Early Enteral Nutrition is Acceptable in Cyanotic Patients with Systemic-Pulmonary Shunt after Cardiovascular Surgery

MinHye So1*, Shinichiro Yoshimura2, Yoshihito Fujita2, Takeshi Sugiura1, Nobuyoshi Kusama1 and Kazuya Sobue1
1Department of Anesthesiology and Intensive Care Medicine, Nagoya City University Graduate School of Medical Sciences, Nagoya, Japan
2Department of Anesthesia, Kenwakai Otemachi Hospital, Otemachi, Japan
3Department of Anesthesiology, Aichi Medical University Hospital, Aichi Prefecture, Japan
*Corresponding author: MinHye So, Department of Anesthesiology and Intensive Care Medicine, Nagoya City University Graduate School of Medical Sciences, 1 Kawasaki, Mizuho-cho, Mizuho-ku, Nagoya 467-8601, Japan, Tel: +81 528538281; Fax: +81 528521148; E-mail: min@snow.ocn.ne.jp
Received Date: 05 June, 2017; Accepted Date: 11 July, 2017; Published Date: 27 July, 2017

Abstract

Objective: To examine whether cyanotic patients, particularly with systemic-pulmonary shunt have more risks to gastrointestinal complications than acyanotic patients by early Enteral Nutrition (EN) after cardiovascular surgery.

Design: Retrospective, observational study.

Setting: Pediatric Intensive Care Unit (PICU) in university hospital.

Patients: 111 infants with congenital heart disease who stayed at PICU for more than 4 days after cardiovascular surgery during the period of January 2010 to December 2012.

Interventions: None.

Measurements and main results: 111 patients after cardiovascular surgery were divided into two groups: cyanotic and acyanotic groups (n=55 vs. n=56, cyanotic group includes 21 cases with systemic- pulmonary shunt). The timing of first feeding after surgery, infectious complications and gastrointestinal complications were investigated. First feeding was divided into three categories: 1) within 24 hours, 2) 24 to 48 hours, and 3) more than 48 hours respectively after surgery. As for the timing of the first feeding, there were no significant differences between cyanotic and acyanotic groups (1): 20 cases vs.15 cases, 2): 21 cases vs. 25 cases, 3): 14 cases vs. 16 cases, P=0.45). As to infectious and gastrointestinal complications, there were no significant differences between two groups. On the other hand, one case of suspected necrotic enterocolitis as a gastrointestinal complication was seen in cyanotic group. The case was hypoplastic left heart syndrome after pulmonary artery banding with prostaglandin E1, not a case with systemic-pulmonary shunt.

Conclusion: Patients were well tolerated to early EN even in cyanotic patients with systemic-pulmonary shunt. Early EN would be beneficial for cyanotic patients after cardiovascular surgery if adequately performed, but close attention might be paid for these patients whose systemic circulation is maintained with patent ductus arteriosus pre-and postoperatively.

Keywords

Cardiovascular Surgery; Cyanotic Patient; Enteral Nutrition; Gastrointestinal Complications; Infants; Systemic-Pulmonary Shunt

Abbreviations

EN : Enteral Nutrition
PICU : Pediatric Intensive Care Unit
NEC : Necrotic Enterocolitis
V-A ECMO : Ventricular-Arterial Extracorporeal Membrane Oxygenation
CPAP : Continuous Positive Airway Pressure
VAP : Ventilator-Associated Pneumonia
CRBSI : Catheter-Related Blood Stream Infections
HLHS : Hypoplastic Left Heart Syndrome
PDA : Patent Ductus Arteriosus

Background

Since several international institutions have announced the efficacy of early Enteral Nutrition (EN) in critically ill adults, early EN in critically ill infants and children has been also preferred in terms of improvement of nutrition outcome and mortality [1-6]. Also, feeding protocol for the initiation and advancement of EN has been reported to be beneficial to the extent of lower prevalence of acquired infections in PICUs [7]. However, there are few data with early EN in pediatric patients after cardiovascular surgery because of their risks to gastrointestinal complications associated with their circulatory instability, result in little protocol for the population. Especially, the cases with cyanotic congenital heart diseases have been reported that they have risks to gastrointestinal complications [8,9]. In addition, it has been reported that cases with systemic-pulmonary shunt are more likely to develop Necrotic Enterocolitis (NEC) [10] whereas there is little supporting research that identifies the threshold above which EN increases the risk of NEC [11]. In our institution, early EN within 48 hours has been applied for pediatric patients after cardiovascular surgery if not contraindicated. The objective of this study is to examine whether cyanotic patients, particularly with systemic-pulmonary shunt have more risks to gastrointestinal complications than acyanotic patients by early EN, making a comparison between cyanotic and acyanotic groups.

Materials and Methods

The Institutional Review Board of Nagoya City University approved this retrospective study. From January 2010, for 2 years, all pediatric patients with congenital heart disease who underwent cardiovascular surgery at Nagoya City University Hospital were retrospectively investigated utilizing their electronic health records. Only cases with Pediatric Intensive Care Unit (PICU) admission >4 days postoperatively were chosen. Cases with Ventricular-Arterial Extracorporeal Membrane Oxygenation (V-A ECMO) were excluded. No priori power analysis was conducted. Patients received standard treatment in the PICU without any additional interventions. Intensivists determined the timing of the initiation of EN via feeding tube postoperatively (first EN) and also directed the content, dose, and frequency of EN when the patients were considered. If the patients were determined to be intolerant to EN after initiation, the intensivists regulated the amount of EN and added medications for bowel hypomobility as needed or altered the administration route to transpyloric feeding, and in some cases, discontinued EN. Patients were divided into cyanotic and acyanotic groups. Cyanotic group was defined as the patient with

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cyanotic (N=55)</th>
<th>Acyanotic (N=56)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age at surgery (month)</td>
<td>5.6 ± 19.2</td>
<td>25.1 ± 26.7</td>
<td>&lt;0.05†</td>
</tr>
<tr>
<td>Use of CPB</td>
<td>21</td>
<td>55</td>
<td>&lt;0.05†</td>
</tr>
<tr>
<td>CPB time (min)</td>
<td>233 ± 115</td>
<td>239 ± 103</td>
<td>0.82</td>
</tr>
<tr>
<td>Use of nitric oxide</td>
<td>9</td>
<td>16</td>
<td>0.19</td>
</tr>
<tr>
<td>Use of peritoneal dialysis</td>
<td>10</td>
<td>8</td>
<td>0.76</td>
</tr>
<tr>
<td>Use of nasal CPAP</td>
<td>28</td>
<td>5</td>
<td>&lt;0.05†</td>
</tr>
<tr>
<td>Use of steroid</td>
<td>23</td>
<td>35</td>
<td>&lt;0.05†</td>
</tr>
<tr>
<td>Prostaglandin E₁</td>
<td>3</td>
<td>2</td>
<td>0.98</td>
</tr>
<tr>
<td>Duration of respiratory support (days)</td>
<td>7.1 ± 8.2</td>
<td>6.4 ± 8.8</td>
<td>0.71</td>
</tr>
<tr>
<td>First EN</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;24hrs</td>
<td>20</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>24-48hrs</td>
<td>21</td>
<td>25</td>
<td>0.45</td>
</tr>
<tr>
<td>&gt;48hrs</td>
<td>14</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Transpyloric feeding</td>
<td>5</td>
<td>1</td>
<td>0.09</td>
</tr>
<tr>
<td>Infectious complications</td>
<td>1</td>
<td>4</td>
<td>0.19</td>
</tr>
<tr>
<td>Gastrointestinal complications</td>
<td>1</td>
<td>0</td>
<td>0.3</td>
</tr>
<tr>
<td>Body weight at birth (g)</td>
<td>2681 ± 561</td>
<td>2818 ± 477</td>
<td>0.18</td>
</tr>
</tbody>
</table>

Table 1: Patient characteristics of cyanotic versus acyanotic patients (N = 111).

CPB: cardiopulmonary bypass
CPAP: continuous positive airway pressure
Data was analyzed using the chi-square test and unpaired T-test.
† Findings of P < 0.05 were considered significant.
cyanosis, for example: single ventricle, tetralogy of Fallot after palliation. Acyanotic group was defined as the patient without cyanosis, for example: tetralogy of Fallot after radical procedure. The timing of the initial EN was investigated, and it was divided into three categories: postoperatively within 24 h, 24-48 h, and >48 h. In addition, the content, amount, and frequency of the first EN; duration of respiratory support; and incidence of infectious and gastrointestinal complications were retrospectively investigated. The use of peritoneal dialysis, steroids, nitric oxide, and nasal Continuous Positive Airway Pressure (CPAP) as risk factors for gastrointestinal complications or indexes for severity of their condition were also recorded from electronic health records. Statistical analyses were performed with the computer program Statistical Package for the Social Sciences (SPSS 19.0, Chicago, IL, USA). Data was analyzed using the chi-square test, Mann-Whitney U-test, and unpaired T-test. Findings with P < 0.05 were considered significant.

Results

Of 111 cases, 55 were cyanotic (including 21 with a systemic-pulmonary shunt) and 56 were acyanotic. Patients’ characteristics are shown in table 1. Age at surgery was much higher in the cyanotic group (25.1 ± 26.7 months vs. 5.6 ± 19.2 months, P < 0.05) because of the specific treatment course of congenital heart disease surgery. Cardio-pulmonary bypass was more frequent in the acyanotic group (56 cases vs. 21 cases, P < 0.05), which included patients undergoing radical surgery. Nasal CPAP after extubation was more frequent in the cyanotic group (23 cases vs. 10 cases, P < 0.05) because of the younger population. Steroid administration to stabilize the patients’ circulation postoperatively was more frequent in acyanotic group than in the cyanotic group (35 cases vs. 23 cases, P < 0.05), mainly because most of them underwent a more invasive procedure using cardio-pulmonary bypass.

Regarding the timing of first EN, there was no significant difference between the cyanotic and acyanotic groups (20 cases vs. 15 cases, 21 cases vs. 25 cases, 14 cases vs. 16 cases, P = 0.45). First EN within 48hrs postoperatively was initiated in 81 patients (73%). The dose of first EN showed no significant difference between two groups (Table 2). The acyanotic group showed a tendency to have more infectious complications than the cyanotic group, although the difference was not statistically significant (P = 0.19). The details of the infectious complications are as follows: one case of aspiration pneumonia in the cyanotic group, and one case of Ventilator-Associated Pneumonia (VAP), two cases of Catheter-Related Bloodstream Infections (CRBSI), and one case of mediastinitis in the acyanotic group. All of the cases that developed an infectious complication were provided early EN, except the case with VAP. A case of suspected Necrotic Enterocolitis (NEC) as a gastrointestinal complication was seen in the cyanotic group. The specific case was a patient with Hypoplastic Left Heart Syndrome (HLHS) after pulmonary artery banding with prostaglandin E₁, whose systemic circulation was maintained with a Patent Ductus Arteriosus (PDA). Early EN in prostaglandin-dependent neonates has been controversial [12,13]. Weiss et al., reported that a hybrid procedure in single-ventricle heart defects after three first-stage palliations was an independent predictor of gastrointestinal complications [14]. Jeffries reported that a weight < 2.5 kg and the development of NEC were each independently related to death in neonates with HLHS after first stage palliation [15]. NEC often occurs in premature and low birth weight neonates. Initiation and escalation of EN is one of the risk factor of developing NEC in premature and low birth weight neonates.

<table>
<thead>
<tr>
<th>Content</th>
<th>S-P shunt (+) (N=21)</th>
<th>S-P shunt (-) (N=34)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breast milk/formula</td>
<td>5</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>5% dextrose</td>
<td>15</td>
<td>23</td>
<td>31</td>
</tr>
<tr>
<td>GFO</td>
<td>1</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Others</td>
<td>0</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>Dose (ml/kg/administration)</td>
<td>2.6 ± 1.1</td>
<td>2.6 ± 1.5</td>
<td>2.2 ± 1.4</td>
</tr>
<tr>
<td>Frequency (times/day)</td>
<td>4.4 ± 1.6</td>
<td>4.1 ± 1.6</td>
<td>3.5 ± 1.2</td>
</tr>
</tbody>
</table>

Table 2: Content and dose of first EN.

S-P shunt: Systemic-pulmonary shunt
GFO: Powdered soft drink containing glutamine, fiber, and oligosaccharides.

discussion

In our study, early EN within 48hrs postoperatively was provided for 73% of the patients. Most of the patients tolerated early EN well, including the cyanotic patients who had a systemic-pulmonary shunt. In patients with systemic-pulmonary shunt, their splanchnic circulations are vulnerable because of the impaired diastolic perfusion [11]. On the other hand, suspected NEC was observed in a patient with HLHS after pulmonary artery banding with prostaglandin E₁, whose systemic circulation was maintained with a Patent Ductus Arteriosus (PDA). Early EN in prostaglandin-dependent neonates has been controversial [12,13]. Weiss et al., reported that a hybrid procedure in single-ventricle heart defects after three first-stage palliations was an independent predictor of gastrointestinal complications [14]. Jeffries reported that a weight < 2.5 kg and the development of NEC were each independently related to death in neonates with HLHS after first stage palliation [15]. NEC often occurs in premature and low birth weight neonates. Initiation and escalation of EN is one of the risk factor of developing NEC in premature and low birth weight neonates.
these populations. Both preoperative and postoperative impaired mesenteric blood flow may have contributed to the complication. The timing of first EN may be reconsidered in these specific patients whose systemic circulation is maintained with a PDA pre-and postoperatively, even if their circulatory condition should be judged to be stable. As to the dose of first EN, it was much smaller than the traditional enteral nutritional support algorithm used for critically ill children, as previously published [16], which may have led to well-tolerated early EN, even in cyanotic patients (Table 2). Additional research is required to identify optimal dose of EN in these high-risk patients.

There is no guideline for early EN with a high catecholamine index, although enteral use is not advised when high doses of alpha-adrenergic drugs are administrated. In this study, the decision to initiate first EN was determined when patient’s circulation was considered stable even with the administration of certain amounts of catecholamines, and few patients developed gastrointestinal complications. Circulatory stabilization may be essential for the initiation of EN.

Considering infectious complications, the acyanotic group showed a tendency to have more infectious complications than cyanotic group and; 3 of the 4 mentioned cases were provided early EN. Two of the infectious complications were CRBSI. The additional catheter insertion in preparation for more invasive procedure may have contributed to this result in the acyanotic group; however, the explanation is unclear.

Our study is limited because of its retrospective nature. In addition, there was no protocol for EN or evaluation for preoperative feeding condition. Furthermore, two groups compared in this study have significant difference in age. Further investigation is required to identify adequate nutritional therapy in these populations.

Conclusion

In this study, pediatric patients tolerated early EN well, including cyanotic patients with systemic-pulmonary shunts following cardiovascular surgery. Early EN would be beneficial in this population if appropriately executed; however, ductus dependent patients should be monitored closely even if their circulatory condition is stable.

References