

Nutritional assessment in infants with congenital heart disease: comparison of two anthropometric classifications

Diagnóstico nutricional en lactantes menores con cardiopatía congénita: comparación de dos clasificaciones antropométricas

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Abstract

Introduction: Children with congenital heart disease (CHD) present a high percentage of undernutrition and the interpretation of their nutritional assessment is difficult. **Objective:** To describe the nutritional status of infants with CHD using two anthropometric classifications and compare them. **Patients and Method:** Non-concurrent cohort study. We studied children under 12 months undergoing cardiac surgery. We excluded preterm infants, small for gestational age, carriers of genetic syndrome or other disease with nutritional compromise. Demographic data, type of CHD, weight and height were recorded. Nutritional assessment was performed using WHO standards per health ministry criteria (HMC) and per an Integrated Anthropometric Classification (IAC), which defines undernutrition if height-for-age Z-score (ZT/E) ≤ -2 and/or weight-for-height (ZP/T) ≤ -2 , risk of undernutrition as ZP/T between -1 to -1.9 , normal as ZP/T between -0.9 to $+0.9$, overweight as ZP/T between $+1$ to $+1.9$ and obesity as ZP/T $\geq +2$. **Results:** 387 interventions were included, 219 (56.6%) were males, median age 3.1 months (IQR:0.4;6.4). A 26.4% presented short stature. Using HMC classification 55 subjects presented two diagnoses by overlap of ZP/E and ZP/T, although with IAC there was no overlap. Comparing HMC with IAC, a difference was found in undernutrition, 28.9% versus 38.5% ($p = 0.001$), risk of undernutrition 27.4% versus 16.3% ($p = 0.01$) and obesity 4.9% versus 3.3% ($p = 0.03$) respectively. Correlation was found between ZP/E and ZP/T, $r = 0.6$ ($p < 0.001$) and between ZP/E and ZT/E, $r = 0.6$ ($p < 0.001$). **Conclusions:** Children with CHD have a high percentage of undernutrition and short stature. Using the same anthropometric measurements IAC did not present overlapping diagnoses and detected more undernutrition. P/E is useful as screening, but insufficient in chronic undernutrition.

Keywords:

congenital heart disease, nutritional assessment, growth, short stature, undernutrition

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Introduction

The nutritional assessment in a child that presents chronic malnutrition by deficit is a challenge in pediatrics since there are no unified standards for its classification and interpretation^{1,2}.

The weight gain and linear growth of children with chronic malnutrition are involved. The anthropometric indicator weight-for-age (W/A) is useful in the diagnosis of malnutrition by deficit or undernutrition due to it being a sensitive indicator, especially in ages of fast growth, detecting changes in the weight velocity. This is one of the reasons why Chilean Ministry of Health (MINSAL) promotes its use in the nutritional assessment of children younger than one year^{3,4}. Furthermore, the height-for-age indicator (H/E) reflects the duration of malnutrition, being the most important indicator in the nutrition monitoring of children with chronic malnutrition (stunting)^{1,5}. Another important anthropometric indicator is the weight-for-height (W/H), which is independent of age and height compromise. It describes the current nutritional state both from excess and deficiency^{5,6}. In this context, an integrated anthropometric classification, made according to the concept published in 1972 by Waterlow et al, would be useful to evaluate more precisely the nutritional status of these patients⁵.

MINSAL's current recommendation for the nutritional evaluation of children younger than 1 year, is to use the weight-for-age indicator (W/A) for the malnutrition (undernutrition), malnutrition risk and appropriate weight diagnosis, the weight-for-height (W/H) for overweight (overweight and obesity), and the height-for-age (H/A) for the diagnosis of short stature (when the H/A is equal or lower than -2DS). It is important to point out that the H/A is not included in the diagnosis of deficiency or excess of weight (Table 1).

Congenital heart diseases (CHD) can cause malnutrition and can compromise the linear growth of children⁷⁻⁹. Studies of children with CHD use different indicators to report the nutritional status, being the W/E the most used one, above the W/A, W/H and H/A indicators^{6-8,10}. The importance of performing an Integrated Nutritional Evaluation, which includes the clinical history and a growth curve in the anthropometric evaluation, is emphasized in Chilean regulations. Afterward, the evaluation must be referred to a nutritional vigilance team for a more specialized attention. This evaluation does not detail a specific anthropometric classification or a classification that differentiates, for example, severe acute malnutrition from chronic malnutrition⁴.

The aim of this study is to describe the nutritional status of infants younger than one year with CHD, by

using two different nutritional classifications and to make a comparison between them.

Patients and Method

We designed a non-concurrent cohort study. We included patients with CHD younger than 12 months who had undergone cardiac surgery (reparative or palliative) with extracorporeal circulation in the Hospital Clínico de la Pontificia Universidad Católica de Chile between January 2009 and December 2013. This medical center is one of the national reference centers for the resolution of operable CHD on patients younger than 15 that is also included in the national program Explicit Health Guarantees (EHG), and patients referred from Private Health System with agreements with our institution.

Each of the cardiac surgical procedures performed during this period was analyzed. In patients who had undergone surgery more than once, the re-interventions due to complications or that had an interval lower than 30 days were excluded.

We excluded patients with prematurity history (lower than 37 weeks of gestation), been small-for-gestational-age and to have an associated genetic syndrome or another chronic disease that could affect the nutritional status.

Clinical and demographic data were registered: gender, age at the moment of surgery, CHD type, weight and height on the admission day. The value of the z-score, according to the WHO standards, for each anthropometric indicator was obtained by the Anthro v 3.2.2 program¹².

The nutritional assessment was made according to two classification types: in accordance with the current MINSAL regulations: MINSAL criteria (MC) (Table 1) and with an integrated anthropometric classification (IAC), made according to Waterlow et al concepts (Table 2), assigning each patient or case the diagnosis according to the indicator suggested for each classification.

Table 1. Nutritional diagnosis by Ministry of Health classification

Nutritional diagnosis	Z score
Undernutrition	W/A < -2
Undernutrition risk	W/A between -1,9 to -1
Appropriate weight	W/A between -0,9 to +0,9
Obesity risk	W/H between +1 to +1,9
Obesity	W/H > +2
Short stature	H/A < -2

Table 2. Nutritional diagnosis by Integrated Anthropometric Classification

Nutritional diagnosis	Z score W/H	Z score H/A
Chronic or secondary undernutrition: active or decompensated	≤ -1	≤ -2
Chronic or secondary undernutrition: compensated	$-0.9 \text{ a } +0.9$	
Chronic or secondary undernutrition: overcompensated	$\geq +1$	
Acute undernutrition	≤ -2	> -2
Undernutrition risk	$-1.9 \text{ a } -1$	
Appropriate weight	$-0.9 \text{ a } +0.9$	
Obesity risk	$+1 \text{ a } +1.9$	
Obesity	$\geq +2$	

Table 3. Principal diagnosis of congenital heart disease

Diagnosis of congenital heart disease.	n (%)
Ventricular septal defect	78 (20.2)
Hypoplastic left heart syndrome	74 (19.1)
Tetralogy of Fallot	48 (12.4)
Transposition of the great arteries	44 (11.4)
Others	38 (9.8)
Tricuspid atresia	20 (5.2)
Double-outlet right ventricle	18 (4.6)
Total anomalous pulmonary venous return	18 (4.6)
Aortic Coarctation	12 (3.1)
Pulmonary Atresia Septum Intact	11 (2.8)
Complete atrioventricular canal	10 (2.6)
Truncus arteriosus	7 (1.8)
Atrial septal defect	5 (1.4)
Valves abnormalities	4 (1)
Total	387 (100)

cation^{4,5}. In those cases where there was a diagnosis superposition according to the MC, in other words, that received simultaneously two nutritional diagnoses, the W/A indicator for the diagnosis assignation of malnutrition (undernutrition) or malnutrition risk was prioritized, without taking into account the obtained W/H. When this superposition happened in children with ZW/A between -0.9 and $+0.9$, but with ZW/H $> +1$, the W/H value was prioritized, remaining the diagnosis of obesity risk or obesity, accordingly¹³.

When analyzing the comparison between MC and IAC, were considered malnutrition or undernutrition in IAC both the acute malnutrition and chronic or secondary malnutrition, with its three classifications.

The statistical analysis was performed using the STATA v12.0 program. A descriptive statistic of the variables was made. For continuous variables, we use Shapiro Wilk test to assess distribution, determining that only W/H had a normal distribution. In the continuous variables, a Spearman correlation was used, and a McNemar test was performed to compare the nutritional diagnosis frequencies according to the different classifications for the same subject. We considered a p value < 0.05 as statistically significant.

This study was approved by the Research Ethics Committee of the School of Medicine, Pontificia Universidad Católica de Chile. Certificate of Approval no 14-032.

Results

During the study period, 1013 CHD surgeries were performed, 387 procedures (38.2%) complied with the inclusion criteria of this study.

From the 387 procedures, 49 children had more than one cardiac surgical intervention, each one being analyzed as the subject of study. The most common diagnosis in the patients that had undergone more than one surgical procedure was the Hypoplastic Left Heart Syndrome (HLHS) (46.6%).

219 patients were male (56.6%) with an average age of 3.1 months (RIC: 0.4;6.4).

Table 3 shows the diagnosis of studied children's CHD. The most common CHD were ventricular septal defect 78 (20.2%), Hypoplastic left heart syndrome (HLHS) 74 (19.1%) and Tetralogy of Fallot 48 (12.4%).

By analyzing each one of the anthropometric indicators, an average for the z-score for W/A (ZW/A) was found, -1.2 (RIC: -2.2 , -0.2) and z-score for W/H (ZW/H), -0.5 ± 1.6 . The z-score for H/A (ZH/A) had an average of -1.2 (RIC: -2.0 , -0.4), presenting short stature in 102 patients (26.4%).

Table 4. Nutritional diagnosis by Ministry of Health classification

	Initial nutritional diagnosis n	Superposition of nutritional diagnosis n	Anthropometric indicator o	Final nutritional diagnosis n (%)
Undernutrition	112			112 (28.9)
Undernutrition risk	106			106 (27.4)
Appropriate weight	161	29	ZP/T entre +1 a +1.9	118 (30.5)
		14	ZP/T $\geq +2$	
Obesity risk	42	4	ZP/E entre -1 a -1.9	32 (8.3)
		6	ZP/E ≤ -2	
Obesity	21	2	ZP/E entre -1 a -1.9	19 (4.9)
Total	442	55		387 (100)

When evaluating the presence of short stature according ZW/A, it was found that the 55.4% of the children with ZW/A ≤ -2 had short stature, 30.2% of the children with ZW/A between -1.9 and -1, and only 5% of the children had ZW/A between -0.9 and +0.9.

55 patient showed two nutritional diagnoses simultaneously, by using the MC's criteria. Regarding the final nutritional diagnosis according to the MC, the undernutrition diagnosis of children with ZW/A ≤ -2 was accepted, thus there was a diminish of 6 patients in the diagnosis of obesity risk, for the diagnosis of undernutrition risk (ZW/A between -1 and -1.9) there was a 4 patients diminish and 2 in obesity, for the diagnosis of appropriate weight, 29 patients that had obesity risk diagnosis were diminished and 14 patients that had obesity diagnosis (Table 4).

The details of the nutritional diagnosis according to the IAC are in table 5.

There was no diagnosis superposition by performing this classification.

The comparison between the nutritional diagnosis by using two classifications, MC and IAC, showed differences in the undernutrition diagnosis (28.9% vs 38.5%, $p = 0.001$), undernutrition risk (27.4% vs 16.3%, $p = 0.01$) and obesity (4.9% vs 3.3%, $p = 0.03$), respectively (Figure 1).

A positive correlation between ZW/A and ZW/H ($r = 0.6$ [$p < 0.001$]), and also between ZW/A and ZH/A ($r = 0.6$ [$p < 0.001$]).

Discussion

Our medical center had a progressive increase in the number of cardiac surgical procedures performed annually, associated with a significant reduction in the operatory mortality¹⁴. The undernutrition state is known factor of cardiac surgical mortality and morbi-

Table 5. Nutritional diagnosis by Integrated Anthropometric Classification

Integrated Anthropometric Classification	n	(%)
Chronic or secondary undernutrition: active or decompensated	36	(9.3)
Chronic or secondary undernutrition: compensated	48	(12.4)
Chronic or secondary undernutrition: overcompensated	18	(4.7)
Acute undernutrition	47	(12.1)
Undernutrition risk	63	(16.3)
Appropriate weight	130	(33.6)
Obesity risk	32	(8.3)
Obesity	13	(3.3)
Total	387	(100)

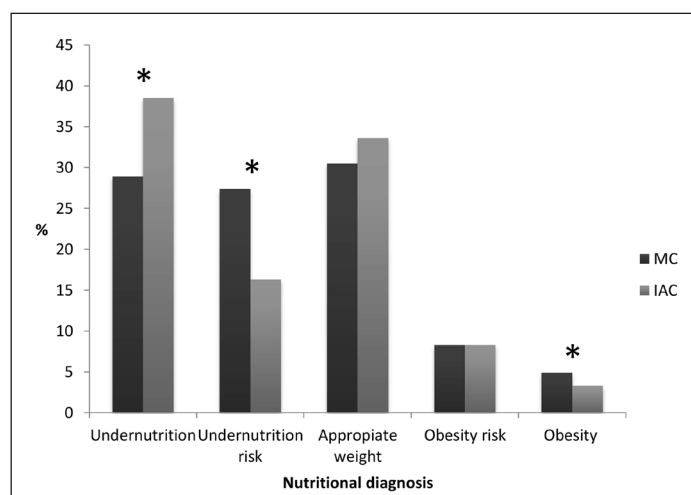


Figure 1. Comparison of Nutritional Diagnoses by Ministry of Health classification (MC) and Integrated Anthropometric Classification (IAC). * $p < 0.05$.

dity, thus performing an accurate nutritional diagnosis is essential to elaborate the adequate treatment and to reduce the incidences. The nutritional state of children that will undergo surgery on a national level has not been studied until now, and this article is the first one that will describe it.

Children with operable CHD can present under-nutrition due to many factors, such as: type or physiopathology of the CHD, cyanosis, pulmonary hypertension or cardiac insufficiency, the age at the moment of the surgery, being small-for-gestation-age or low-birth-weight, having a genetic syndrome or another non-cardiac severe disease, frequent hospitalizations and inadequate oral intake due to anorexia, dyspnea or diminished gastric volume due to hepatomegaly that causes early satiety^{6,10,15,16}. Many of these factors cannot be reversed, even with the adequate medical treatment, thus, it is difficult to achieve a similar growth in healthy children.

A quarter of the studied children had short stature; this number is very higher than the one registered in Chilean children that assist to the public health network (2%)¹⁷, but it is quite similar to international publications of children with CHD, where older children and children in different phases were also included^{6,8}. It is important to remember that there is a number of children that were considered in two opportunities, since there was an analysis for each intervention and not for each patient during the studied time, which can be increasing the number of children with short stature, considering that these children have a CHD with a recognized compromise of their nutritional status.

In relation to the other anthropometric indicators (ZW/A and ZW/H), no publications where only address children younger than one year were found, but it is possible to compare the nutritional evaluation performed by the MC in our patients with Chilean children that assist to the Chilean public health network. This comparison highlights a great difference in the diagnosis for malnutrition by malnourishment, where the national numbers are significantly lower to the ones found in children with CHD, between 0.3% and 1.4% vs 28.9% in this studied group, and for under-nutrition risk, between 2.6% and 4.7% vs 27.4% respectively. Being an inverse situation in the diagnosis for obesity risk, between 9.4% and 26.4% in children from general population vs 8.3% of children with CHD, and for obesity, between 2% and 9.1% vs 4.9%, respectively¹⁷.

The nutritional diagnosis superposition, by using MC, is one of the results of most importance in this investigation, situation that happened in patients who had a ZW/A corresponding to appropriate weight or deficiency, but that also had ZW/H which diagnosed

them with malnutrition due to excess, which also creates confusion at the moment of interpreting the nutritional diagnosis. This explains the high number of children with short stature in the sample, thus, at the moment of classifying only by W/A, there will children with excessive weight for their height, even though by having a W/A in malnutrition by malnourishment or appropriate weight. This conflict does not occur when the IAC's criteria are used since it uses the ZH/A and ZW/H to make a nutritional diagnosis.

This IAC is based on concepts already published related to the nutritional evaluation with a more critical perspective of children with malnutrition by chronic malnourishment, principally, due to them having a more severe chronic disease and that is currently informally used in specialized attention in pediatric nutrition⁵. There are more specific diagnoses in this classification, such as active chronic undernutrition, in other words, children with height compromise whose nutritional status is deficient for weight-for-height and chronically malnourished children over-compensated, in other words, their energy input is excessive in the management of nutritional recovery. This is why an accurate nutritional diagnosis can guide us in the energy requirements of each child, especially when there is evidence that both in malnutrition by malnourishment and excess grant higher morbidity^{16,18}.

The IAC does not specify children with CHD, thus, this classification is useful in different disease with height compromise.

A significant difference in the assignation of extreme diagnosis, found by comparing the nutritional diagnosis between both classifications, such as under-nutrition, undernutrition risk, and obesity. The IAC diagnosed more undernutrition, while the MC diagnosed more undernutrition risk and obesity. The higher number of undernutrition is explained, partially, by the inclusion of the chronic malnutrition diagnosis, defined as $ZH/A \leq -2$, in other words, short stature that is not included in the MC evaluation, which gives a more severe nutritional diagnosis since it is a reflection of chronic or secondary malnutrition that it has also been studied that in children with CHD it may not be fully recovered over time, despite specific medical treatments or a posterior cardiac surgical intervention^{7-9,19}.

Care should be taken when using the short stature, secondary and chronic undernutrition diagnosis, which can be solved by performing an integrated nutritional diagnosis and observing the H/A curves of each child with history of small-for-gestation-age, low-birth-weight, prematurity, height of the parents, ethnicity, number of previous hospitalizations, received nutrition support, which has been studied as low growth factors and malnutrition in children with CHD, but

that were not discussed in this investigation, which is also one of the limitations of this study^{6,7,10,15}.

The W/A is considered among the national guides for operable CHD as criteria in the decisions of some cardiac surgeries, and that has also demonstrated to be a good indicator of higher risk in post-surgical morbidities^{11,16}. As a nutritional indicator, the W/A is useful as a screening tool in malnutrition by malnourishment, and there was also a mild correlation of ZW/A with ZH/A and ZW/H, however, these results might be insufficient for the undernutrition diagnosis in children with chronic malnutrition by deficit. Only one diagnosis is being made for both classifications with the anthropometric measurements at the right moment, it is always important to meticulously evaluate the growth curves and the clinical history for signs of changes in the growth curves described in the MC⁴.

The main objective of this investigation is to compare both anthropometric classifications, this is reason why all cardiac surgical interventions, performed during the studied period, were included even if the same patients had two different interventions in its first year of life, which is probably in children with HLHS since they require a series of programmed interventions during their life, palliative surgeries in phases. Regarding this, the frequency of different nutritional diagnosis according to each cardiopathy was not analyzed, considering that 12.7% of the sample had undergone surgery two or more times.

This investigation's contributions are: making a description of the nutritional status of children with operable CHD, propose a classification of the nutritional status using the same anthropometric measurements that are performed habitually, but that can produce adequate and specific diagnosis, and less confusing at the moment of interpretation of the anthropometric indicators and that guide the nutritional support management.

Due to the high percentage of malnutrition by deficit in this group, an adequate nutritional support should be considered in the EHG in order to diminish

this acute and chronic malnutrition in children with CHD. To conclude, children with CHD in our center present a significant percentage of undernutrition and short stature before the surgery. The IAC uses the same anthropometric measurements but gives more information of the nutritional status without generating diagnosis superposition, which would create less confusion during the interpretation of anthropometric indicators that would allow a better nutritional management in each child.

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.

Rights to privacy and informed consent: The authors state that the information has been obtained anonymously from previous data, therefore, Research Ethics Committee, in its discretion, has exempted from obtaining an informed consent, which is recorded in the respective form

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.

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