REVISTA CHILENA DE PEDIATRÍA

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Rev Chil Pediatr. 2018;89(1):24-31
DOI: 10.4067/S0370-41062018000100024

ORIGINAL ARTICLE

Nutritional recovery after cardiac surgery in children with congenital heart disease

Recuperación nutricional post cirugía cardiaca en niños con cardiopatía congénita

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Received: 16-03-2017; Accepted: 08-09-2017

Abstract

Introduction: Malnutrition is common in children with congenital heart disease (CHD). Medical treatment and surgical interventions contribute improving the nutritional status of these children. **Objective:** To describe nutritional recovery in children with CHD and associated factors after surgery. **Patients and Method:** Longitudinal study. 46 Children under 18 years old admitted for CHD surgery between April 2015 and April 2016 were recruited. The following CHD were included: Ventricular septal defect (VSD), Atrial septal defect (ASD), Hypoplastic left heart syndrome (HLHS), Tetralogy of Fallot (TOF), and Transposition of great arteries (dTGA). Children with genetic syndromes and other diseases that could compromise nutritional status were excluded. We obtained demographic, CHD, nasogastric tube use (NGT), nutritional evaluation, and weight and height data at the time of admission and one, three and six months after surgery and. Z-score to assess anthropometric measures were calculated according to WHO standards. **Results:** Median age was 8 months (IQR: 3,26), 24 (52%) male, 6 (13%) preterm and 12 (26,1%) small for gestational age (SGA). CHD diagnosis were: 9 (19,6%) VSD, 8 (17,4%) ASD, 12 (26,1%) HLHS, 9 (19,6%) TOF and 8 (17,4%) dTGA. The mean weight-for-heigth-BMI-for-age-z-score (W/H-BMI/AZ) was 0,6 ± 1,5 SD, (28.3% of undernutrition). The mean heigth-for-age-z-score (H/AZ) was -0,86 ± 1.3sd (21.7% of short stature). We found differences between each CHD and age, use of NGT and been under nutritional follow-up. There was an improvement between H/AZ at admission and 3rd month (p = 0,02), and W/H-BMI/AZ at 3th (p = 0,046) and 6th month (p = 0,001). Use of NGT decreased from admission to 6th month (19 *vs* 3) (p = 0,0016). We found correlation between admission W/H-BMI/AZ and nutritional recovery (r = -0,7; p < 0,001). **Conclusion:** There is a high prevalence of prematurity, SGA, undernutrition and short stature use of with weight recovery but not in heigth after cardio-surgery.

Keywords:
Congenital heart disease,
Nutritional status,
Malnutrition,
Congenital heart surgery

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Introduction

Congenital heart diseases (CHD) are the most common congenital malformation in pediatrics. In Chile and around the world, there is an estimated prevalence of 4 to 10 cases per 1,000 live births. A 35% of them requires surgery in their first year of life[1-4]. Malnutrition is a common problem in this group of patients, which represents between 15% to 50%[5-8]. There is a lack of literature regarding nutritional recovery after surgery. Longitudinal studies show that after surgical intervention, there is a significant weight recovery but not in height. This assessment has been performed by grouping together all children with CHD without distinguishing between the different types of heart defects[9,10]. This recovery starts early and mainly during the first three months after surgery, which would influence the hemodynamic correction, allowing a better dietary intake and nutrient utilization. Pre-surgical nutritional status, parents height, and age of cardiac surgery have been found to be factors associated with a better nutritional recovery[10]. However, after a year the growth charts show a stabilization, which suggests that other factors may play a role in the nutritional status[10-12].

In our country, we have not studied what happens from the nutritional point of view in those children who have CHD surgery. The objective of this study is to describe the nutritional recovery after cardiac surgery of some CHD and the possible associated factors.

Patients and Method

Longitudinal study of a concurrent cohort. Children admitted between April 2015 and April 2016 to the cardiac center of the hospital of the Pontifical Catholic University of Chile for CHD surgery were recruited. The following CHD were included: Ventricular septal defect (VSD), Atrial septal defect (ASD), Hypoplastic left heart syndrome (HLHS), Tetralogy of Fallot (TOF), Transposition of great arteries (dTGA). Confirmed or under study genetic syndromes, patients older than 18 years of age, and those with another disease which may compromise the nutritional status were excluded.

Upon admission to surgery, the following data were recorded through a structured questionnaire by consulting the parents and clinical records: demographic data, type of CHD according to the *International Paediatric and Congenital Cardiac Code* (IPCCC)[13]; surgical risk using the classification system RACHS-1 (*Risk Adjustment in Congenital Heart Surgery*)[14]; use of nasogastric tube (NGT) or another enteral feeding device; nutritional follow-up before surgery performed by a pediatrician or a pediatric nutritionist and medication in use. The weight and height assessment was performed by a nursing team at the time of admission. In the preterm patients, the age was corrected according to the Chilean norm[15]. At the moment of discharge, parents were given a sheet to record the data according to the subsequent controls of this study in order to facilitate the information delivery at the time of contact.

The follow-up was carried out during six months, via telephone, e-mail and/or text message by the principal investigator at one, three and six months after surgery. In every stage of the follow-up, the entire group recruited was called, independently of not have been contacted in the previous control. The following information was requested during follow-up: weight, height, use of NGT and nutritional control.

The nutritional diagnosis was performed with WHO standards, through Anthro 3.2.2 and Anthro plus v1.04 softwares[16,17]. H/AZ was used in all patients, W/HZ in children under 5 years of age and BMI/AZ in children over 5 years of age. Short stature was defined as H/AZ $\leq$ -2 SD, undernutrition if W/H-BMI/AZ $\leq$ -1SD, eutrophy if W/H-BMI/AZ was between -0.9 to 0.9SD and malnutrition by excess if W/H-BMI/AZ $\geq$ 1SD. Nutritional recovery was assessed as ΔW/H-BMI/AZ (W/H-BMI/AZ 6 months-W/H-BMI/AZ admission) and of height was ΔH/AZ (H/AZ 6 months-H/AZ admission).

An interval of days was considered for follow-up times as follows: day 1: day of surgery; month 1: between 20 and 40 days after surgery; month 3: between 75 and 105 days after surgery; and month 6: between 150 and 210 days after surgery.

Informed consent was obtained from the parents and children over 7 years of age had given their assent to participate this study.

For the statistical analysis STATA 12.0 software was used. For continuous variables, descriptive statistics and Shapiro Wilks test of normality test were performed. Chi-squared test was used to study the association between the different CHD and the categorical variables and Kruskal-Wallis to compare the age of different CHD. To assess the weight and height improvement in children between the admission and the postoperative follow-up (related samples), Student's T-Test or Wilcoxon signed-rank test, were used. The assessment of differences between ratios, a proportion test for two samples was performed. A value of $p < 0.05$ was considered statistically significant.

This study was approved by the Clinical Research Ethics Committee of Pontifical Catholic University of Chile in March 2015 (Project 15-017).

Results

A total of 46 children who were admitted for CHD surgery met the inclusion criteria. Table 1 shows the demographic and nutritional characteristics at the moment of admission.

Table 2 describes age, factors related to nutritional management, and nutritional diagnoses according to the studied CHD. There was a statistically significant difference between the different CHD, the time of surgery, use of NGT, and to be under nutritional follow-up. Patients with HLHS and dTGA had a higher rate of use of NGT. HLHS, VSD, and dTGA patients stand out for their higher frequency of nutritional follow-up. Instead, children with ASD did not require NGT or nutritional follow-up.

There was a higher number of children with short stature in VSD and increased nutritional compromise by deficit in children with VSD and HLHS, however, it was not statistically significant when analyzing all the CHD.

No correlations were observed between different CHD or nutritional diagnosis and other studied variables, such as gender, prematurity, SGA, H/AZ, short stature, W/H-BMIZ or nutritional diagnosis.

During the the study, only one patient died in the third month. At one month after surgery the information of 42 children was obtained, at three months, from 38 children and at six months from 34 children.

Regarding nutritional follow-up, 22 out of 46 children (47.8%) were in control after their surgery, similar to the proportion observed after six months of surgery (13 out of 34 children, 38.2%), with no significant difference ($p = 0.4$). In turn, there was a difference in the use of NGT; at the time of admission, 19 children (41%) use it and after six months, only 3 of them (9.1%, $p = 0.0016$). Figure 1 shows these results and by each CHD.

The analysis of CHD as a whole showed that there is a significant improvement between the H/AZ at surgery admission and the H/AZ three months after surgery, H/AZ -0.9 and H/AZ -0.4 respectively ($p = 0.02$), however, six months after, this difference turned out not to be significant. Assessing all study subjects, a recovery of W/H-BMI/AZ was found between admission and three months after surgery, with a W/H-BMI/AZ of -0.6 and -0.3, respectively ($p = 0.046$), which remained between admission and after six months (W/H-BMI/AZ at 6 months 0.09, $p = 0.001$, figure 2).

Table 1. Demographic and nutrition characteristics at admission

Characteristic	
Total patients, n	46
Male, n (%)	24 (52)
Age (months), median (IQR)	8 (3.26)
Prematures, n (%)	6 (13)
Metropolitan Region, n (%)	23 (50)
Complex RACHS-1 (Category ≥ 3), n (%)	19 (41)
Use of cardiologic drugs, n (%)	29 (63)
Birth weight (gr), mean (± SD)	3087 (696.7)
Birth height (cm), median (IQR)	49 (47.51)
SGA, n (%)	12 (26.1)
LFAZ, mean (± SD)	-0.86 (1.3)
Short stature, n (%)	10 (21.7)
WFL-BMIFAZ, mean (± SD)	-0.6 (1.5)
Undernutrition, n (%)	13 (28.3)
Overnutrition, n (%)	7 (15.2)
Eutrophy, n (%)	26 (56.5)

Table 2. Nutritional characteristics by CHD at admission

	VSD	ASD	HLHS	TOF	dTGA	p
n (%)	9 (19.6)	8 (17.4)	12 (26.1)	9 (19.6)	8 (17.4)	
Age (months), median (IQR)	4 (3.8)	58 (35.98)	7 (0.8)	8 (7.9)	6 (0.27)	0.002
Nutritional evaluation, n	5	0	11	2	4	0.001
NGT feeding, n	3	0	8	2	6	0.005
Short stature, n	4	0	3	1	2	0.2
Nutritional status						0.7
Undernutrition, n	4	1	5	2	1	
Eutrophy, n	4	5	6	6	5	
Overnutrition, n	1	2	1	1	2	

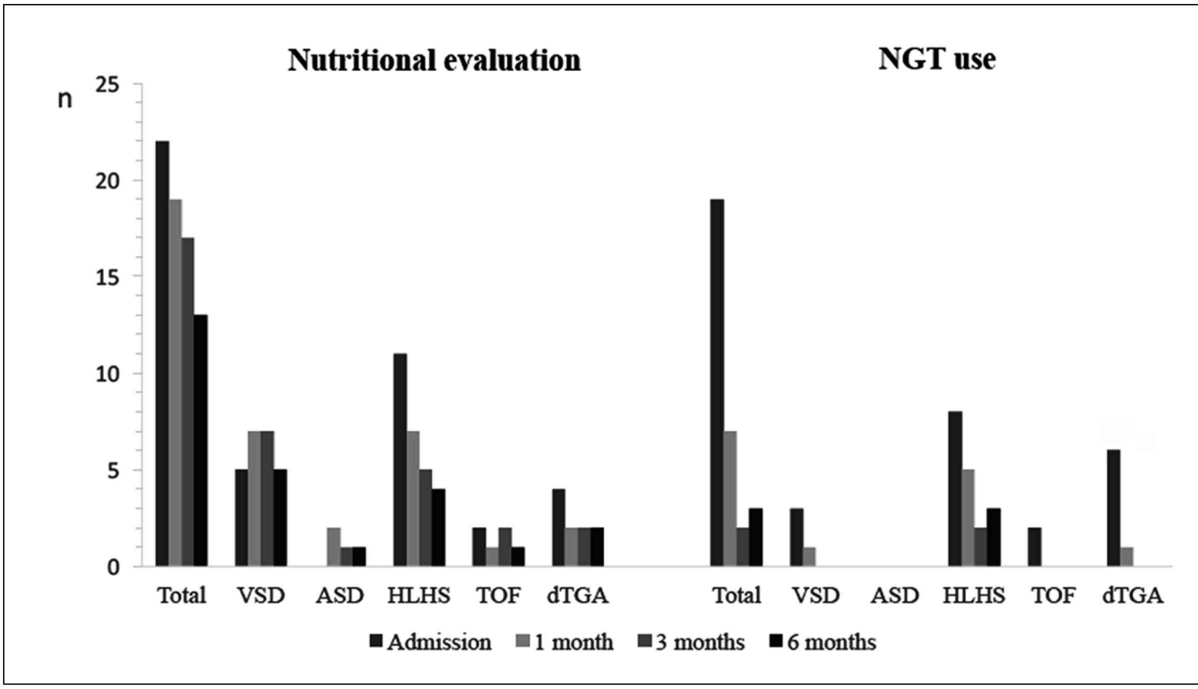
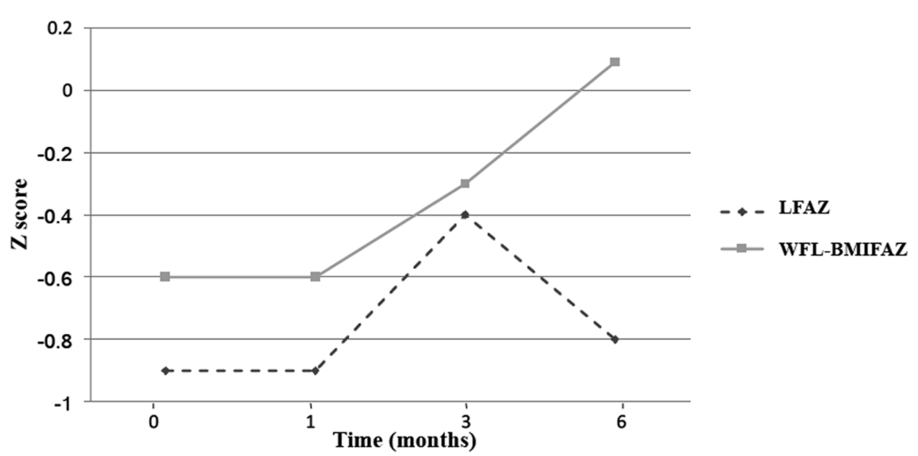


Figure 1. Nutritional clinical evaluation and NGT use by CHD at follow up.



Time	Admission	1 month	3 months	6 months
LFAZ	-0.9	-0.9	-0.4*	-0.8
WFL-BMIFAZ	-0.6	-0.6	-0.3*	0.09*
n	46	42	38	34

*P<0.05 between admission and time at follow up

Figure 2. Anthropometric follow up after cardiac surgery.

There was a correlation between nutritional status at admission and nutritional recovery. The lower the W/H-BMI/AZ at admission, the higher the weight recovery at the end of follow-up ($r = -0.7$; $p < 0.001$. figure 3).

When analyzing each CHD, the weight recovery remains only in VSD, both between admission and after three months (W/H-BMI/AZ -0.8 and -0.2 respectively, $p = 0.04$) and between admission and six months after surgery (W/H-BMI/AZ at six months 0.3, $p = 0.001$). There was no weight or height recovery in other CHD when analyzing each separately.

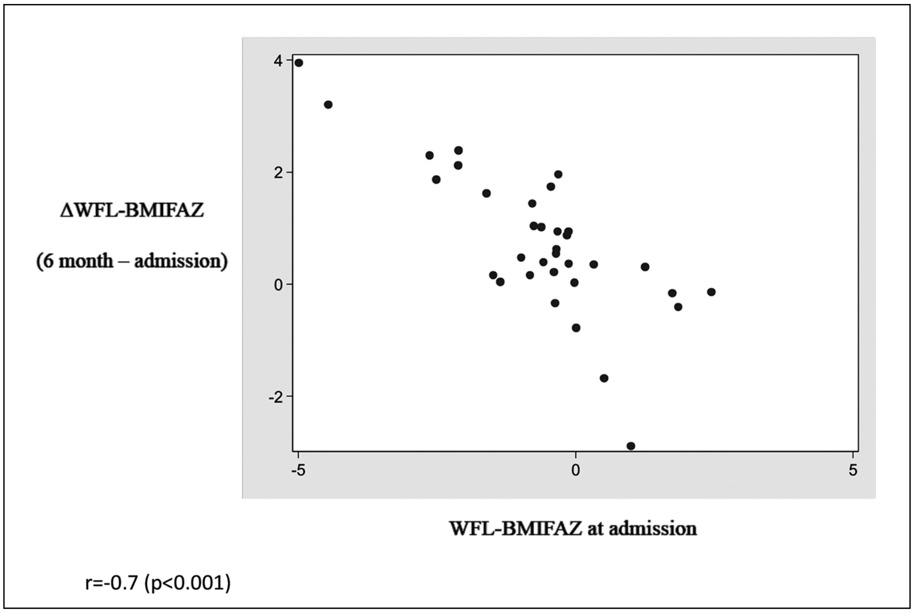


Figure 3. Correlation between WFL-BMIFAZ at admission and ΔWFL-BMIFAZ.

Discussion

In the studied children with CHD, we found a higher percentage of prematurity in relation to the total Chilean population, which is considered a 7.2%[18]. This finding coincides with a study carried out in France, in which 2,189 live births with CHD were assessed, finding a 12.5% of prematurity, and with another study conducted in England where 16% of children with CHD[19,20] were preterm.

The high percentage of short stature was striking, although similar to other children with CHD in Australia and United States[11,21], where they reported a 16% and 24% of short stature respectively.

Twenty six percent of the children had history of SGA, which is a higher percentage than in population without CHD. According to the definition given, in Latin America, a prevalence of SGA is estimated in 2.3% (if evaluated as < -2SD), to 10% (if < p10 is used), according to published data in 2011 by the Latin American Consensus for Children Born Small for Gestational Age[22].

Children showed a high rate of undernutrition, defined as ≤ -1SD of W/HZ or BMI/AZ depending on the age, in contrast with the prevalence in Chilean children under six years of age monitored in the public health system in the different regions of the country. According to data published by the Ministry of Health of Chile in 2013, there is a 2.7% of undernutrition, this value comprises the undernutrition risk and undernutrition[18]. While this finding was expected, because it is known that patients with CHD have a high level of undernutrition at the time of surgery[5,6,7,23,24], it is important to know the true extent of the problem in children with CHD in our area to make early nutritional interventions in order to prevent the potential consequences of increased morbidity and mortality due to a poor nutritional status[25-27].

Another important finding is the presence of overnutrition which, although is lower than current national prevalence of overnutrition[18], coincides with other studies in which there has been reported a prevalence of 17% of overweight and 18% of obesity during the follow-up of children with CHD surgery[9,28]. Moreover, in a study conducted in the United States, the prevalence of overnutrition in children admitted for Fontan procedure was 10.7%, increasing to 30% in the next five years of follow-up[29]. This further reinforces the importance of making an appropriate diagnosis and nutritional follow-up in these children in order to optimize the nutritional intake according to each child and each CHD in particular.

The different CHD included in this study had similar numbers of children, which allowed to analyze and compare their behavior from a nutritional point of view. Although no statistical significance was found in relation to nutritional diagnoses and the diagnosis of heart defect, the CHD with more nutritional compromise and short stature were VSD and HLHS. The type of CHD has a fundamental role, being higher the nutritional compromise in those heart diseases that present single ventricle physiology, cyanosis, hypertension and some left to right shunts[7,30,31]. These factors could explain the increased compromise observed in VSD and HLHS patients.

The nutritional support received by each child before their surgery was different according to each CHD. Those patients who were already in nutritional supervision maintained it during follow-up, but this was not the case with the use of NGT, where there was a decrease in its use over time. This finding of decreased use of NGT coincides with a retrospective study of children with CHD who were hospitalized for surgical correction. In this study, only 50% of children with undernutrition have adequate caloric intake, coinciding with inadequate nutritional support and low use of enteral feeding devices[7]. This reduced use of NGT over time may be related to the nutritional interventions carried out. Also could be explained by the reduction of nutritional support after surgical correction and the consequent improvement in hemodynamic status, better heart failure control, changes in energy expenditure, less dyspnea, and cyanosis, and better intake. This was particularly notable in children with VSD surgery, where one of the indications of surgery is the nutritional compromise, which significantly improves once their hemodynamic condition is normalized[32-34]. Regarding children with HLHS using NGT at the sixth month after surgery, it was maintained in a larger number of children compared to the other CHD, which has been reported in other studies[35,36]. This is explained by the fact that after the first stage in children with HLHS, the increased metabolic demand persists in the context of decreased or insufficient cardiac output. In addition, these patients frequently present other co-morbidities, such as gastroesophageal reflux, difficulties or tiredness when feeding orally and vocal cord paralysis that requires feeding by NGT until paralysis is corrected[37,38]. A recent consensus on nutritional management in these patients supports the early use of NGT until the second stage of surgery[39].

Given these findings, despite the clinical improvement and post-operative hemodynamics, we should be careful when suspending the use of enteral feeding devices and ensure beforehand that adequate dietary intake is being achieved.

In the follow-up period of six months, a weight recovery was found after evaluating the complete sample, reflected in the improvement of W/H-BMI/AZ comparing the beginning and the end of the study. There was no improvement in height between admission and 6 months after, which coincides with a study of Vaidyanathan B et al. of 476 children with CHD in the south of India[10]. Tamayo et al, also reported no height recovery, even seven years after surgical correction, during a follow-up of 725 children with CHD in Canada[9]. This might be due to a noxa during a crucial period of the growth, with a suboptimal caloric intake for the caloric demands[34].

An interesting finding was the significant improvement in H/A between admission and three months after surgery, a situation that we did not find in the literature and that was not associated with any of the factors studied. It could be influenced by the size of the sample and the remote parental reporting since nearly 50% of our sample was controlled in different regions of our country and in centers other than ours.

In the analysis of each CHD, weight recovery was only found in VSD, but not in the other CHD. We can infer that each CHD behaves differently in its postoperative nutritional recovery. However, it could be the sample size that does not allow to see this finding in the other CHD.

A previously undescribed finding is the inverse correlation between lower W/H-BMI/A at admission and a higher difference in weight change at the end of follow-up.

It was not possible to find any association between the nutritional diagnosis and the variables studied. A larger sample size or longer follow-up time may be needed.

The strengths of this study are its prospective nature and differentiated analysis of nutritional status according to the main cardiological diagnosis. This study was conducted in a cardiac center, comparable to international centers[40], which is reflected in the high percentage of children with complex RACHS-1 and a high percentage of drugs use. These characteristics allowed to form a sample of children with operable CHD that comparable with other international cardiac surgery centers.

Some limitations of this study are that most patients were not controlled in our center because we are a referral center, so we do not know some specific interventions from a nutritional point of view that may have existed. In that setting, anthropometry was performed by different evaluators and the reporting of anthropometric data was reported verbally.

Conclusions

There is a high percentage of malnutrition and short stature in children with CHD at the time of surgery. There is a higher compromise in VSD and HLHS patients. During the follow-up, there is a nutritional recovery in relation to weight gain, where the lower the W/H-BMI/AZ at admission, the higher the weight gain, but this does not occur in length recovery, which is consistent with other international studies. Timely nutritional support is essential in a critical growth period that could minimize this nutritional compromise. It is recommended in the multidisciplinary management to consider nutritional care by a team specialized in the pre- and post-operative management of children with operable CHD.

Ethical responsibilities

Human Beings and animals protection: Disclosure the authors state that the procedures were followed according to the Declaration of Helsinki and the World Medical Association regarding human experimentation developed for the medical community.

Data confidentiality: The authors state that they have followed the protocols of their Center and Local regulations on the publication of patient data.

Rights to privacy and informed consent: The authors have obtained the informed consent of the patients and/or subjects referred to in the article. This document is in the possession of the correspondence author.

Financial Disclosure

Authors state that no economic support has been associated with the present study.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

Aknowledgments

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