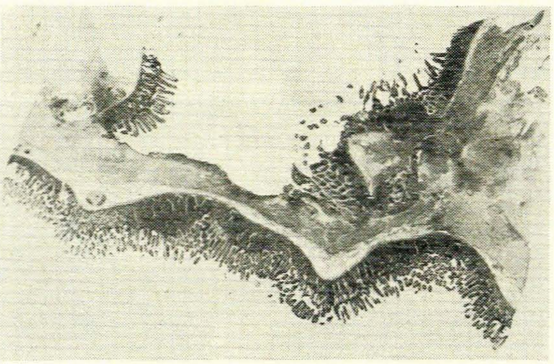

Fig. 4. Histology showing peptic digestion in the centre and creeping in of generated mucosa on the sides.

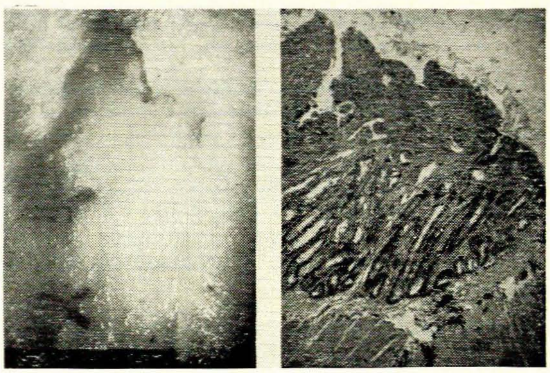

Fig. 5. The resected segment of bowel and histology showing generated mucosa.

From these experiments we were able to conclude that the small bowel mucosa does regenerate, thus increasing the mucosal surface area. The next step was to establish whether this new mucosa has absorptive capacity.

In the first instance, biopsy specimens were taken from the generated mucosa and from normal adjacent mucosa of the small bowel, and the disaccharidase activity of these were evaluated. The disaccharidase activity was comparable between the normal mucosa and the generated mucosa. Further evaluation of the absorptive capacity of this generated mucosa was carried out in our laboratories by Dr Margaret Mayell.

Dogs on whom the operation for generating small bowel mucosa, as described above, was performed 6 - 7 months previously were re-operated upon. The donor limb of small bowel was opened along its mesenteric border for several inches to display the whole mucosal surface, with the newly generated mucosa centrally placed (Fig. 6 (a)). The whole of the donor limb was then dissected off the recipient limb round the generated mucosa. The recipient loop of bowel now looked normal except for the patch of mucosa on its serosal surface (Fig. 6 (b)). The donor portion was resected and discarded. The distal end of the limb of small bowel bearing the generated mucosa was closed and folded upon itself and sutured round the margin of the generated mucosa to form an enclosed sac. Bowel continuity was restored by fashioning a Roux en Y anastomosis and the abdomen was closed in layers (Fig. 6 (c) and (d)).

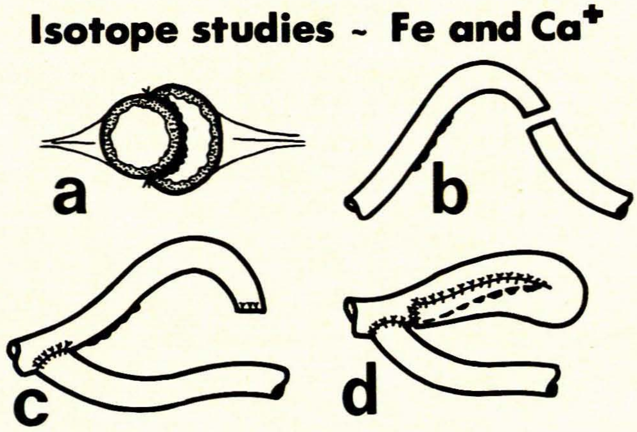

Fig. 6. (a - d). Steps of procedure performed to study absorption of iron and calcium.

The area of the generated mucosa in these dogs measured 5 - 6 cm by 1·5 - 2 cm.

These dogs were re-opened 3 months later. The enclosed pouches were opened and were found to be distended with a mucopurulent fluid which was washed out with saline. Labelled iron and calcium were then instilled. Five millilitres of blood was taken from the superior mesenteric vein at 5-minute intervals for one hour. These isotope studies were carried out by Professor Dowdle's laboratory and showed that absorption did take place.

However, we now have to repeat these experiments making pouches without the mucosa, to show that the isotopes are not absorbed by the serosal surface of the small bowel. We also still have to establish the maximum area that can be safely generated.

I have presented our experimental work on generation of small bowel mucosa. The clinical application of this procedure is self-evident, provided some small bowel is present.

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