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Controlled Tissue Expansion in the Initial Management of the Short Bowel State

F. Murphy · B. A. Khalil · S. Gozzini · B. King · A. Bianchi · A. Morabito

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Abstract The treatment of short gut syndrome has evolved dramatically during the past decade. The combination of surgical techniques and medical management in the context of a multidisciplinary approach has improved the outcomes of these children. The authors describe in detail their technique of controlled tissue expansion of the bowel before lengthening procedures. Monitoring of the child and troubleshooting actions during the controlled tissue expansion program also are discussed.

Introduction

The management of children with short bowel syndrome is quite challenging. With improvements in medical management and surgical technique, the outlook for these children has improved significantly. Advances in total parenteral nutrition (TPN) and prevention of liver disease have been pivotal in the survival of these patients. Surgical techniques have been developed to enhance bowel adaptation and reduce transit time. These techniques have been further integrated with medical management to provide a holistic approach to the management of short bowel syndrome in the context of a multidisciplinary intestinal failure unit. Our team has published on the use of initial controlled tissue expansion for the short gut state [1, 2]. In this paper, we describe the technique of the controlled tissue expansion (CTE) program as applied to patients with short bowel in preparation for bowel lengthening at the Royal Manchester Children's Hospital. The goal is to increase the length and circumferential diameter of the bowel during a period of 20–24 weeks. This creates a new and greater surface area for absorption and more tissue for lengthening and tailoring.

The tissue expansion program is based on research from Birmingham, Alabama, United States. Pig models were used and underwent partial intestinal obstruction, resulting in an increase in total mucosal thickness, villus height, crypt depth, and villus density. Surface index and intestinal circumference were significantly greater after a 5-week period [3].

Material and methods

Surgical steps

Once the short bowel state has been established, the following steps are taken in the initial laparotomy:

1. A large tube (usually a size 12 Malecot catheter) is passed into the end of proximal bowel and is brought out onto the abdominal wall as a tube jejunostomy/ileostomy.
2. A second tube is placed in the lumen of the distal colon and brought out onto the abdominal wall as a tube colostomy.
3. Both tube stomas are fashioned by tightening a purse string suture on the bowel wall around the tube and securing it to the abdominal wall (Figs. 1 and 2).

Postoperative care

Once the acute postoperative period is over and the child is ready to feed, a controlled tissue expansion program of the

F. Murphy (✉) · B. A. Khalil · S. Gozzini · B. King · A. Bianchi · A. Morabito
Department of Paediatric Surgery, Royal Manchester Children's Hospital, Oxford Road, Manchester M13 9WL, England, UK
e-mail: Fiona.murphy@doctors.org.uk

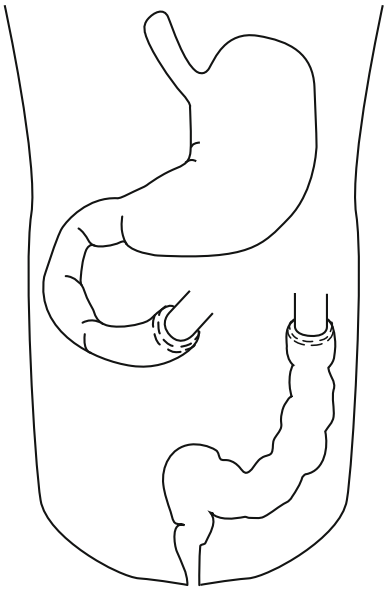

Fig. 1 Schematic of proximal and distal tube stomas

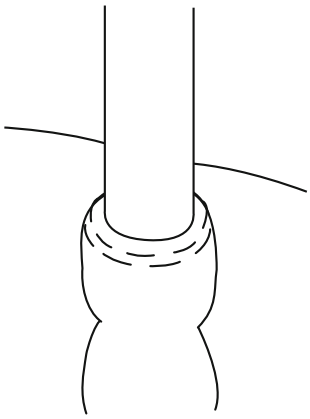

Fig. 2 Purse string suture forming tube stoma

bowel is initiated. In our unit, we have a protocol for this technique as follows:

1. The child is fed preferably via the oral route and if that is not possible via gastrostomy/NG.
2. At the time of feeding, the proximal catheter is clamped for a period of time (routinely starting at 5 min and increased by 5 min/day as tolerated). The gastrostomy/NG (if present) also is clamped.
3. After the period of clamping is over, the catheter is unclamped.
4. Proximal stoma effluent is then recycled into the distal stoma (proximal and distal tubes labelled) over a period of time (30–90 minutes depending on the volume) and not as a bolus, thus avoiding diarrhea.
5. The clamping period is increased alongside the increase in the volume of feed. The goal is to get the child to full complement of feeds at 3–4-h intervals with the clamp on throughout the interval period. The proximal tube is unclamped before each feed.
6. The proximal tube stoma is washed weekly with normal saline to ensure that there is no stasis of bowel effluents or feeds.

Monitoring during the CTE program

1. Daily strict input and output charts, including volume of feed, stoma effluent consistency and volume recycled, and volume and consistency of stool passed per rectum.
2. Routine monitoring of bloods, urinary sodium, weight, and multidisciplinary review.

Troubleshooting

The most common problems that we have encountered in the program and the actions taken are as follows:

1. Vomiting

   a. Unclamp proximal tube
   b. Flush catheter to ensure it is not blocked or kinked
   c. Unclamp gastrostomy/NG if present
   d. Reduce clamping time and volume of feed to previous level for 24 h
   e. Restart program after 24 h if the child is well and tolerating feeds and clamping time

2. Dislodgement of catheter

   a. If this happens during the early postoperative period, another catheter is placed under radiological guidance. Occasionally surgery is indicated to replace the catheter.
   b. If this happens more than weeks postoperatively, a Foley's catheter can be inserted with the balloon inflated just to keep it the catheter snug. If in doubt, radiological confirmation is obtained. Under no circumstances should the catheter be left in if there is any doubt on its position.

3. Sepsis

   a. If the child develops sepsis due to a line infection or any other factors, the expansion program is put to a halt until the episode of sepsis is over.
   b. The treatment of sepsis in these cases is the same as any other case with appropriate administration of antibiotics guided by microbiologist's advice and results of cultures.

4. Fluid and electrolyte imbalance

    a. Aggressive correction of electrolyte disturbances
    b. Intravenous fluids may be necessary
    c. Tailoring of TPN content to each child.

Results

CTE has been used in all patients with severe nondilated short bowel—a total of 10 patients during a 9-year period from 2000–2009. The length of the remaining bowel is measured by the same operator before starting the expansion program and at the time of the lengthening procedure. We have noticed that the circumferential expansion (double the initial circumference) goes alongside a degree of elongation of the bowel at the end of the 20- to 24-week program, with a mean gain in length of 2.4 cm (17.5% increase; Table 1; Fig. 3). Preterm babies were excluded from this calculation [2].

All ten patients underwent a LILT lengthening procedure and nine of the ten patients are off PN. The tenth patient is currently on 50% oral intake 50% PN nutritional support on a weaning regimen.

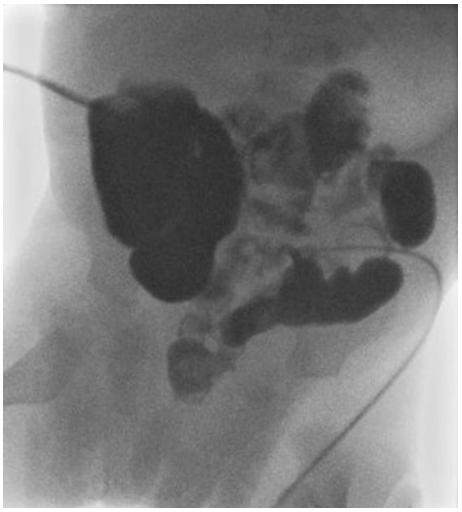

Fig. 3 Contrast study following CTE prior to LILT. Proximal stoma seen on left hand side with significant dilatation of the bowel demonstrated

Discussion

Patients needing tissue expansion are a select group of children who have undergone a catastrophic gastrointestinal event and once recovered from the acute episode are left with minimal length of small bowel (<30 cm) and on TPN. It is essential for these patients' survival that they are enrolled in a structured program of intestinal reconstruction and rehabilitation as soon as possible and before they develop complications related to TPN, loss of venous access, or they are referred for transplantation as the only surgical option. We suggest the formation of tube stomas at the initial surgery and would commence tissue expansion from approximately day seven postoperatively. Nontransplant surgery (lengthening procedure) has a definitive role to help patients toward enteral autonomy. For successful bowel lengthening, it is necessary to preserve and increase the amount of tissue available. Controlled tissue expansion is used to create additional tissue (mainly in circumference but also in length), which is then lengthened longitudinally or transversely [4, 5]. This requires the monitoring and adaption of input and output (volume and consistency) to achieve easily reproducible results. The pig model used a similar partial obstruction but during a short period of five weeks in an uncontrolled manner. We have been able to modify this technique to achieve controlled expansion. We

Table 1 Results of controlled tissue expansion

Patient	Age at formation of stoma	Problem	Initial bowel length (cm)	Post expansion length (cm)	Increase in length (cm)	% increase in length
1	8 months	Volvulus	5	8	3	60
2	4 days	Vanishing gastroschisis	10	13	3	30
3	48 months	Gastroschisis with atresia	25	28	3	15
4	2 days	Gastroschisis with atresia	20	23	3	15
5	8 months	Gastroschisis with atresia	25	27	2	8
6	2 days	Vanishing gastroschisis	18	22	4	22
7	1 days	Gastroschisis with atresia	30	30	0	0
8	2 days	Gastroschisis with atresia	22	24	2	9
9	2 days	Gastroschisis with atresia	25	29	4	16
10	3 months	NEC	25	25	0	0

NEC necrotising enterocolitis

slowly increase clamping time and oral intake to achieve expansion during a longer period of 20–24 weeks, thus avoiding patient discomfort, stasis, and bacterial overgrowth and preventing the need for selective decontamination of the digestive tract (SDD). This program allows direct access to the proximal stoma, which is washed with normal saline weekly to avoid stasis and bacterial translocation.

By the end of the tissue expansion program, the child is able to take his or her full complement of feeds at 3–4-h intervals with the proximal tube clamped throughout the interval period. The distal bowel catheter allows a convenient way of recycling the proximal effluents. Because these are tube stomas, the risk of prolapse is minimal. In addition, skin excoriation usually seen in proximal jejunostomies/ileostomies is kept to a minimum by using tube stomas. Nursing these children is much easier with these tubes and volumes of effluents are measured in a more precise manner. Recycling is very important, because it prevents disuse atrophy of the distal gut and enhances further absorption of water and nutrients, thus reducing the incidence of fluid imbalance. The use of distal tube stoma allows proximal effluents to be recycled in a controlled fashion and during longer periods of time (via a pump if necessary). This prevents the effluents from getting "dumped" out through the anus causing diarrhea. It also allows for maximal contact of the proximal effluent with the distal bowel, thus maximizing absorption.

This CTE program is specifically designed to create tissue to prepare patients for bowel lengthening and is not a solution in isolation. The end result should be a healthy dilated bowel that is amenable to lengthening. This program should not be performed without the expertise for bowel lengthening at the end of expansion. It is important that patients are managed using a multidisciplinary approach in centers that can deal with the management of such problems, including autologous gastrointestinal reconstruction (AGIR), as part of an intestinal rehabilitation program.

Conclusions

CTE is a convenient and controlled way of slowly expanding bowel. It enhances bowel absorption by increasing the proximal bowel circumference and allows for easy and controlled recycling of the proximal effluents.

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