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Original article

Home enteral nutrition for infants after gastrointestinal surgery

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SUMMARY

Background: Home enteral nutrition (HEN) is a safe and effective alternative to hospital-based enteral nutrition in North American and European countries; however, there is less data involving the use of HEN in infants in developing countries. We review our experience and data with HEN in patients who were followed in our center during the past 10 years.

Methods: This was a retrospective review of 58 patients who entered the HEN program in the Department of Neonatal Surgery at Children's Hospital of Nanjing Medical University between July 1, 2008 and June 30, 2018. Two kinds of nasal feeding programs were used in this study (24 h of continuously pumped milk [group A] and oral milk every 3 h in the daytime with continuously pumped milk for 12 h in the nighttime [group B]). The gender, age, primary disease, mode of HEN, and complications were reviewed.

Results: The average duration of HEN to full oral feeding was 3.5 months in group A and 3 months in group B. The incidence of diarrhea, vomiting, aspiration, and constipation between the two groups did not differ. Fifteen patients encountered problems related to the tube and 6 patients had problems with the micro-pump. The monthly cost of HEN was 3400 RMB in group A and 3200 RMB in group B.

Conclusion: Under high quality care, HEN is safe and well-tolerated by infants after gastrointestinal surgery. Either as a continuous pump or as oral milk in the daytime and a continuous pump in the nighttime.

1. Introduction

Good nutritional status facilitates recovery of infants after gastrointestinal surgery; however, a significant number of infants do not meet their energy requirements with oral feeding. In these cases, temporary or long-term effective nutritional support with enteral nutrition (EN) may be necessary. EN is primarily suitable for patients with some or all functions of the intestinal tract intact, but some infants have difficulty adequately grow and develop. Initial EN can be derived from support using fortified foods, additional snacks, and/or oral supplements, but if the nutritional requirements are not met by oral nutrition, enteral nutrition via tube feeding to the gastrointestinal tract should be implemented [1]. EN is generally required for months or even years. The clinical use of home enteral nutrition (HEN), however, has eliminated the need for long-term hospitalization.

In the current study, HEN was defined as various types of tube feeding in the home. The origin of the HEN program was initiated by Ricour and Duhamel in the 1970s, and preceded home parenteral nutrition (HPN) [2]. HEN has gained popularity in developed countries in the last few decades. In North America, HEN was provided to 500,000 patients in 1997, of which 20% were children [3–5]. In Britain, HEN was provided to 40 per million individuals in the population, of which 30%–40% were children [3,4,6]. The prevalence of HEN has increased due to diversification of tubes, improvement in the production process, improved surgical techniques, and improved home care in past decades [7–9].

HEN is a safe and effective alternative to hospital-based EN in North American and European countries. The information available regarding the use of HEN in children and infants is less than adults, especially in developing countries. Is HEN also effective and safe to adopt in Chinese children? This study provides information about HEN based on our experience and data in patients who were

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followed in our center during the past 10 years, and the purpose of this study is to confirm the safety of HEN infants after gastrointestinal surgery.

2. Materials and methods

2.1. Subjects

This was a retrospective review of 58 infants who entered the HEN program in the Department of Pediatric Surgery at Children's Hospital of Nanjing Medical University between July 1, 2008 and June 30, 2018. All of the parents or guardians of the infants consented to this study. Informed consent: Informed consent was obtained from all individual participants included in the study. Ethical approval of this study was approved by the Ethics Committee of Children's Hospital of Nanjing Medical University. The gender, age, primary disease, mode of HEN, and complications in the long-term follow-up group (3 months–2 years) were reviewed. Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

2.2. Feeding tubes

The feeding tubes used in our center are made of silicone, including nasogastric and nasojejunal feeding tubes. The nasogastric tube includes 17 specifications of the outer diameter (2–13 mm; Jiangsu Hua Fei Technology Co., Ltd., Yangzhou, China). The nasojejunal feeding tube is 1500 mm in length with an outer diameter of 2 mm (6Fr; Dalian Kuli Aite Medical Product Co., Ltd., Dalian, China). The type of nasal feeding tube was based on the infant's age, weight, size of the nostril, and length and function of the intestines. In the current study, all of the parents declined gastrostomies.

2.3. Feeding programs

The nutrients of these infants were derived a low osmolality, extensively-hydrolyzed formula (Alfaré, Nestle, Netherlands). We utilize two nasal feeding programs, as follows: (1) 24 h of continuously pumped milk (group A); and (2) oral milk every 3 h in the daytime and continuously pumped milk for 12 h in the nighttime (group B).

2.4. Data collection

Patient data including gender, age, clinical details, kind of disease and incidences of complications in the long-term follow-up group (3 months–2 years) such as diarrhea, vomiting, aspiration, constipation were collected.

2.5. Statistical analysis

Statistical analysis was carried out with SPSS software (version 20.0; SPSS, Inc., Chicago, IL, USA). A Pearson chi-square test was used to compare the complications between the two groups.

3. Results

3.1. Patients

Finally, 58 patients were included in the study: group A (n = 30 patients; 16 males and 14 females) was diagnosed with intestinal atresia (n = 16), neonatal necrotizing enterocolitis (n = 8), volvulus (n = 4), and Hirschsprung's disease (n = 2); and group B (n = 28 patients; 15 males and 13 females) was diagnosed with intestinal atresia (n = 8), neonatal necrotizing enterocolitis (n = 7), volvulus (n = 6), Hirschsprung's disease (n = 3), gastroschisis (n = 2), congenital intestinal rotation (n = 1), and annular pancreas (n = 1). Eight patients were readmitted for parenteral nutrition (14%), because HEN was not adequate for growth and development. One patient was off treatment by the parents. The average duration of HEN to full oral feeding was 3.5 months in group A and 3 months in group B. The characteristics of the patients in the two groups are presented in Table 1.

3.2. Complications

The incidences of diarrhea, vomiting, aspiration, and constipation in group A was 36.7%, 10%, 6.7%, and 3.3%, respectively. The incidences of diarrhea, vomiting, aspiration, and constipation in group B was 25%, 14.3%, 3.5%, and 3.5%, respectively. The incidences of diarrhea, vomiting, aspiration, and constipation between the two groups did not differ (Fig. 1). In the long-term follow-up group, nine patients in group A (clogging [n = 3], and inadvertent removal [n = 6]) and six patients in group B (clogging [n = 1], malposition [n = 1], and inadvertent removal [n = 4]) encountered problems relating to the tube and four in group A (misoperation [n = 2] and alarms [n = 2]) and two in group B (misoperation [n = 1] and alarms [n = 1]) had problems with the micro-pump. Six parents (two in group A and four in group B) did not comply with HEN because of difficulty with the feeding tube.

3.3. Cost of HEN

The monthly cost of HEN was 3400 RMB in group A and 3200 RMB in group B, which included nutrients, disposable equipment, and the pump. There was no significant difference in cost of HEN between the two groups.

4. Discussion

Enteral feeding can help infants achieve nutritional requirements in the hospital [10]. When effective EN maintains normal growth and development, HEN is an option.

EN can be divided into short- and long-term use according to the duration of EN. In previous studies, nasojejunal or nasogastric tube feeding was often used short-term and gastrostomy was most commonly used long-term [11–14]; however, in the current study, all of the parents declined gastrostomies, and nasojejunal or nasogastric tubes were more acceptable by parents.

There are several methods used to deliver EN, including pump-controlled techniques, bolus feeding, and gravity feeding. In the current study, accurate control of nutrient intake was achieved using micro-pumps. No patients had gravity feeding, unlike other reports. The continuous feeding method reduces energy expenditure [15], strengthens duodenal function [16], and reduces pulmonary complications [17], but in the current study, pulmonary complications in the two groups were not significantly different. Bolus feeding improves the cyclic form of gastrointestinal tract hormone release, and these hormones, such as gastrin, gastric inhibitory peptide, and enteroglucagon, may affect gastrointestinal tract growth, development, and metabolic homeostasis [18]. Bolus feeding is closer to oral administration to some extent. A randomized study is warranted to compare the advantages and disadvantages of the two feeding methods in future.

HEN is complex and has potential risks. The indications for HEN include the following: patients who are able to receive nutrition

Table 1
Patient data.

	Group A	Group B
Cases(n)	30	28
Gender		
Male	16	15
Female	14	13
Age		
≤28 days	28	19
28 days–1 year	2	9
Clinical details		
Birth weight (g), median (IQR)	2260 (720–3210)	2780 (920–3160)
Length of small bowel (cm), median (IQR)	53 (25–85)	65 (35–70)
Disease		
Intestinal atresia	16	8
NEC	8	7
Volvulus	4	6
HD	2	3
Gastroschisis	0	2
Congenital intestinal rotation	0	1
Annular pancreas	0	1

IQR: interquartile range, NEC: neonatal necrotizing enterocolitis, HD: Hirschsprung's disease.

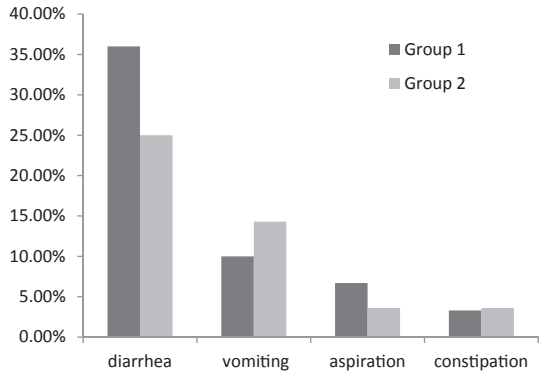

Fig. 1. Show the incidences of complications of the two groups.

support at home; gastrointestinal diseases, such as inflammatory bowel diseases and short bowel syndrome; children with oral feeding difficulties, such as problems with swallowing; and other diseases, including prematurity, chronic renal failure, liver cholestatic diseases, and cancer undergoing chemotherapy [19]. Our center focused on gastrointestinal diseases, thus HEN is mainly used for gastrointestinal diseases, such as short bowel syndrome caused by malformations of the digestive tract.

When tube feeding is required for a long time, even for several years, home tube feeding may be more beneficial for such patients than hospital-based EN [20]. Indeed, children treated with HEN are more active and happier at home [21]. HEN has many advantages, such as improving the nutritional status of infants, reducing the time of hospitalization, and reducing the cost of treatment in the hospital [22–24]. A previous study has shown that the nutritional status of children is improved after HEN and the mortality rate is low [21]. Prolonged hospitalizations increase expenditures and impairs the quality of life of children and parents. The cost of HEN in our patients included specific nutrients, instruments, consumable materials needed for EN, and personnel nursing. A 1998 United States research report showed that HEN cost approximately USD $18,000/patient [25]. A 2015 Spanish research report showed that HEN cost about 266 euros/patient/month [26]. The total cost of HEN in our patients was approximately 3200 RMB/month, which is lower than in the United States, and slightly higher than in Spain. HEN can save expenses compared to hospitalization, and the cost effectiveness of HEN plays an important role in determining the use of HEN and future health policies. HEN has many advantages, but at the same time, HEN also has some shortcomings and complications.

There are disadvantages associated with nasogastric feeding. In a previously study, 42% of chronic illnesses in children are due to feeding issues [27]. Moreover, if the pump is not cared for in the process of pumping milk, the tube can easily be pulled out by the infant. Tube misplacement is more common in low-weight babies than older children. To solve this complication, tube position should be confirmed and the external tube length must be verified. The parents were asked to go to the hospital to recheck tube position every 2 weeks. If there is an emergency, the patient can come to the hospital at any time to reset the tube. The most threatening complications of tube feeding are vomiting and aspiration [21]. Vomiting and aspiration are mainly due to malposition of the feeding tube, gastroesophageal reflux, and overdose of nutrients pumped through a micropump [19]. The most common complication of EN is diarrhea, which is mainly due to high osmolarity, an excessive infusion, and bacterial contamination of the formula [19]. With the use of deep hydrolyzed formula (Alfaré, Nestle, Netherlands) with a low osmotic pressure, the problem of high osmotic pressure has been reduced, and with the standardization of formula preparation technology, bacterial contamination is minimized. Moreover, because of the use of silicone tubes, mechanical complications, such as damage to the esophagus or stomach, rarely occur.

In addition to focusing on infants, attention should also be paid to the needs of infant caregivers [28]. Caregivers need to know the indications, complications, advantages, and disadvantages of enteral tube feeding, and pay attention to the nursing process. Parents need to master the placement of feeding tubes and troubleshooting skills. All parents of these infants undergo technical training and psychological guidance prior to infant discharge. In the current study, 96.6% of infants (56 cases) were given EN by parents or guardians and 3.4% (two cases) were given EN by homecare nurse. The parents and caregivers are trained to place the tube and how to care for the tube. The parents and caregivers need adequate education about the technical aspects, risks, complications, and the way to manage risks and complications, which requires guidance from the surgeon, nurses, and dietitians. In our center, the duration of the teaching program is 2 weeks.

The success and the quality of HEN are closely related to the organization and close collaboration of nutrition support teams and high quality nursing methods. The efficacy and stabilization of EN must be established in the hospital. Daily communication between parents and our team for effective discharge planning include the prescription of feeding methods and daily follow-up. The hospital team remains in touch with the patients, and if the parents need a consultation or an emergency arises, the parents can contact the physician by telephone or WeChat at any time, which ensures the safely of HEN with few complications.

In conclusion, with the developments of silicone tubes, commercially available pediatric diets and economical and effective nursing methods, HEN using these two nasal feeding programs is both safe and well-tolerated by infants after gastrointestinal surgery in our center. Effective training is still needs to be strengthened to avoid problems related to feeding tube and micro-pump problems.

Conflict of interest

The authors declare no conflict of interest.

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Ethical approval

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Informed consent

Informed consent was obtained from all individual participants included in the study.

Weibing Tang design study, Weiwei Jiang, Jie Zhang, Xiaofeng Lv, and Qiming Geng practical performance, Weiwei Jiang data analysis, Weiwei Jiang preparation manuscript, Xiaoqun Xu, and Weibing Tang critical review manuscript.

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