

## Original Article

# Causes of interruptions in postoperative enteral nutrition in children with congenital heart disease

Jirong Qi MD<sup>1</sup>, Zhuo Li MD<sup>2</sup>, Yueshuang Cun MD<sup>1</sup>, Xiaonan Li MD, PhD<sup>3</sup>

<sup>1</sup>Department of Cardiothoracic Surgery, Children's Hospital of Nanjing Medical University, Nanjing, Jiangsu, China

<sup>2</sup>Department of Emergency, Children's Hospital of Nanjing Medical University, Nanjing, Jiangsu, China

<sup>3</sup>Department of Child Health Care, Children's Hospital of Nanjing Medical University, Nanjing, Jiangsu, China

**Background and Objectives:** Perioperative nutritional support has become a hot topic in the clinical management of congenital heart disease (CHD). Postoperative enteral nutrition (EN) offers many benefits, such as protection of the intestinal mucosa, reduced risk of infection, and low clinical costs. Interruptions in EN frequently influence nutritional support and clinical outcomes. We, therefore, aimed to determine the causes of interruptions in postoperative EN in CHD patients and discuss clinical counter measures. **Methods and Study Design:** We analyzed the data of 360 CHD patients to determine the causes of interruptions in postoperative EN and develop possible clinical strategies to prevent such interruptions. **Results:** Of the 360 patients (aged from 1 month to 6 years), 198 patients had at least one EN interruption. The total number of interruptions was 498 (average, 2.52 interruptions/patient). Non-gastrointestinal factors (airway management, fluid overload, invasive procedure, increased intracranial pressure, feeding tube block, and clinical deterioration) accounted for 67.8% (338/498) of all interruptions and gastrointestinal factors (vomiting, gastrointestinal bleeding, diarrhea, constipation, and large gastric residual volume) accounted for 32.2% (160/498). The total number of interruptions and the number of interruptions due to gastrointestinal factors were significantly higher in younger patients (aged from 1–12 months) than in older patients (aged from 1–6 years). **Conclusions:** Non-gastrointestinal factors were the main causes of interruptions in postoperative EN in CHD patients. Younger patients had a greater number of interruptions as a whole, and more interruptions caused by gastrointestinal factors. Gastrointestinal factors can be reduced by tube feeding and use of gastrointestinal motility drugs.

**Key Words:** congenital heart disease, enteral nutrition, feeding interruption, gastrointestinal factors, non gastrointestinal factors

## INTRODUCTION

Postoperative nutritional support in the clinical management of congenital heart disease (CHD) continues to receive much attention.<sup>1</sup> Nutritional support includes management of fluid and energy requirements (glucose, protein, fat) to provide sufficient calories, while avoiding fluid overload.<sup>2</sup> Early postoperative nutritional support is usually provided via parenteral nutrition (PN) plus enteral nutrition (EN). Compared to PN, EN offers several benefits, including protection of the intestinal mucosa, reduced risk of infection, and low clinical costs.<sup>3</sup> Consequently, EN has become the main strategy for postoperative nutritional support of patients with CHD.<sup>4</sup> The unique pathophysiological features of CHD and the use of cardiopulmonary bypass during heart surgery lead to ischemia-reperfusion injuries of the heart and gastrointestinal tissues. Furthermore, interruption of EN occurs relatively frequently in CHD patients in the postoperative stage, especially when there are complications of heart failure and pulmonary arterial hypertension. Interruptions, such as vomiting and gastrointestinal bleeding, frequently influence nutritional support and subsequent clinical out-

come.<sup>5</sup>

Thus, the aims of this study were to identify different causes of postoperative EN interruptions among CHD patients and assess the utility of clinical countermeasures.

## MATERIALS AND METHODS

### Study subjects

The study subjects included 360 patients admitted to the cardiac intensive care unit (CICU) of Nanjing Children's Hospital Affiliated to Nanjing Medical University between August 2013 and December 2014 for treatment of ventricular septal defect, atrial septal defect, and tetralogy of Fallot, who met the following selection criteria: treat-

**Corresponding Author:** Dr Xiaonan Li, Department of Child Health Care, Children's Hospital of Nanjing Medical University, No. 72 Guangzhou Road, Nanjing 210008, Jiangsu province, P.R. China.

Tel: +86 13851996066; Fax: 011 86 25 83304239

Email: xnli@njmu.edu.cn

Manuscript received 13 June 2015. Initial review completed 13 September 2015. Revision accepted 28 January 2016.

doi: 10.6133/apjcn.032016.05

**Table 1.** General patient characteristics

Age/number	Male	Female	VSD	ASD	TOF	Readmitted	Deaths
1–12 months/198	103	95	164	16	18	5	2
1–6 years/162	87	75	54	73	35	1	1
Total: 360	190	170	218	89	53	6	3

VSD: ventricular septal defect; ASD: atrial septal defect; TOF: tetralogy of fallot.

ment with cardiovascular drugs (dopamine or milrinone) and EN support during the same 24-h period. The exclusion criteria included secondary chest closure and peritoneal dialysis.

### Study design

The study protocol was approved by the local research and ethics committee. For patients who were ventilated for less than 24 h after surgery, EN support was commenced 6 h after the respirator was turned off. For those who were ventilated for more than 24 h after surgery, standard nasogastric tube feeding was provided. Patients with gastroesophageal reflux or a severe cleft palate deformity routinely underwent nasoduodenal tube insertion and EN support was commenced 24 h after surgery. Patients younger than 1 year were fed 0.8 kcal/100 mL of extensively hydrolyzed milk protein, while those older than 1 year received 1.0 kcal/100 mL of extensively hydrolyzed milk protein. For patients whose conditions were not particularly severe and older patients, it was possible to provide sustenance directly via the mouth. For infants, tube feeding was provided continuously or intermittently using a micropump and a gravity drip delivery system. For some infants with an extremely low body weight, it was possible to use a micropump to deliver very small quantities of formula. After initiation of EN, PN support was gradually reduced until transition to complete EN.

A standardized data sheet was used by Cardiac Surgery Intensive Care Unit (CICU) specialists (professionally trained nurses and doctors) to collect information on patient age, sex, diagnosis, feeding route, incidence of vomiting, constipation, gastrointestinal complications, and feeding interruption, and reasons for feeding interruption. Data were collected from the time of feeding initiation until the patient either reached goal feedings for a period of 8 consecutive days or was discharged from the CICU. CICU specialists in conjunction with clinical nutritionists made all decisions regarding nutrition for patients admitted to the CICU.

### Statistical assessment

Measurement data are expressed as means  $\pm$  standard deviations (SD). Differences among groups were analyzed using the Student's *t*-test. One-way analysis of variance, the Student-Newman-Keuls test, or the least significant difference method was used for multiple comparisons. Qualitative data are expressed as percentages and were analyzed using the chi-square test or Fisher's exact test, as indicated. A two-sided probability (*p*) value of  $<0.05$  was considered statistically significant. All analyses were performed using SPSS software version 13.0 (IBM-SPSS, Inc., Chicago, IL, USA).

**Table 2.** Causes of EN interruptions

Reason	Number (%) of times (total 498)
Airway management	246 (49.4)
Fluid overload	46 (9.2)
Invasive procedure	16 (3.2)
Increased intracranial pressure	6 (1.2)
Feeding tube block	12 (2.4)
Clinical deterioration	12 (2.4)
Vomiting	48 (9.7)
Gastrointestinal bleeding	28 (5.7)
Diarrhea	22 (4.4)
Constipation	12 (2.4)
Large gastric residual	34 (6.8)
Unknown causes	16 (3.2)

EN: enteral nutrition.

### RESULTS

Of the 360 patients (190 boys and 170 girls; aged 1–12 months,  $n=198$ ; and 1–6 years,  $n=162$ ) included in this study, 357 survived and were discharged from the CICU, while 3 (0.8%) died of heart failure. The average CICU stay was  $48\pm 12$  h and the average duration of mechanical ventilation was  $32\pm 17$  h. A total of 63 patients received postoperative enteral nutrition directly via the mouth, 270 received standard nasogastric tube feeding, and 27 with gastroesophageal reflux or a severe cleft deformity received nutritional support via a nasoduodenal tube (Table 1).

Of the 360 patients, EN was interrupted at least once in 198 (55%), while the remaining patients experienced no interruptions during the time in the CICU. Among the 198 patients, there was a total of 498 interruptions (average, 2.52 interruptions/person; range, 1–6 interruptions/person). The most common cause of interruption was airway blockage, followed by vomiting, fluid overload, large gastric residual volume, gastrointestinal bleeding, diarrhea, invasive procedure, feeding tube blockage, clinical deterioration, constipation, increased intracranial pressure, and unknown causes (Table 2). The causes of interruptions were classified as non-gastrointestinal or gastrointestinal in origin. Non-gastrointestinal causes included airway blockage, fluid overload, invasive procedures, clinical deterioration, and increased intracranial pressure, which accounted for 67.8% of all interruptions, while 32.2% of interruptions were gastrointestinal in origin caused by vomiting, gastrointestinal bleeding, diarrhea, constipation, large gastric residual volume, or unknown causes.

The total number of interruptions and the number of interruptions due to gastrointestinal factors were significantly higher in younger patients (age, 1–12 months) than older patients (age, 1–6 years; Table 3). However, there was no significant difference in the number of interrup-

**Table 3.** Causes of EN interruptions according to age

Age/number	All interruptions, n	Gastrointestinal, n (%)	Non-gastrointestinal, n (%)
1–12 months/198	297	116 (39)*	181 (61)
1–6 years/162	201	44 (22)	157 (78)
Total	498	160	338

\*Significant difference between age groups ( $p=0.053$ ).

tions due to non-gastrointestinal factors between the two age groups.

## DISCUSSION

The aim of this study was to identify causes of interruptions to postoperative EN among pediatric CHD patients and assess the proportion of gastrointestinal and non-gastrointestinal causes of EN interruptions. In the present study, the incidence of EN interruptions was 55% (198/360). These interruptions were more frequently caused by non-gastrointestinal factors than gastrointestinal factors, and young patients tended to have a greater number of interruptions and a greater number of interruptions attributable to gastrointestinal factors. This is an intriguing finding that has not been documented previously among pediatric CHD patients undergoing cardiopulmonary bypass surgery. Therefore, nutritional management of CHD patients, especially for younger patients, should be carefully monitored.

Ramakrishnan et al<sup>6</sup> reported that in a multidisciplinary CICU, the incidence of EN interruptions was 55.9%, which is consistent with our findings. However, the authors also reported that gastrointestinal factors were the most common cause of interruptions followed by ventilation-related factors. In our study, non-gastrointestinal causes, such as respiratory factors, fluid overload, invasive procedures, and neurological symptoms, accounted for 67.8% (338/498) of all interruptions. The conflicting results of these two studies may be attributable to differences in patient characteristics. Postoperative hemodynamic fluctuations often lead to prolonged ventilation and more invasive procedures among CHD patients, which could have contributed to the above discrepancy in the results of these two studies. A study by Cabrera et al<sup>7</sup> suggested that cardiac drugs contributed to hemodynamic stability and less need for invasive procedures, thus helping to reduce the incidence of postoperative EN interruption. In clinical practice, non-gastrointestinal factors should be managed by intensive care specialists and heart surgeons. Our study showed that gastrointestinal factors, including vomiting, diarrhea, abdominal distension, retention of gastric fluid, and constipation, accounted for only 32.2% (160/398) of all EN interruptions. Vomiting was the most common gastrointestinal factor leading to EN interruption. These causes can be explained by the unique pathophysiological features of CHD, such as ischemia–reperfusion injuries to the heart and gastrointestinal tissue due to the use of cardiopulmonary bypass and perioperative hemodynamic fluctuations. Gastrointestinal causes of EN interruptions should be managed by intensive care specialists in conjunction with clinical nutritionists. Gastrointestinal ischemia–reperfusion injuries, post-cardiac surgery stress responses, and the use of cardiac, sedative, or analgesic drugs can lead to gastrointestinal intolerance

and EN interruption. Cimetidine is often administered to overcome stress reactions and gastrointestinal motility drugs are used to improve related symptoms. However, the effectiveness of these approaches remains uncertain. Constipation, also a major factor in gastrointestinal intolerance, can be caused by the use of anesthetic and analgesic drugs; therefore, once heart function has improved after surgery, these drugs should be discontinued as soon as possible.<sup>8</sup> Lichtenberg et al<sup>9</sup> and Sanchez et al<sup>10</sup> also reported that early provision of EN support, the use different feeding patterns, extensively hydrolyzed milk protein, and gastrointestinal motility drugs, as well as recovery of the normal intestinal flora and other measures that protect the gastrointestinal mucosa and normal flora, and early recovery of gastrointestinal motility are beneficial in terms of improving EN support and reducing the incidence of feeding interruptions. The results of our study also showed that compared with older patients, younger patients had a greater number of total interruptions and interruptions due to gastrointestinal factors. With improvements in surgical techniques and the level of care in the CICU, an increasing number of infants, and even newborns, with CHD can successfully undergo early surgery, and the growth and development of these patients can easily catch up with those of healthy children. However, early surgery is associated with greater risks of morbidity and mortality, including more challenging nutritional management owing to factors such as EN interruptions.<sup>11</sup> Therefore, nutritional management of CHD patients, especially for younger patients, should be carefully monitored. Fortunately, the clinical importance of perioperative EN in CHD patients is widely recognized.<sup>12</sup>

This study is limited by its descriptive design. In addition, the severity of CHD was not taken into account. Nonetheless, these findings provide important information about interruptions in perioperative EN in CHD patients and can help to reduce the incidence of such interruptions and improve perioperative nutritional support.

## ACKNOWLEDGEMENTS

This work was jointly supported by grants from the Nanjing Medical Key Science and Technology Fund (ZKX12030), the Health Opportunity for People Everywhere (HOPE) fund (AFINS-HOPE-2013-02), and the Nanjing Health Youth Resources Project (QRX11054). We thank Xuming Mo, PhD, Nanjing Children's Hospital Affiliated to Nanjing Medical University for his helpful administrative assistance, Yaqin Shu, MD for programming and technical support, and Ruiheng Li for data analysis.

## AUTHOR DISCLOSURES

The authors declare that they have no conflict of interest.

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