

REVIEWS

HISTORICAL DEVELOPMENT OF T-TUBE ENTEROSTOMY

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ABSTRACT

INTRODUCTION: The word *stoma* comes from the Greek *stomoun* (making an opening or mouth). The term *ostomy* in childhood includes any surgically created opening between a hollow organ (e.g., stomach, small or large intestine) and the skin, connected directly (stoma) or by means of a tube. Creating an intestinal stoma in childhood is considered a drastic procedure and has long been avoided due to the high incidence of complications and mortality. Despite the successful application of enterostomy methods of the large intestine and later—of the small intestine, in children, this technique has developed relatively slowly. Stoma removal techniques, originally developed for adults, have been modified and adapted for pediatric patients.

MATERIALS AND METHODS: Information from the worldwide database on the historical development of T-tube enterostomy was selected and analyzed. A systematic literature search was performed using PubMed, MEDLINE, EMBASE, the Cochrane database, and Scopus, using the following terms: *T-tube, enterostomy, pediatric, childhood*.

RESULTS AND DISCUSSION: In February 1981, the treatment of uncomplicated meconium ileus in neonates by means of a T-tube enterostomy was first reported by Harberg et al. T-tube ileostomy was first used at Texas Children's Hospital in 1959. In their first report, the authors reported on 11 newborns with uncomplicated meconium ileus who underwent a T-tube ileostomy within 24 to 96 hours after birth. Of 7 girls and 4 boys, only two were unable to overcome the ileus. One infant required re-examination for persistent obstruction, and 1 infant died due to pulmonary infection and intracranial hemorrhage. The remaining 9 infants overcame the ileus between the 1st and 11th days. The T-tube was removed by pulling it between days 10 and 14 after the spontaneous closing of the T-tube fistula in all patients. Experience with T-tube ileostomy has shown that resection of the dilated but viable ileum is not necessary for rapid recovery of intestinal function in the newborn. With the use of intraluminal administration of pancreatic enzyme, stringy meconium can be rapidly lysed and passed through the rectum or T-tube, and mechanical removal is not required during the operative procedure.

CONCLUSION: Using a T-tube has several advantages. One of them is the smaller surgical intervention and minimal intra-abdominal bowel manipulation. Spontaneous closure of the fistula occurs rapidly after T-tube removal. This technique shows less morbidity and mortality than conventional ostomy.

Keywords: *T-tube, enterostomy, pediatric, newborn*

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INTRODUCTION

The word *stoma* comes from the Greek *stomoun* (making an opening or mouth). The term *ostomy* in childhood includes any surgically created opening between a hollow organ (e.g., stomach, small or large intestine) and the skin, connected directly (stoma) or by means of a tube. The history of enterostomies is long (1). In fact, the concept of treating intestinal ob-



struction with colostomy dates back to the 18th century, and among the first survivors were children with anal atresia (2).

Creating an intestinal stoma in childhood is considered a drastic procedure and has long been avoided due to the high incidence of complications and mortality. Despite the successful application of enterostomy methods of the large intestine, and later of the small intestine, in children, this technique developed relatively slowly. The evolving surgical technique, adequate resuscitation, and care are leading to an increase in the need for enterostomy as the survival rate of critically ill neonates increases.

Stoma removal techniques, originally developed for adults (1,3), have been modified and adapted for pediatric patients. The first approaches in the second half of the nineteenth century focused on newborns with congenital intestinal obstruction (4–7). These were followed by new techniques combining proximal decompression with distal enteral feeding for neonates with high intestinal atresia (8–10). Several other techniques have been introduced for the removal of small and large bowel stomas, specifically aimed at children, since the 1980s (11–19).

In neonatal surgery, some conditions often require the formation of an enterostomy (20). This requires diseases such as: necrotizing enterocolitis, meconium ileus, intestinal atresia or stenosis, anorectal malformation, intestinal malrotation, Hirschsprung's disease, intestinal volvulus.

In children and adolescents with the following conditions, a stoma must be removed: inflammatory bowel disease, intestinal malrotation, intestinal volvulus, trauma, Gardner syndrome and other intestinal polyposis syndromes, typhlitic conditions, intestinal pseudo-obstruction.

Furthermore, the emergence of minimally invasive techniques provides new opportunities to create feeding, decompression, and irrigation stomas (21–28).

The knowledge and experience gained from enterostomal care has led to the creation of pediatric-specific devices in a wide variety of types and sizes, such as better-tolerated biomaterials, and advanced techniques. Another important development is the creation of non-medical support systems and organizations for enterostomy patients (29). In addition,

a considerable number of publications are available, useful for parents caring for such patients (30–36).

Although pediatric surgeons and gastroenterologists who care for these patients are constantly developing and trying to create alternatives to stomas (37), stoma removal, care, and closure continue to be a significant part of their practice (38). An alternative method to the classic enterostomy is the removal of the enterostomy using a T-tube. The purpose of our article is to trace the historical development of the T-tube enterostomy, from its introduction to the use of the technique for a number of diseases in the neonatal period.

MATERIALS AND METHODS

Information from the worldwide database on the historical development of T tube enterostomy was selected and analyzed. A systematic literature search was performed using PubMed, MEDLINE, EMBASE, the Cochrane database, and Scopus, using the following terms: *T-tube, enterostomy, pediatric, childhood*.

RESULTS AND DISCUSSION

In February 1981, the treatment of uncomplicated meconium ileus in neonates by means of a T-tube enterostomy was first reported by Harberg et al. T-tube ileostomy was first used at Texas Children's Hospital in 1959. In their first report, the authors reported on 11 newborns with uncomplicated meconium ileus who underwent a T-tube ileostomy within 24 to 96 hours after birth. Of 7 girls and 4 boys, only two were unable to overcome the ileus. One infant required re-examination for persistent obstruction, and 1 infant died due to pulmonary infection and intracranial hemorrhage. The remaining 9 infants overcame the ileus between the 1st and 11th days. The T-tube was removed by pulling it between days 10 and 14 after the spontaneous closing of the T-tube fistula in all patients. Experience with T-tube ileostomy has shown that resection of the dilated but viable ileum is not necessary for rapid recovery of intestinal function in the newborn. With the use of intraluminal administration of pancreatic enzyme, stringy meconium can be rapidly lysed and passed through the rectum or T-tube, and mechanical removal is not required during the operative procedure (15).

In 1988, Millar AJ et al. also reported the effectiveness of the method in the treatment of meconium ileus (39).

In addition to meconium ileus, the T-shaped ileostomy has later been used in a number of other diseases that require decompression of the gastrointestinal tract.

Later in 2000, Mak et al. published a report on their 40-year experience with T-shaped ileostomy in children with cystic fibrosis (40).

They reported on operative treatment performed in 60 out of 83 patients for meconium ileus complications or failure of meconium evacuation after contrast enema. Of these patients, 21 (about 35%) underwent an ileostomy with a T-tube. Eight additional patients who underwent T-tube ileostomy were identified, but were not included in the database. Out of a total of 29 patients who have been treated by T-tube ileostomy since 1959 at Texas Children's Hospital, five patients were excluded from the study due to insufficient data or incorrect diagnosis. One of the 24 patients died from complications related to pulmonary immaturity. A total of 20 out of 23 patients experienced meconium liquefaction and resolution of intestinal obstruction after administration of N-acetylcysteine or pancreatic enzymes through the T-tube. Three patients required additional surgery to overcome intestinal obstruction. In all patients, the T-tube was removed within the first 8 weeks after surgery. Postoperative hernia repair was required in two patients. No complications were observed with this procedure with a mean follow-up of 11.5 years.

In 2016, Claudio De Carli et al. (22) reported a clinical case of a newborn with proximal jejunal atresia of type III-A complicated by volvulus due to the presence of a congenital bridge, in which an innovative and alternative procedure compared to other functionalizing and decompressive ileostomy techniques was applied.

In 2016, Maher Al-Zaiem et al. (41) summarized their experience with a T-tube enterostomy. They described a retrospective review of sixty-two neonates who underwent operative treatment and the T-shaped enterostomy technique between January 1990 and January 2013. According to pathology, they grouped their patients as follows: 34 cases of jejunal atresia, 13 cases of meconium ileus, 8 cases

of perforated necrotizing enterocolitis (NEC), three cases of meconium peritonitis, three cases of intestinal resection due to intestinal volvulus, and one case of gastroschisis. They published their results, noting that the mean duration of T-tube placement was 13 days (range 9 to 20 days) and the T-tube site closed spontaneously in an average of 2 days (range 1–4 days). Oral nutrition was started between the sixth and 16th postoperative day. None of the patients had complications related to the placement of the T-tube. Four patients died from other causes, such as sepsis, respiratory failure, and prematurity. And in conclusion, they noted that enterostomy using a T-tube was an effective and safe technique for the treatment of certain cases in neonatal surgery. This technique shows less morbidity and mortality than conventional ostomy. Therefore, it is considered a useful approach in cases where there is a risk of hypoperistaltic dilated bowel close to anastomosis.

Rygl et al. reported that they performed a T-tube ileostomy in five cases of intestinal perforation in extremely low birth weight infants (birth weight 600 to 900 g, gestational age 25 to 27 weeks), and all patients survived without severe complications (42). In four of them, a tube was placed during the primary operation and in one newborn, 8 days after the primary anastomosis. All patients survived and there were no major complications related to T-tube placement. The median duration of the T-tube placement was 4 weeks (range 3–8 weeks), full enteral nutrition after the T-tube placement was achieved in 4 weeks (range 1–6 weeks). The T-tube site closed spontaneously in all. They concluded that an ileostomy using a T-tube is an effective and safe technique for the treatment of selected cases of intestinal perforation in extremely low birth weight infants.

Pandey et al. (43) also reported the effectiveness of a T-tube in children with typhoid perforation. They performed a prospective evaluation of a cohort of children with proven intestinal perforation in typhoid fever. Patients with multiple perforations and impaired general condition were treated with by T-tube placed in the intestinal lumen after the closure of all distal perforations (Group 3). To determine the effectiveness of using a T-tube, they compared them with patients who had a primary closure of the perforation (Group 1) or bowel resection (Group 2).

The total number of patients from groups 1, 2, and 3 was 51, 4, and 12, respectively (n=67). The mean number of perforations for the three groups was 1, 3.5 ± 0.58 , and 4.25 ± 0.97 , respectively. The operative time for the three groups was 37.29 ± 3.24 , 59.25 ± 3.09 , and 59.17 ± 4.17 minutes, respectively. The T-tube was removed on average between 13 and 17 days. The mean duration of closure of the T-tube site and complete healing was 8.58 ± 2.11 days. The total follow-up period was 10.94 ± 1.15 months, and none of the patients developed intestinal obstruction during the observation period.

Stevens A. published his work on behavior in patients with duodenal trauma. Fifteen cases of duodenal trauma admitted to Westmead Hospital between 1979 and July 1986 were reviewed. The treatment of duodenal rupture without a penetrating wound to the abdominal wall or puncture injuries was by primary closure of the serosal defect, most commonly—by a decompressive duodenostomy using a T-tube. No patient had intestinal content leakage from the duodenal drain site. Two patients died, and the cause of death was not due to complications of the duodenal injury. Pyloric exclusion, duodenal diverticulation, or pancreaticoduodenectomy were not recorded in any patient. The morbidity of the duodenal hematoma in the form of persistent abdominal pain was avoided by intraoperative drainage.

In 2011, Michal B et al. also published their work on the use of a T-tube for enterostomy. They reported that, at their hospital, T-tube enterostomy was used primarily in the 1990s in neonates for surgical treatment of meconium ileus that did not respond to conservative therapy. The use of T-tube enterostomy has been expanded further due to its simplicity and effectiveness in selected cases of necrotizing enterocolitis, spontaneous intestinal perforation, and intermediate celosomia (gastroschisis and omphalocele) (44).

CONCLUSION

Using a T-tube has several advantages. One of them is the smaller surgical intervention and minimal intra-abdominal bowel manipulation. Resection of a distended but viable segment of the ileum is not necessary. An immediate and safe postoperative administration of medication or food through the tube can be performed. Removal of the T-tube is

done by extraction, without requiring additional surgical intervention. Spontaneous closure of the fistula occurs rapidly after T-tube removal. This technique shows less morbidity and mortality than conventional ostomy.

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