ORIGINAL ARTICLE

Impact of nutritional support on length of hospitalization and mortality in children after open heart surgery

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Abstract

Background. Malnutrition is a common cause of morbidity in children with congenital heart disease (CHD). The aim of this study was to assess the impact of malnutrition and nutritional support on the length of hospitalization and mortality at the Pediatric Intensive Care Unit (PICU) in children with CHD after undergoing surgery.

Methods. Clinical records (2000-2008) of patients ≤3 years old with CHD who were admitted for surgery were evaluated for nutritional status, nutritional support, and risk factors. Mortality was evaluated from the beginning of surgery and during the patient's stay at the PICU. Long-term hospitalization was considered according to the length of hospital stay on percentile >50. A multiple logistic regression model was used.

Results. Two hundred eighty nine patients were included. Factors related to mortality were malnutrition before surgery (OR 3.447; 95% CI 1.006–11.812, p = 0.049), early or delayed enteral nutrition (OR 0.007; 95% CI 0.000–0.097, p = 0.000, and OR 0.011; 95% CI 0.001–0.126, p = 0.000, respectively), and early parenteral nutrition (OR 0.032; 95% CI 0.002–0.452, p = 0.000) vs. no nutritional support. Factors related to long-term stay were malnutrition at birth (OR 2.772; 95% CI 1.282–5.995, p = 0.010) and delayed parenteral nutrition (OR 12.049; 95% CI 1.626–94.724, p = 0.015).

Conclusion. Malnutrition at birth and before surgery increases length of stay and mortality of children after open heart surgery. Early nutritional support reduces length of stay and mortality.

Key words: pediatric cardiology, surgery, nutrition, Pediatric Intensive Care Unit

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Introduction

Malnutrition is a common cause of morbidity in children with congenital heart disease (CHD).[1-11] Despite advances in intensive cardiologic treatment, these children have a torpid evolution including prolonged mechanical ventilation, longer stay at the Pediatric Intensive Care Unit (PICU), increased rate of infections, reinterventions, reintubation, and early mortality (within 30 days).[12-19]

Although many techniques have been developed to rapidly correct the malformation, mortality remains at 10%.[20-22] Recently, malnutrition has been found to be a strong risk factor for many complications such as infection, longer stay at the PICU, reintubation and death, among others.[23] However, no studies have reported the prevalence and determinants of a long stay and mortality in the PICU related to malnutrition and nutritional support in our population. Such information is needed to design nutritional interventions for these children. Therefore, we designed this study to report the prevalence of these variables and the effect on length of stay and mortality at PICU.

Patients and methods

This is a retrospective cohort study. Clinical records of children with CHD <3 years old who underwent their first surgical corrective intervention with extracorporeal circulation from January 2003 to August 2008, at the *Instituto Nacional de Cardiología "Ignacio Chávez"* were reviewed. Forty nine percent of the charts were excluded for the following reasons: nonelective surgery, congenital syndrome, did not require extracorporeal circulation during surgery, had already had a previous major surgery, had been hospitalized for other causes, charts were incomplete, and had esophageal atresia. The total charts eligible were 490 and, of these, 289 were included.

A comprehensive evaluation of determinants for a long stay at the PICU and death was performed. These included information on demographics, birth history, cardiac status, socioeconomic class, and pre-, intra-, and postsurgical factors as well as nutritional support at the PICU. Malnutrition was defined as <90% of weight/age at birth using National Centre for Health Statistics (NCHS) charts and a Z-score of < -2 for body mass index (BMI) before surgery.[24]

Evaluated variables

According to the chronology of the event, the variables were grouped into four periods: 1) before hospitalization: sociodemographic (socioeconomic status) and clinical variables (sex and cardiologic diagnosis); 2) pre-surgical: anthropometric and medical treatment; 3) intrasurgical: time of aortic clamp, transfusions, bleeding, inotropics infused, and adverse events (bleeding, arrhythmia, cardiac arrest and cardiogenic shock); and 4) postsurgical: fasting, nutrition support infusion (early <72 h fasting, delayed >73hs fasting) enteral or parenteral nutrition, intubation, and transfusions. Long stay (>6 days) and death (before or after 72 h at the PICU) were evaluated as outcomes.

Statistical analysis

To test the association between nutritional status and treatment with long stay at the PICU and death, a bivariate analysis was done using χ^2; all covariates were also evaluated. Later, two groups of independent multivariate analysis were conducted: 1) for evaluating nutritional status (early and late death patients were included), and 2) for evaluating nutritional treatment (only late mortality patients were included). Both analyses were adjusted for every variable collected. For nutritional diagnosis, the analysis was adjusted by baseline, pre- and intrasurgical variables (age, sex, socioeconomic status, prematurity, Risk Adjustment for Congenital Heart Surgery (RACHS), presurgical transfusions, adverse events, bleeding, time of aortic clamp, inotropics). For nutritional support variables, analysis was done adjusting for the

baseline, pre-, intra-, and postsurgical variables (age, sex, socioeconomic status, prematurity, RACHS, presurgical transfusions, adverse events, bleeding, time of aortic clamp, inotropics, infection, and prolonged mechanical ventilation (only for mortality).

In both analyses, each variable was contrasted against long stay and death at the PICU. In all cases, p ≤0.05 was considered significant (SPSS v.12 for Windows).

The study was approved by the Ethics and Research Committee Board of the institution.

Results

Four hundred ninety medical records of children submitted to corrective intervention with extracorporeal circulation for CHD were evaluated and 289 (59%) were included. The median age was 10.6 months (range: 0.1-36 months). There were 56% infants (≤1 year old) and 44% were >1 year if age. The sample included 51.5% boys and 48% girls. We reported a long stay (>6 days) at

Table 1. Baseline characteristics of the study population

Cardiologic diagnosis	n	%
Patent ductus arteriosus	109	18.9
Ventricular septal defect	106	18.3
Total anomalous pulmonary venous connection	71	12.2
Atrial septal defect	65	11.2
Patent foramen ovale	49	8.4
Transposition of great arteries	34	6
Tetralogy of Fallot	33	5.6
Pulmonary valve stenosis	26	4.4
Double outlet right ventricle	18	3.0
Truncus arteriosus	18	3.0
Others	49	8.5
Total	578	100
Number of cardiologic malformations		
1–2	210	72.6
3	54	18.6
4–5	25	8.6

the PICU in 50.5% of cases and a mortality rate of 15.5%.

The most common cardiac diagnoses were patent ductus arteriosus, ventricular septal defect, and total anomalous pulmonary venous connections. The frequency of each malformation is listed in Table 1. Because many patients had more than one malformation, there was a total frequency of 578 diagnoses. Children were categorized into one of four groups according to cardiac diagnosis: a) acyanotic with increased pulmonary blood flow, b) acyanotic with normal pulmonary blood flow, c) cyanotic with increased pulmonary blood flow or d) cyanotic with diminished pulmonary blood flow. These diagnoses were made a priori by the attending physician using X-ray, echocardiography and in some cases hemodynamic procedures (Table 1).[25]

Bivariate analysis

The prevalence of long stays at the PICU was 25.6% of the acyanotic with increased pulmonary blood flow (AIPF) patients, 38.9% of the acyanotic with normal pulmonary blood flow (ANPF), 59.2% for the cyanotic with increased pulmonary blood flow (CIPF) group, and 76.3% of the cyanotic with decreased pulmonary blood flow (CDPF) group (p = 0.000). Mortality was reported in 5.8% of the AIPF group, 22.2% in the ANPF group, 17.6% in the CIPF group, and 26.3% in the CDPF group (p = 0.002) (Table 2).

The prevalence of prematurity in our study was 15%, of which 44.7% had a long stay and 10.5% died. Of the full-term children, 51.4% had a long stay and 16.2% died (p = 0.445 and 0.367).

Nutritional status at birth was evaluated: 46.5% of patients with normal weight had a long stay, whereas 56.9% of low-weight patients had a long stay (p = 0.112). There was a mortality rate of 13.4% in the normal-weight children and one of 19.6% of those with low weight (p = 0.151). Regarding nutritional diagnosis before surgery, 47.6% of the normal BMI children, 53.2% of the

Table 2. Bivariate analysis

Variable	Long stay n/N (%)	p	Death n/N (%)	p
Nutritional status at birth				
Normal*	87/187 (46.5)		25/187 (13.4)	
Malnourished	58/102 (56.9)	0.112	20/102 (19.6)	0.151
Cardiologic Diagnosis				
Acyanotic with increased pulmonary blood flow*	22/86 (25.6)		5/86 (5.8)	
Acyanotic with normal pulmonary blood flow	7/18 (38.9)		4/18 (22.2)	
Cyanotic with increased pulmonary blood flow	87/147 (59.2)		26/147 (17.6)	
Cyanotic with diminished pulmonary blood flow	29/38 (76.3)	0.000	10/38 (26.3)	0.002
RACHS				
1*	22/85 (25.9)		4/85 (4.7)	
2	78/141 (55.3)		30/141 (21.3)	
3	45/63 (71.4)	0.000	11/63 (17.5)	0.018
Presurgical nutritional diagnosis				
Normal*	59/124 (47.6)		17/124 (13.7)	
Malnourished	84/152 (55.3)		27/154 (17.5)	
Overweight	6/13 (46.1)	0.345	1/13 (9.1)	0.372
Aortic clamp time				
< 120 min*	117/253 (46.2)		38/253 (15)	
> 121 min	28/36 (77.8)	0.000	7/36 (19.4)	0.534
Number of inotropic infusions				
1*	70/174 (40.2)		19/174 (10.9)	
2	45/81 (55.6)		15/81 (18.5)	
3 or more	30/34 (88.2)	0.000	11/34 (32.4)	0.004
Surgical bleeding				
Low (<5 mL/kg/h)*	57/150 (38)		16/150 (10.7)	
Moderate (6-8 mL/kg/h)	80/128 (62.5)		26/128 (20.3)	
High (>9 mL/kg/h)	8/11 (72.7)	0.000	3/11 (27.3)	0.053
Other adverse events				
0*	139/281 (49.5)		41/281 (14.5)	
1	6/8 (75)	0.16	4/8 (50)	0.006
Mechanical ventilation				
Short (<48 h)*			0/99 (0)	
Long (>49 h)			45/190 (23.7)	0.000
Infection				
No*	86/215 (40)		32/215 (14.9)	
Yes	59/74 (79.7)	0.000	13/74 (17.6)	0.645
Nutritional support				
Early enteral nutrition*	12/105 (11.4)		1/105 (1)	
Delayed enteral nutrition	34/68 (50)		2/68 (2.9)	
Early parenteral nutrition	20/29 (69)		2/29 (6.9)	
Delayed parenteral nutrition	44/46 (95.7)		10/46 (21.7)	
No nutritional support	10/16 (62.5)	0.000	5/16 (31.3)	0.000
No nutritional support (death before 72 h)	25/25 (100)		25/25 (100)	

Analysis: linear by linear trend
*Group used as comparison for risk evaluation.

malnourished children, and 36.4% of overweight children had long stays (p = 0.345). Mortality was reported in 13.7% of the normal BMI children, 17.5% of the malnourished children, and 9.1% of the overweight children (p = 0.372) (Table 2).

Long stay according to the nutritional support received was as follows: for early and delayed enteral nutritional support, early and delayed parenteral support and no nutritional support: 11.4, 50, 69, 95.7 and 62.5%, respectively (p = 0.000). Mortality was reported in 1, 2.9, 6.9, 21.7 and 31.3% of each group, respectively (p = 0.000) (Table 2).

Multivariate analysis

In the multivariate analysis, malnutrition at birth increased the risk for long stay (OR 2.772; 95%

CI 1.282–5.995; p <0.010), and malnutrition before surgery increased the risk for mortality (OR 3.447; 95% CI 1.006–11.812; p <0.049). They were adjusted for every variable involved in the outcome (Tables 3 and 4).

Nutritional therapy also showed an impact on both outcomes; delayed parenteral support increased the risk for a long stay in the PICU (OR 12.409; 95% CI 1.626–94.724, p = 0.015) and early enteral support had a protective effect on the same outcome (OR 0.11; 95% CI 0.026–0.472, p = 0.003) compared with patients without nutritional support (Tables 3 and 4). For mortality, early parenteral nutrition (OR 0.032, 95% CI 0.002–0.452, p = 0.011), delayed enteral support (OR 0.011; 95% CI 0.001–0.126, p = 0.000), and early enteral nutrition (OR 0.007; 95% CI

Table 3. Adjusted analysis of nutritional diagnosis *vs.* long stay and mortality at the PICU

Nutrition diagnosis

Outcome	At birth Malnutrition* n 102			Presurgical Malnutrition* n = 152			Overweight* n = 13		
	OR	95% CI	P	OR	95% CI	p	OR	95% CI	p
Long stay	2.772	1.282–5.995	0.010	0.716	0.327–1.566	0.402	0.490	0.089–2.692	0.412
Mortality	2.355	0.786–7.062	0.126	3.447	1.006–11.812	0.049	0.773	0.024–24.414	0.884

*Compared to children with normal weight and height.
Adjusted for baseline, pre- and intrasurgical variables (nutritional status at birth and before surgery, age, sex, socioeconomic status, prematurity, RACHS, presurgical transfusions, adverse events, bleeding, time of aortic clamp, and inotropics).

Table 4. Adjusted analysis of nutritional support *vs.* long stay and mortality at the PICU

Nutritional support

Outcome	Early enteral* n 105			Delayed enteral* n 68			Early parenteral* n 29			Delayed parenteral* n 46		
	OR	95% CI	p	OR	95% CI	p	OR	IC 95%	p	OR	IC 95%	p
Long Stay	0.110	0.026 –0.472	0.003	0.592	0.150 –2.334	0.454	0.919	0.184 –4.582	0.918	12.409	1.626 –94.724	0.015
Mortality	0.007	0.000–0.097	0.000	0.011	0.001–0.126	0.000	0.032	0.002–0.452	0.011	0.247	0.039–1.582	0.140

*Compared to children with no nutritional support.
Adjusted for baseline, pre-, intra-, and postsurgical variables (nutritional status at birth and before surgery, age, sex, socioeconomic status, prematurity, RACHS, presurgical transfusions, adverse events, bleeding, time of aortic clamp, and inotropics), infection and prolonged mechanical ventilation (only for mortality).

0.007–0.097, p = 0.000) were found to have a protective effect compared with those patients without any nutritional support, reaching statistical significance. They were also adjusted for every group of variables involved in the outcome (pre- and intrasurgical variables, nutritional status at birth and before surgery, age, sex, socioeconomic status, prematurity, RACHS, presurgical transfusions, adverse events, bleeding, time of aortic clamp, and inotropics) (Tables 3 and 4).

Discussion

This study shows a strong association between nutritional diagnosis and nutrition support for the surgically treated CHD pediatric patient with a long stay, as well as mortality at the PICU. Our results show the independent and statistical effects of malnutrition and nutritional support on both outcomes. Among the included variables, cardiologic diagnosis, RACHS, aortic clamp time, mechanical ventilation, and infection also appeared to be predictors for both outcomes (data not shown).

For a long stay at the PICU, early enteral nutrition acts as a protective factor. Malnutrition at birth and delayed parenteral support increased the risk for this outcome. Death was more prevalent among patients with malnutrition before surgery, and early enteral and parenteral nutrition had protective effects for that outcome. Sex of the patient and premature birth did not show any association with either outcome (data not shown).

Our study is different than those previously reported. Prognosis stratification was used for the logistic regression analysis. This method more precisely assesses the effect of malnutrition and nutrition support, considering every variable involved in the event, from birth to the medical treatment at the PICU.

For nutritional diagnosis before surgery, we chose the BMI Z score because, in our study, this proved to be a better predictive variable than weight, age, and height indexes developed by Waterloo and Gómez. This should be considered in new prognostic studies involving nutrition.[26-31]

It is important to consider that the effect of nutritional support on length of stay and mortality is closely related with the critical state of the patients. Parenteral support was the one of the best options for those patients with a dysfunctional gastrointestinal tract. This group and the group with no nutritional support included the sickest patients. To confirm this hypothesis, we performed a bivariate analysis in this group of patients showing that they had a RACHS score higher than the other groups, reflecting the worst prognosis (p = 0.000).

Our results agreed with those reported in the adult population where malnutrition was strongly associated with increased infection rates, late recovery, long mechanical ventilation support, and a long stay in the ICU.[32-35] Marin et al. reported that some of the predictors for a long stay in the PICU are age <12 months, previous admissions, emergency admissions, and chronic treatment requirements (parenteral nutrition and tracheotomy), among others.[33]

With reference to nutritional support, several studies have reported that early parenteral nutrition in trauma patients increases infection and aggravates clinical outcomes. We found a similar association with long stay and delayed parenteral nutrition.[34,36,37]

Some of our results are similar to those reported in a recent study in Turkey, which associated eight risk factors for mortality at the ICU: age, APACHE II score (OR 1.99; 95% CI 1.5–2.64), mechanical ventilation (OR 1.98; 95% CI 1.33–2.95), length of stay in the ICU (OR 0.41; 95% CI 0.27–0.61), enteral nutrition (OR 0.43; 95% CI 0.29–0.65), tracheotomy (OR 0.26; 95% CI 0.094–0.75), steroid use or chemotherapy (OR 1.61; 95% CI 1.13–2.29), nosocomial pneumonia, and sepsis (OR 0.59; 95% CI 0.38–0.92).[32]

Additionally, regarding previous results we found that time of fasting prior to nutritional sup-

port is important. An increased risk for mortality in the delayed parenteral support group but not in the early group—was found in our patients. However, in the adult population, some meta-analysis and systematic reviews that did not find such association have concluded that parenteral nutrition support has no effect on mortality, only on the infection rate.[38,39]

Early enteral nutrition (before 24 h of admission) decreases the infection rate. Intrapyloric enteral nutrition as an alternative for those patients at risk for bronchoaspiration secondary to mechanical ventilation has been reported as a positive maneuver.[40,41] On an experimental level, the advantages of enteral nutrition over parenteral nutrition are due to the use of substrates through the gastrointestinal route, which improves the local and systemic immune response and retains the barrier function of the bowel.[42,43]

Study limitations

The information was extracted from clinical charts; therefore, the measures and evaluations cannot be verified. However, clinical records show the usual clinical practice, and in certain way this reflects the effectiveness of the measure in real life. The clinical reasons for leaving a patient fasting or choosing parenteral support over enteral nutrition were not fully reported in the clinical charts. No clinical differences, however, were observed in patients with enteral or parenteral nutritional support.

The study also has several strengths including sample size, patient homogeneity, inclusion of almost any variable involved in the event chronologically, and the multivariate model that allowed us to discriminate between the effect of malnutrition and nutrition support on length of stay and mortality independent of the many variables affecting the outcome. Evidence-based information of the increased risk for a long stay or mortality due to malnutrition or nutrition therapy on these children may modify the clinician's treatment, improving the evolution and prognosis for these children.

As other publications, we were able to only report retrospective results. The need for prospective clinical trials is clear, but the difficulties of this design regarding these topics prevent the different groups in carrying out these studies.

We conclude that our findings emphasize the importance of early detection of malnutrition and the use of postsurgical early nutritional support, preferentially enteral nutrition. This may also impact treatment costs in these patients.

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