Original Article

Effects of early enteral nutrition on gastrointestinal function recovery and nutritional status after gastrointestinal surgery in children

Zhifeng Mo[1], Lubin Yan[2], Wei Zhang[1], Hanzhong He[3], Shaomin Huang[1], Wenbin Yang[1]

[1]Department of Emergency and Disaster Medicine, the Seventh Affiliated Hospital of Sun Yat-sen University, Shenzhen 518000, China; [2]Department of Pediatrics Surgery, the Sixth Affiliated Hospital of Sun Yat-sen University, Guangzhou 510000, China; [3]Department of Pediatric Surgery, Guangzhou Women and Children's Medical Center, Guangzhou 510000, China

Contributions: (I) Conception and design: Z Mo, L Yan, W Yang; (II) Administrative support: None; (III) Provision of study materials or patients: Z Mo, L Yan, H He; (IV) Collection and assembly of data: L Yan, W Zhang, S Huang; (V) Data analysis and interpretation: Z Mo, L Yan, H He; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

Correspondence to: Wenbin Yang. Department of Emergency and Disaster Medicine, the Seventh Affiliated Hospital of Sun Yat-sen University, Shenzhen 518000, China. Email: 39218287@qq.com.

Background: Young children are at a developmental stage, and any change in their body growth/development and nutritional status during this period has a direct impact on the prognosis of a specific disease. Clinically, most of the pediatric patients receiving an abdominal surgery are children with congenital malformations of the digestive system. They often have compromised nutritional status after the surgery due to factors including surgical trauma and stress reaction. Therefore, reasonable nutrition support has become a required intervention. In this prospective study, we investigated the influence of early enteral nutrition (EEN) on gastrointestinal (GI) function recovery and nutritional status after GI surgery in children.

Methods: A total of 60 children with GI diseases undergoing surgical treatment in our center from January 2017 to December 2018 were enrolled in this study. They were randomly divided into the control group and the EEN group according to the order of admission. No EEN was applied in the control group; in contrast, the EEN group received EEN via percutaneous endoscopic jejunostomy (PEJ) tube and postoperative jejunostomy tube. The recovery of GI function, changes in biochemical indicators within 7 days after surgery, postoperative nutritional status, and complications were compared between these two groups.

Results: After the surgery, the time to eating solid food and the time to first flatus/defecation were significantly shorter in the EEN group than in the control group (all $P<0.05$). Serum albumin (ALB), potassium, and serum calcium levels in the EEN group were significantly higher than those in the control group 7 days after surgery (all $P<0.05$). In the EEN group, the mean EN support time was 7.6±2.4 days, and the duration of jejunostomy feeding lasted 45.1±4.2 days. During the jejunostomy feeding, the body mass grew at a rate of 18.4±2.7 g/d in 11 newborns. Five children in the EEN group developed postoperative complications (mild in 4 cases and severe in 1 case).

Conclusions: Proper EEN after a GI surgery can increase the survival rate, accelerate the recovery of GI function, and improve the nutritional status in pediatric patients. This intervention can be further applied in clinical settings.

Keywords: Early enteral nutrition (EEN); gastrointestinal surgery (GI surgery); recovery of gastrointestinal function (recovery of GI function); nutritional status; biochemical indicators

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Introduction

Enteral nutrition (EN) support was considered unfeasible for newborns and children following a gastrointestinal (GI) surgery (1,2). However, recent studies on GI function have shown EN to be an economic and physiologically feasible nutritional support that can promote GI development after surgery, with few complications. The patient often has an anastomosis after upper GI surgery, and intraoperative anastomotic drainage and EN justify the early enteral nutrition (EEN) in patients undergoing upper GI surgery (3,4). In our current study, we investigated the efficacy of EEN in promoting GI function recovery and improving nutritional status after GI surgery in children.

Methods

Clinical data

A total of 60 children with GI diseases undergoing surgical treatment in our center from January 2017 to December 2018 were enrolled in this study. They were randomly divided into the control group and the EEN group according to the order of admission, with 30 patients in each group.

The EEN group included 17 males and 13 females aged 9 days to 9 years. There were 11 newborns, including 6 males and 5 females. The birth weight of these 30 children was 1.12 to 3.98 kg, with an average body mass of 2.41±0.56 kg. Symptoms in the EEN group included short bowel syndrome (n=5), intestinal perforation (n=2), large protruding umbilicus (n=5), intestinal malrotation (n=4), jejunal atresia (n=2), esophageal atresia (n=4), gastric wall muscular layer defect (n=2), duodenal atresia (n=2), intestinal fistula (n=2), and heterotopic pancreas (n=2). The surgeries were performed 11 days to 9 years after birth.

The control group included 19 males and 11 females aged 10 days to 9 years. There were 13 newborns, including 7 males and 6 females. The birth weight of these 30 children was 1.16 to 4.02 kg, with an average body mass of 2.45±0.59 kg. Symptoms in the control group included short bowel syndrome (n=5), intestinal malrotation (n=5), large protruding umbilicus (n=3), esophageal atresia (n=3), jejunal atresia (n=3), duodenal atresia (n=3), intestinal perforation (n=2), intestinal fistula (n=2), and heterotopic pancreas (n=2). The surgeries were performed 11 days to 9 years after birth.

Informed consent was obtained from parents before GI surgery in both groups. The study protocol was approved by the Ethics Committee of the Seventh Hospital Affiliated to Sun Yat-sen University, and the ethical approval number is No.2017SYSUSH-004.

Methodology

No EEN was applied in the control group; in contrast, the EEN group received EEN via percutaneous endoscopic jejunostomy (PEJ) tube and postoperative jejunostomy tube. A splittable PEJ tube (Flocare; CH5, with an outer diameter of 1.7 mm) was used in the EEN group. EEN was applied as follows:

Jejunostomy

After the surgery was completely performed and before the abdomen was closed, the puncture trocar was applied. The lateral wall of the intestine was punctured at the mesentery about 20 cm under the anastomosis. The jejunostomy tube was inserted via the trocar until the distal end of the intestine. After the trocar was withdrawn, the puncture cannula penetrated the left upper abdominal wall to introduce the catheter. The trocar was withdrawn and torn, and then silk sutures were applied for closure and fixation.

Formulation and infusion of nutrient solutions

Newborns were breast-fed. For children who were unable to receive maternal milk, formula milk was used instead: Pre-LACTOGEN (Nestle) was used for pre-term infants and NAN (Nestle) was used for full-term newborns; for pediatric patients aged 1 year or older, Peptamen Junior (Nestle) was applied. All the nutrient solutions were prepared in the Nutrition Center of our hospital. Before the infusion of nutrient solution, an appropriate amount of normal saline was infused first. The nutrient solution was infused from a low volume concentration (1:1 formula milk) to a high volume concentration (2:1 formula milk). The starting volume was 1 to 2 mL and then gradually increased. After continuous infusion for 2 to 7 days, the intestine became tolerant to the nutrient solution; then, the dose was increased to 2 mL each time. After 1 week of jejunostomy feeding, the feeding mode was gradually transited to single oral administration. During the jejunostomy feeding, any insufficient caloric intake was supplemented with intravenous nutrition. During the feeding process, the children's symptoms should be monitored. If there were any adverse reactions such as distension, vomiting, and diarrhea, increase in feeding dose was stopped and changes in these symptoms were closely observed. If necessary, use of the

Table 1 Comparison of postoperative recovery between the two groups

Group	n	Adverse reactions	Time to eating solid food (h)	Time to first flatus (h)	Time to first defecation (h)
Control group	30	7	57.2±3.4	54.6±5.2	57.4±4.7
EEN group	30	5	40.3±4.1	39.8±2.7	45.8±2.2
x^2/t	–	0.417	17.379	13.835	12.243
P	–	>0.05	<0.05	<0.05	<0.05

EEN, early enteral nutrition.

Table 2 Comparisons of biochemical indicators between both groups 7 days after surgery

Group	n	ALB (g/L)	Serum potassium (mmol/L)	Serum calcium (mmol/L)	Serum sodium (mmol/L)
Control group	30	34.12±0.75	3.91±0.36	1.92±0.87	141.50±12.04
EEN group	30	36.73±1.22	4.56±0.53	2.41±0.58	144.12±11.53
t	–	9.982	5.557	2.567	0.861
P	–	<0.05	<0.05	<0.05	>0.05

EEN, early enteral nutrition; ALB, albumin.

nutrient solution was stopped and EN was gradually applied only after the symptoms disappeared. Oral feeding typically started 7 to 21 days after jejunostomy feeding. The specific nutrition program and nutrient solution formulation could be adjusted according to the results of daily ward rounds.

Main measures

During the treatment, the liver function was monitored and a routine blood test was performed. The body weight, blood glucose level, and electrolyte indicators of the children were measured and recorded. The recovery of GI function, changes in biochemical indicators within 7 days after surgery, postoperative nutritional status, and complications were compared between these two groups.

Statistical analysis

Statistical analysis was performed by using the SPSS 16.0 software package. The time and biochemical indicators are presented as mean ± standard deviations, and the intergroup differences were compared with *t*-test. Count data including adverse reactions are described by percentages, and intergroup differences were compared with chi square test. A P value of less than 0.05 was considered statistically significant.

Results

Postoperative recovery

There was no significant difference in the incidence of postoperative complications between the EEN group and control group (P>0.05). After the surgery, the time to eating solid food and the time to first flatus/defecation were significantly shorter in the EEN group than in the control group (all P<0.05) (*Table 1*).

Comparison of biochemical indicators between both groups 7 days after surgery

Serum albumin (ALB), potassium, and serum calcium levels in the EEN group were significantly higher than those in the control group 7 days after surgery (all P<0.05). The serum sodium level showed no significant difference (P>0.05) (*Table 2*).

Postoperative EN in the EEN group

In the EEN group, jejunal EN was started 1 to 60 days after surgery, with an average EN duration of 7.6±2.4 days. The jejunostomy feeding lasted 14 to 180 days (mean 45.1±4.2 days). Oral feeding was gradually reintroduced 0 to 1 day after jejunostomy feeding (7 to 74 days after surgery), with

an average reintroduction period of 10.9±2.5 days. During the jejunostomy feeding, the body mass grew at a rate of 18.4±2.7 g/d in 11 newborns.

Postoperative complications in the EEN group

Five children in the EEN group suffered from complications after the GI surgery (mild in 4 cases and severe in 1 case). The jejunal tube slipped out in 3 cases; since all of these three children were able to start oral administration, a second catheterization was not performed. The tube was blocked 33 days after catheterization in one case; since the patient was able to receive oral feeding, the tube was removed. In the remaining 1 patient, the jejunal tube was found to penetrate the intestinal wall and cause abdominal distension 3 days after catheterization; a second surgery was then performed, and the jejunal tube was re-placed. No complications were observed in the remaining 25 patients in the EEN group.

Discussion

Young children are at a developmental stage, and any change in body growth/development and nutritional status during this period will have a direct impact on the prognosis of the disease. Clinically, most of the pediatric patients receiving an abdominal surgery are children with congenital malformations of the digestive system. They often have compromised nutritional status after the surgery due to factors including surgical trauma and stress reaction. Therefore, reasonable nutrition support has become a required intervention. The clinical application of total parenteral nutrition (TPN) has dramatically lowered the case-fatality rate and improved the nutritional status of children undergoing abdominal surgery (5-7). However, TPN is also a main cause of postoperative cholestasis, intestinal mucosal atrophy, and increased intestinal permeability. Furthermore, TPN can increase the risk of gut flora translocation, sepsis, liver damage, and other conditions. Proper EN support can effectively promote intestinal mucosal growth, accelerate the recovery of intestinal endocrine function, and speed up the healing of anastomosis (8-10). The advances in PEJ plus catheterization technology have remarkably increased the feasibility of EEN in children undergoing abdominal surgery.

In our current study, patients in the EEN group began to receive jejunostomy feeding 1 to 60 days after GI surgery, and the nutritional support lasted 14 to 180 days. During the jejunostomy feeding, the body mass grew at a rate of 18.4±2.7 g/d in 11 newborns. The jejunostomy feeding lasted up to 6 months, and no complications were observed during the interventions. Five children in the EEN group developed postoperative complications (mild in 4 cases and severe in 1 case); after intervention and prompt management, no severe complication occurred. No complication was observed in the remaining 25 patients in the EEN group. These results suggest that PEJ plus catheterization can be applied in patients undergoing GI surgery for a long period of time and offer certain nutritional support. However, jejunostomy feeding as a method of EN support following surgical intervention is associated with some complications. Clinically, PEJ plus catheterization may cause common GI complications such as abdominal pain, distension, diarrhea, dyspepsia, vomiting, and intestinal obstruction. Mechanical complications (e.g., inhalation lung injury and catheter obstruction) and metabolic and infectious complications (e.g., bacterial colonization, bacterial invasion, and fluid imbalance) may also occur (11,12). For children who suffer from GI complications during jejunostomy feeding, all the symptoms must be closely monitored and promptly managed. In children who have developed metabolic and infectious complications, the biochemical and electrolyte indicators need to be monitored, along with stoma care and jejunostomy tube nursing. Intervention of mechanical complications should be carried out in a standardized manner during surgery and/or jejunostomy feeding. The jejunostomy tube needs to be flushed with normal saline after each jejunostomy feeding session (13,14). In our current study, the time to eating solid food and the time to first flatus/defecation after the surgery were significantly shorter in the EEN group than in the control group ($P<0.05$), while serum ALB, potassium, and serum calcium levels in the EEN group were significantly higher than those in the control group 7 days after surgery.

In summary, proper EEN after a GI surgery can increase the survival rate, accelerate the recovery of GI function, and improve the nutritional status in pediatric patients. This intervention can be further applied in clinical settings.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The patients in this study were fully informed and signed informed consent statements. This study was approved by the Ethics Committee of the Seventh Hospital Affiliated to Sun Yat-sen University (No. 2017SYSUSH-004). The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

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