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Early Enteral Feeding of Neonates with Congenital Heart Disease Undergoing Congenital Heart Surgery

Konjenital Kalp Hastalığı Nedeni ile Ameliyat Edilen Yenidoğanlarda Erken Enteral Beslenme

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ABSTRACT

Objective: Appropriate nutritional support has positive effects on both the growth and morbidity of patients who have undergone surgery due to congenital heart disease during their neonatal period. The aims of this study were to determine enteral feeding characteristics throughout the post-operative period, to define difficulties and obstacles in oral feeding, and to establish dietary guidelines based on the acquired data.

Methods: From January 2012 to December 2014, 87 patients were retrospectively evaluated. All patients were diagnosed with transposition of the great arteries and were operated on during their neonatal periods. The median age of the cases was 9.37±5.73 5.73 days (3-30 days). Pre-operative, intraoperative, and post-operative parameters were recorded.

Results: During the intensive care unit stay, factors that delayed the transition to full enteral feeding or resulted in the discontinuation of feeding were identified. Enteral feeding was applicable to all patients within the first 24 h. Full enteral feeding was achieved at a median of 3.3 days. Gastric residual was observed in 63.2% of the patients; this was considered to be one of the major reasons for stopping feeding. In patients with gastric residual, transition to full enteral feeding was delayed, and the frequency of interruption and discontinuation of feeding increased. It was observed that patients with feeding discontinuations had longer periods of transition to full enteral feeding.

Conclusion: It is believed that early post-operative enteral feeding contributes to shortening the hospitalization stay, to providing discharge without the requirement of feeding support, and to reducing post-discharge homecare feeding difficulties.

Keywords: Newborn, congenital heart disease, early enteral feeding, intensive care, TGA

ÖZ

Amaç: Yenidoğan döneminde konjenital kalp hastalığı nedeniyle ameliyat edilen hastaların uygun beslenme desteği alabilmeleri, morbidite ve büyümeyi olumlu şekilde etkiler. Bu çalışmada amacımız, postoperatif dönemde enteral beslenme karakteristiklerinin belirlenmesi, oral beslenmedeki güçlükler ve engellerin belirlenmesi ve buradan elde edilen verilerle beslenme kılavuzunun oluşturulmasıdır.

Yöntem: Ocak 2012-Aralık 2014 tarihleri arasında büyük arter transpozisyonu tanısı alan ve ameliyat edilen 87 hasta retrospektif olarak değerlendirildi. Olguların ortalama yaşı 9,37±5,73 gündü (3-30 gün). Ameliyat öncesi, ameliyat sırası ve ameliyat sonrası parametreler kaydedildi.

Bulgular: Yoğun bakım izlemi sırasında tam enteral beslenmeye geçiş zamanını uzatan ya da beslenmenin kesintiye uğramasına neden olan faktörler belirlendi. İlk 24 saatte tüm hastalarda enteral beslenmeye başlanabildi. Tam olarak enteral beslenmeye ortalama 3,3 günde geçilebildi. Gastrik rezidü hastaların %63,2'sinde görüldü ve beslenmenin atlanmasına neden olan önemli faktörler arasındaydı.

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Gastrik rezidüsü olan hastalarda tam enteral beslenmeye geçiş uzadı, beslenmenin atlanması ve beslenmeye ara verilme sıklığı arttı. Beslenmeye ara verilmek zorunda kalınan hastalarda tam enteral beslenmeye geçiş süresinin daha uzun olduğu görüldü.

Sonuç: Cerrahi sonrası erken dönemde enteral beslenmeye başlamanın, hastanede yatış süresinin kısalmasına, yardımcı beslenme tekniklerine ihtiyaç duyulmadan taburculuğun sağlanabilmesine ve taburculuk sonrası evde bakım sırasında beslenme güçlüklerinin azalmasına katkıda bulunduğuna inanmaktayız.

Anahtar Kelimeler: Yenidoğan, konjenital kalp hastalığı, erken enteral beslenme, yoğun bakım, TGA

INTRODUCTION

Congenital heart defects occur in 0.8% of all live-born neonates. Transposition of the great arteries (TGA) accounts for 3-5% of neonates with congenital heart defects.[1] Arterial switch operation is the most frequently referred surgical treatment for TGA and is performed within the first 2 weeks of life.[1-3]

Neonates who have undergone cardiopulmonary bypass (CBP) surgery have more severe metabolic stress responses than older children and adults. On the other hand, the metabolic reserves of neonates are lower than those of older children and adults; therefore, neonates are more susceptible to stress-induced negative metabolic effects.[4]

Enteral feeding provides the continuance of intestinal physiology, prevents intestinal villus atrophy, reduces intestinal permeability, acts prophylactically against ischemic reperfusion injury by stimulating intestinal perfusion, provides the continuance of intestinal barrier against various injuries, improves regional and systemic immune responses, and increases epithelial proliferation. Early enteral feeding (<24 hours post-operatively) is recommended if the hemodynamics of intensive care unit (ICU) patients are balanced and gastrointestinal system functions are adequate.[5] Early initiation of enteral feeding has been shown to accelerate wound healing, increase survival rates after surgery and severe trauma, and reduce septic complications.[6]

Compared with an adult patient, a newborn's need for nutritional support is a complex issue. In addition to the increased metabolic requirements due to a major surgical intervention, the newborn's small body, rapid growth, variable fluid requirements, immature organ systems, and low-calorie reserves must also be considered.[7]

The aims of this study were to determine enteral feeding characteristics throughout the post-operative period, to define difficulties and obstacles in oral feeding, and to establish dietary guidelines based on the acquired data.

METHODS

It was retrospectively identified that from January 2012 to December 2014, 98 TGA patients underwent surgery at the clinic (Department of Pediatric Cardiology, Başkent University Faculty of Medicine). Among these patients, 87 were eligible based on the research criteria; thus, only their data were considered.

The exclusion criteria were; infants older than 30 days at the time of surgery, infants who were transferred to the ICU with no sternal closure at the end of the operation, and premature deliveries (≤36 weeks).

Ethical approval was obtained from the Ethics Committee of the Başkent University Faculty of Medicine Hospital (project no: KA15/115, date: 31.03.2015).

Statistical Analysis

Statistical evaluation of the data was performed using Statistical Package for the Social Sciences for Windows 11.5. Chi-square and Fisher's exact tests were used in the comparison of categorical data. Independent sample t-tests were used to compare quantitative data with normal distributions. The Mann-Whitney U test was used to compare quantitative variables without normal distributions. Spearman rank correlation analysis was used to assess the relationships between quantitative variables. Univariate logistic regression analysis was used to investigate the factors affecting ≥4 feeding interruptions. Frequency and percentages were used as descriptive values for categorical variables, and mean±standard deviation and medians were used for quantitative data. The statistical significance limit was set at 0.05.

RESULTS

The study group consisted of 87 patients [60 (69%) males and 27 (31%) females] who underwent arterial switch surgery due to TGA. The median age of the patients was 9.37±5.73 days (3-30 days). Post-operation ICU parameters were reviewed (Table 1).

Before operations, balloon atrial septostomy was performed in 53 patients (Table 1). The duration of surgery, cross-clamp duration, and the duration of stay in the pump are elaborated in Table 1.

All patients were admitted to the ICU on mechanical ventilation for respiratory support postoperatively. The average length of ICU stay was 10.4±7.3 days (Table 1).

Initiation of enteral feeding was possible within the first 24 h for all patients in the research group (Table 2).

In 59 patients, feeding was interrupted at least once. Not every gastric residual incidence caused interruption; however, each distension incidence resulted in interruption.

Factors for feeding interruption were gastric residual, extubation, distension, vomiting, re-intubation, chest tube removal, and catheter removal (Table 2). In 28 patients, feedings were never interrupted. In 16 of the patients, feeding was discontinued (≥4 consecutive interruptions).

Factors affecting the period of transition to full enteral feeding (PTFEF) are indicated in Table 3. It was observed that as the duration of stay in the ICU (10.4±7.3 median: 8 days) was prolonged, the PTFEF was also extended (r=0.58, p=0.0001). As the duration of intubation was prolonged, PTFEF was also delayed (r=0.42, p=0.0001).

Discontinuation of feeding was statistically more significant among patients with a longer aortic clamping duration and prolonged stay in the pump (p=0.002 and p=0.005) (Table 4). There was a possibility of feeding discontinuation if the surgery duration was prolonged; however, this was found

Table 1. Surgery associated data

Pre-operative data		
	Mean±SD	**Distribution/percent**
Age (days)	9.4±5.8	3-30
Sex		
Female (number)	27	31
Male (number)	60	69
Birth weight (grams)	3326.3±432.8	2495-4660
Pre-operation weight (grams)	3428.7±433.3	2400-4750
BAS performed (number)	53	60.9
Intra-operative data		
	Mean±SD	Distribution
Cross clamp duration (minutes)	95.7±18.0	12-144
Duration of stay in the pump (minutes)	150.5±22.9	115-272
Duration of surgery (minutes)	229.3±35.0	70-330
Post-operative data		
	Mean±SD	Distribution/median
Duration of stay (days)	10.4±7.3	8
Duration of mechanical ventilation (hours)	89.6±107.1	68
Weight at the end of ICU monitoring (grams)	3524.2±407.2	2420-4500

TGA: Transposition of the great arteries, ICU: Intensive care unit, BAS: Balloon atrial septostomy, SD: Standard deviation

Table 2. Feeding associated data

	Mean±SD	**Distribution/median**
Enteral feeding initiation time (hours)	19.9±3.4	20
Feeding initiation within the first 24 hours (number)	87	100%
Feeding initiation quantity per meal (milliliters)	6.6±2.6	3-15
Total feeding quantity in the first day (milliliters)	98.1±59.8	10-255
Total enteral feeding initiation time (hours)	80.6±67.7	70
Feeding discontinuations and causes		
	Number	**%**
≥4 more interruptions	16	18.4
Minimum 1 interruption	59	67.8
Distension	12	13.8
Gastric residue	55	63.2
Necrotizing enterocolitis	0	0
Interruption causes†		
- Gastric residue	42	71.2
- Extubation	23	39
- Distension	12	20.3
- Vomiting	7	11.9
- Re-intubation	6	10.2
- Chest tube removal	2	3.4
- Catheter removal	2	3.4

†Some patients had more than one interruption cause.
SD: Standard deviation

to be statistically insignificant (p=0.080). The duration of surgery was 224.3±33.4 min in the group with <4 feeding interruptions, whereas the duration was 241.9±34.6 min in the group with ≥4 feeding interruptions. As feeding discontinuations increased, the duration of stay in the ICU was extended (p=0.047) (Table 4). In the group with <4 feeding interruptions, the duration of intubation (69.8±71.1 median: 64.5 hours) was shorter than that in the group with ≥4 feeding interruptions (168.3±179.3 median: 70 hours). As the intubation durations extended, the frequency of discontinuation increased (p=0.014) (Table 4). As the period of intubation extended, the amount of residue (r=0.275, p=0.011) and the number of feeding interruptions (r=0.341, p=0.001) increased. As the amount of residue increased, feeding interruptions also increased (r=0.573, p=0.0001). It was understood that the presence of infection had no effect on PTFEF (p=0.573). However, the correlation between infection and discontinuation was found to be statistically significant (p=0.011) (Table 4).

Variables arising from the feeding action are shown in Table 5. PTFEF was statistically longer in patients with gastric residual (p=0.001) (Table 5). If the amount of gastric residual was less than half of the total intake volume, feeding proceeded. However, if the residue volume was more than half or if the residue content looked dissimilar to breast milk or formula, feeding was interrupted. Although the mean durations were almost equivalent, half of the patients without residue were able to begin full enteral feeding in less than 53 h; however, in the other group, the median time was significantly longer at 77.5 h. The mean PTFEF was 84.6±46.7 h (median: 81 hours) in patients

Table 3. Factors affecting the period of transition to full enteral feeding

	Mean±SD	Median	p
Sex Female Male	 73.2±30.0 79.8±80.0	 64.5 69	 0.938
Cross-clamp duration (minutes)	95.6±18.0	-	0.439 r=0.085
Pumping duration (minutes)	150.5±22.9	-	0.881 r=0.017
Surgery duration (minutes)	229.3±35.0	-	0.842 r=0.022
Diaphragm paralysis (minutes)	113.2±155	73	0.230
ICU duration of stay (days)	10.4±7.3	8	0.0001* r=0.58
Duration of mechanical ventilation (hours)	89.6±107.0	68	0.0001* r=0.42
Presence of infection (hours†)	67.8±42.1	68	0.573

†PTFEF of patients with infection, *Statistically significant.
SD: Standard deviation, ICU: Intensive care unit, PTFEF: Period of transition to full enteral feeding

Table 4. Factors affecting the number of interrupted feedings

	<4 (mean±SD)	≥4 (mean±SD)	p
Sex (number) Female Male	 23 45	 3 13	 0.369
Cross-clamp duration (minutes)	92.2±17.1	106.4±14.7	0.002*
Pumping duration (minutes)	144.6±15.0	163.5±22.8	0.005*
Surgery duration (minutes)	224.3±33.4	241.9±34.6	0.080
Diaphragm paralysis (number)	14	2	0.724
ICU duration of stay (days)	9.4±6.4	14.8±9.5	0.047*
Duration of mechanical ventilation (hours)	69.8±71.1 Median: 64.5	168.3±179.3 Median: 70	0.014*
Presence of infection (number)	12	8	0.011

*Statistically significant.
ICU: Intensive care unit, SD: Standard deviation

with distension. On the other hand, the mean period was 77.6±71.2 h (median: 64.5 hours) in patients without distension. The difference was found to be statistically insignificant (p=0.136); nevertheless, the distinction between the medians seemed evident. In patients with <4 interruptions, the PTFEF was 67.5±24.5 h (median: 62 hours), whereas it was 129.2±148.2 h (median: 91 hours) in patients with ≥4 interruptions. PTFEF in patients with feeding discontinuations was statistically longer (p=0.006) (Table 5).

Fifteen out of 55 (27.3%) patients with gastric residual had ≥4 interruptions, whereas one of the 29 patients (3.4%) without gastric residual had ≥4 interruptions. In patients with gastric residual, the number of interruptions and discontinuation intervals were both greater (p=0.008) (Table 5). Seven out of 12 patients (58.3%) with distension had ≥4 interruptions, whereas 9 out of 71 patients (12.7%) without distension had ≥4 interruptions. In patients with distention, the number of interruptions and discontinuation intervals were both greater (p=0.001) (Table 5).

Risk Analysis

Factors affecting ≥4 feeding interruptions:

- Distension increases the risk 9.64 times [odds ratio (OR)=9.64, p=0.001],

- Gastric residual increases the risk 10.5 times (OR=10.5, p=0.027),

- A 1-min extension of the duration in cross clamp increases the risk by 8.3%,

- A 1-min extension of the duration of stay in the pump increases the risk by 6.2%.

Neopulmonary failure, neoaortic stenosis, pericardial effusion, pleural effusion, and residual ventricular septal defect (VSD) were the most common post-operative residual cardiac defects. Statistically, residual cardiac defects had no effects on PTFEF, feeding interruption, or feeding discontinuation.

It was observed that metabolic factors such as blood glucose level or electrolyte imbalance (hypo/hyperglycemia, hypo/hypernatremia, hypokalemia, hypocalcemia, elevated creatinine levels) did not alter PTFEF.

DISCUSSION

A good number of studies have been conducted to assess child nutrition and to determine the difficulties adapting to a normal feeding pattern. However, this study is authentic in its approach to determining feeding difficulties during the ICU stay of neonates who had surgery due to congenital heart disease and its analyses of the benefits of transition to early enteral feeding.

The mechanism of intestinal damage in infants with cardiac disease is not fully understood. Even a small amount of breast milk may protect the gastrointestinal epithelium, promote beneficial bacteria, and reduce intestinal permeability.[8] In our study group, it was possible to feed 65% of the patients breast milk. In a recent study evaluating the impact of the type of enteral feeding in infants with cardiac surgery, it was shown that, after surgery exclusively breastmilk fed babies had better outcomes and less infectious complications than those having formula or breastmilk and formula together.[9]

This study examines the difficulties involved in enteral feeding. Factors that prolong PTFEF (with no parenteral support) are examined, and causes for feeding discontinuation are investigated.

Patients who have undergone CBP surgery have intestinal functions with reduced absorption, reduced perfusion, and increased permeability due to the emergence of hypotension.[10] Sables-Baus et al.[11] conducted a retrospective study on 56 newborns with congenital heart disease who underwent early-stage surgeries, in which difficulties in the transition to enteral feeding were

Table 5. Variables arising from the feeding action itself

1. Factors affecting the period of transition to full enteral feeding					
	Yes (mean±SD, median) (hours)		**No (mean±SD, median) (hours)**		**p**
Gastric residue	78.5±30.1	77.5	78.2±107.5	53	0.001*
Distension	84.6±46.7	81	77.6±71.2	64.5	0.136
≥4 interruptions	129.2±148.2	91	67.5±24.5	62	0.006*
2. Factors affecting the number of feeding interruptions					
	<4 (number)		**≥4 (number)**		**p**
Gastric residue	40		15		0.008
Distension	5		7		0.001

*Statistically significant.
ICU: Intensive care unit, SD: Standard deviation

evaluated. It was observed that intraoperative factors such as cross clamp duration and deep hypothermic circulatory arrest negatively affected oral feeding. In another study conducted by Jadcherla et al.[10] with cyanotic patients who underwent CBP surgery, it was observed that the duration of hospital stay was prolonged and initial feeding, maximum enteral feeding, and full breast feeding were significantly delayed. On the other hand, our study has observed that the durations of aortic clamping, stay in the pump, and surgery had no prolongation effect on PTFEF. However, feeding discontinuation was significantly elevated in patients with longer aortic clamp duration and longer stay in the pump. Each 1-min increase in the durations of aortic clamp and stay in the pump resulted in 8.3 and 6.2 times increases in the rate of feeding discontinuations, respectively.

Mechanical ventilation or other non-invasive respiratory support systems have adverse effects on oral feeding.[9,10] Prolongation of intubation impedes coordination of swallowing, makes oral feeding more difficult, and increases the risk of oropharyngeal aspiration.[12,13] Likewise, our study also observed that as the duration of intubation was prolonged, PTFEF was delayed and feeding discontinuations increased. The mean duration of intubation in this study was 3.7 days, and all patients were discharged with oral feeding. Because all patients could change over to complete oral feeding, it was not possible to determine the risks of prolonged intubations about other assisted feeding techniques such as nasogastric catheter or gastrostomy.

As expected, patients with more frequent feeding interruptions or with further belated transitions to full enteral feeding had prolonged durations of ICU stay Gastric residual was identified as one of the major contributors to feeding interruptions. Patients with gastric residual had prolonged PTFEF and increased frequencies of interruptions and discontinuations. Not every gastric residual incidence caused interruption; however, each distension incidence resulted in interruption. In patients with distention, the number of interruptions and intervals of discontinuation were both increased; however, no prolongations were observed regarding PTFEF. The risk of feeding discontinuation was increased 9.6 times in distention and 10.5 times in gastric residual. It was observed that PTFEF was longer among patients with feeding discontinuations.

Maurer et al.[14] retrospectively examined 82 patients, of whom 28 were operated on for TGA. Nasogastric feeding was initiated in the first 24 h in 55 of the 82 patients. The remaining patients had a nasogastric catheter inserted under anesthesiato initiate feeding in the early post-operative period. Percutaneous endoscopic gastrostomy was required in five patients. A strong correlation was observed among hospitalization stay, period of intubation, period of ICU stay, and period of nasogastric tube feeding. Birth weight, gestational age, sex, operation age, maternal age, or poorly educated parents did not increase the risk of nutritional disorders. Similarly, our study was unable to correlate nutrition disorder with birth weight, sex, or operation age. Maternal age and education level of parents were not within our research parameters because this study focused only on postoperative ICU follow-ups.

Congenital heart disease and neonatal heart surgery are risk factors for necrotizing enterocolitis (NEC). The predisposing factor for NEC in such patients is splanchnic ischemia, which develops due to impairments in splanchnic blood flow and oxygen transport.[15,16] In our study, there were no NEC incidents. Because premature neonates were excluded from the study, a crucial predisposing factor for NEC was ruled out.

Diaphragm paralysis due to phrenic nerve damage may develop after congenital heart disease surgery, leading to respiratory failure, lung infection, prolonged hospital stays, or even death.[17] Diaphragmatic paralysis was observed in 18.4% of our patients. When the current literature was examined, surgery-induced diaphragm paralysis was found not to have been investigated in terms of its effect on feeding. Our study has identified that diaphragm paralysis has no influence on either PTFEF or the discontinuation of feeding. Another retrospective study conducted in our clinic from 1996 to 2005 examined 3.071 children who were operated on for congenital heart disease and found that the incidence of diaphragm paralysis was 4.9% and was more frequent after arterial switch operation.[18]

Echocardiographic findings of the patients were examined, with particular respect to residual cardiac lesions. The more commonly observed lesions were trivial or mild neopulmonary failure, neoaortic stenosis, pericardial effusion, pleural effusion, and residual VSD. No relationship was discovered between residual lesions and enteral feeding. In another study from our clinic, the somatic growth of the great majority of patients who underwent corrective cardiac surgery was normal by the end of the first year following surgery. Residual cardiac lesions were detected in 18.3% of patients.[19] Although our study could not correlate residual heart lesions with early nutritional difficulties, growth in the forthcoming periods may still be adversely affected.

Infection incidences after cardiac surgeries are common in children (13-31%), which significantly increases mortality and morbidity rates.[20] We observed that in patients

with infection, PTFEF was not prolonged, but feeding interruptions were increased. Feeding was interrupted within 40% of patients with infection.

Ideally, if there is no contraindication, enteral feeding support should be administered as soon as possible, after surgery.[21] In a study on neonates and infants who underwent heart surgery, patients were randomized into two groups. One group received enteral feeds 4-6 h after surgery, and the other group received feeds 48 h after surgery. They showed that, in the early enteral feeding group, the duration of mechanical ventilation and ICU stay were shorter.[22] In our study, enteral feeding was initiated in all patients within the first 24 h. Distinguishing from the literature, all our patients were being orally fed at the time of ICU discharge.

Study Limitations

The retrospective design was the restricting aspect of our study. Prospective randomized studies will contribute to the development of optimal feeding strategies for infants who have undergone surgery due to congenital heart disease.

CONCLUSION

In conclusion, there are multiple complex difficulties in achieving successful oral feeding in neonates with congenital heart disease surgery. As administered at our clinic, early initiation of post-operative enteral feeding contributes to a shortened hospitalization stay, achieving a discharge without the requirement of feeding support techniques, and reducing postdischarge homecare feeding difficulties.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Ethics Committee of the Başkent University Faculty of Medicine Hospital (project no: KA15/115, date: 31.03.2015).

Informed Consent: Retrospective study.

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Authorship Contributions

Surgical and Medical Practices: M.Ö., Concept: E.O., N.K.T., Design: E.O., N.K.T., Data Collection or Processing: E.O., M.Ö., Analysis or Interpretation: E.O., N.K.T., B.V., İ.E., Literature Search: E.O., N.K.T., Writing: E.O.

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