Original article

Nutritional Status of Pediatric Patients with Congenital Heart Disease: Pre- and Post-Cardiac Surgery

Adel S.Elsayed, Kirollos N.Youssef, Ahmad A.Sobeih

Department of Pediatrics, Faculty of Medicine Benha University, Egypt.

Corresponding to: Kirollos N.Youssef, Department of Pediatrics, Faculty of Medicine Benha University, Egypt.

Email:
Kirolosnageh90@ Gmail.com

Abstract:

Background: Congenital Heart Disease (CHD) is often associated with malnutrition and failure to thrive. **Objectives:** To evaluate the nutritional status and growth pattern in CHD children after cardiac surgery. **Patients and methods:** The following CHD were included: ventricular septal defect (VSD), atrial septal defect (ASD), Hypoplastic left heart syndrome (HLHS), Tetralogy of Fallot (TOF) or Transposition of great arteries (dTGA). All patients have been subjected to history taking, examination, laboratory investigations, radiological findings and arterial oxygen saturation. **Results:** 47.1% were female. Also, 79.4% were acyanotic CHD and 20.6% were cyanotic CHD. There was statistically significant difference in patient with cyanotic in comparison to patient a cyanotic CHD as regards weight, length, BMI for age Z score. Our study has found that 7.4% of cases with acyanotic CHD and 42.8% of cases with cyanotic CHD had severe malnutrition and 1.9% of cases with acyanotic CHD and 35.7% of cases with cyanotic CHD had moderate malnutrition. Statistically, there was significant difference in nutritional status as regards acyanotic CHD and cyanotic CHD. In our study, 79.4% were with no clinical heart failure. About 13.2% of our cases with CHD had mild heart failure, 4.4% had moderate heart failure and 2.9% had severe heart failure. The most common CHD was Patent ductus arteriosus 32.4% and the less common 5.9% was Atrio-ventricular canal 5.9%. **Conclusion**: Malnutrition in children with CHD is a major problem as the prevalence of malnutrition among those children was high postoperative caloric data improved when compared to the preoperative caloric data. **Keywords**: Congenital heart disease, nutrition, children

Introduction

A congenital heart Disease (CHD) is a defect in the structure of the heart and great vessels which is present at birth. Many types of heart diseases exist, most of which either obstruct blood flow in the heart or vessels near it, or cause blood to flow through the heart in an abnormal pattern. Other diseases, such as long QT syndrome, affect the heart's rhythm. Heart diseases are among the most common birth defects and are the leading cause of

birth defect-related deaths. It is the commonest of all congenital lesions and is the most common type of heart diseases among children (1).

Children with congenital heart defects (HD) have an increase prevalence of malnutrition and growth failure malnutrition widely ranges from mild under nutrition to severe failure to thrive (FTT) (2).

A link was reported between CHD and malnutrition. It has been shown that heart injuries associated with cyanosis, congestive heart failure, and pulmonary hypertension lead to growth velocity, weight gain, and height development. Furthermore, children with CHD are commonly malnourished for multiple reasons that may include hypermetabolic state, inadequate caloric intake, malabsorption, genetic factors, or a consequence of fluid restriction as part of hemodynamic intervention (3).

The nutritional status of children with CHD was assessed and found a high prevalence of severe malnutrition in patients with congenital heart disease preoperatively, and they have a further loss in weight postoperatively. Malnutrition increase ventilation time, pediatric intensive care length of stay, and consequently the cost. PNI may be a useful index for nutritional assessment and potential prediction for PICU length of stay. Delayed postop enteral feeding may increase the risk of infection and mortality (4).

The aim of this study is to evaluate the nutritional status and growth pattern in CHD children after cardiac surgery.

Patients and Methods

This was a cross-sectional observational study of children with different symptomatic operated CHD presented to Cardiology Unit and Cardiothoracic Surgery Clinic in Elgalaa Military Hospital. The following CHD were included: ventricular septal defect (VSD), atrial septal defect (ASD), Hypoplastic left heart syndrome (HLHS), Tetralogy of Fallot (TOF) or Transposition of great arteries (dTGA).

Duration of study: from October 2021 to April 2022

Date of Research Ethics Committee: 2022

Inclusion criteria:

- The sex of this study including both males and females, age ranged from 3 months to 6 years at least 3 months postoperatively.

- Patients with different symptomatic operated CHD.

Exclusion criteria:

- Patients less than 3 months and patients more than 6 years.

- Patients with congenital anomalies other than cardiac anomalies.

- Patients with other chronic diseases affecting the growth or the nutritional status of the children.

- Complicated cases in PICU.

Methods:

History taking:

- Personal history: Name, age, sex, birth weight gestational age, birth order and family size.

- Social history: Parental education, occupation and income. According this information, we classified children into upper class, middle class and lower class.

- The time and type of operations.

- Detailed dietetic history was taken from the mother using two types of questionnaires.
- Full data about the echocardiography results postoperatively that compared to preoperatively.

Examination:

Weight, length/height, weight for height, head circumference and mid upper arm circumference (MAC).

Laboratory investigations:

They were done with particular attention to hemoglobin, serum proteins, and iron status and blood electrolytes (such as serum sodium, serum potassium, serum phosphorus, and serum calcium and serum magnesium).

Radiological findings:

Echocardiography for measurement of pulmonary artery pressure, CXR and pelvi-abdominal U/S.

Arterial oxygen saturation (%):

Using a digital pulse oximetry.

Statistical analysis:

Data were entered checked and analyzed using Epi-Info version 6 and SPP for Windows version 8. Data were summarized using the arithmetic mean, standard deviation, student t test and chi-squared test.

For all above mentioned statistical tests done, the threshold of significance is fixed at 5% level (p-value). The results were considered:

- Significant when the probability of error is less than 5% ($p < 0.05$).

- Non-significant when the probability of error is more than 5% ($p > 0.05$).

- Highly significant when the probability of error is less than 0.1% ($p < 0.001$).

The smaller the p-value obtained, the more significant are the results.

Results:

Figure (1) **shows** that 79.4% were acyanotic CHD and 20.6% were cyanotic CHD.

Table (1) shows that there was statistically significant difference in patient with cyanotic in comparison to patient a cyanotic CHD as regards weight, length, BMI for age ,(mid arm circumference and weight) Z score but there was no statistically significant difference in HC, (height for age and weight for height) Z score.

Table (2) shows that there was statistically significant difference in nutritional status and O2 saturation% as regards acyanotic CHD and Cyanotic CHD.

Figure (2) shows that 79.4% were with no clinical heart failure in the studied patients.

Table (1): Comparison between Acyanotic CHD and Cyanotic CHD as regards anthropometric measures

	Acyanotic CHD (No.= 54)		Cyanotic CHD (No.= 14)		Independent t test	
	Mean	SD	Mean	SD	t	P value
Weight	12.11	2.79	9.23	3.92	2.578	0.012
Head circumference	46.34	2.27	45.35	3.35	-1.041	0.302
Length	86.79	12.16	81.12	8.06	2.097	0.039
BMI for age	14.33	1.38	13.37	1.53	2.132	0.036
Z score						
Height for age Z-Score	-0.50	1.02	-0.33	0.95	0.576	0.567
Weight for age Z-Score	-1.04	0.50	-0.83	0.21	2.259	0.027
Weight for Height Z-Score	-0.86	1.23	-0.56	1.34	0.762	0.449
Mid arm circumference Z-Score	-1.07	0.16	-0.95	0.23	2.273	0.026

Table (2): Comparison between Acyanotic CHD and Cyanotic CHD as regards nutritional status and O2 saturation%

|		Acyanotic CHD (No.=54)		Cyanotic CHD (No.=14)		Chi square test	
		No.	%	No.	%	X^2	P value
Nutritional status	**Normal**	49	90.7 %	3	21.4 %	30.933	<0.001
	Moderate malnutrition	1	1.9 %	5	35.7 %		
	Severe malnutrition	4	7.4%	6	42.8 %		
O2 saturation %	**Mean ± SD**	92.89	3.60%	84.62	4.57%	7.230	<0.001

Table (3) shows that most common CHD was Patent ductus arteriosus 32.4% and the less common 5.9% was Atrio-ventricular canal 5.9%.

Figure (3) shows that mean age of operations time was 6.7 with range from 3 to 18 months and 89.7% were corrective operations.
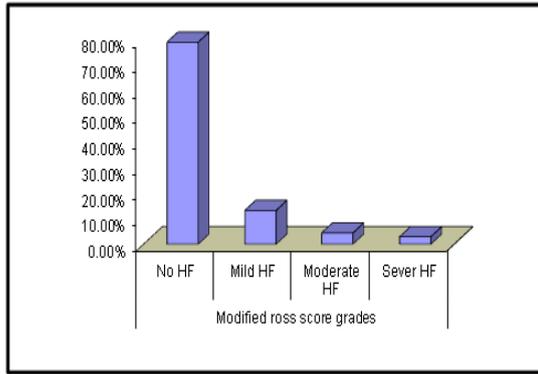
Figure (4) shows that 19.1% were Cardiac function improvement with corrective operations.

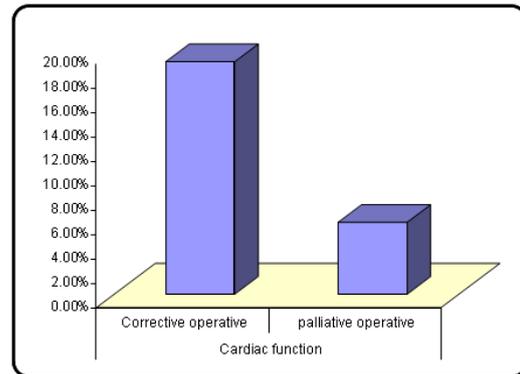Table (4) shows that mean of postoperative calori were 1096.4 with range from 451 to 1973 and mean of ideal were 1175.66 with range from 515 to 1715.
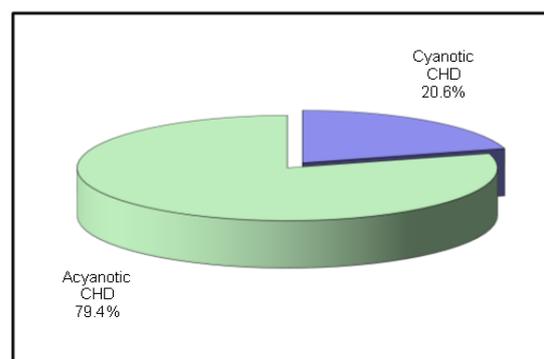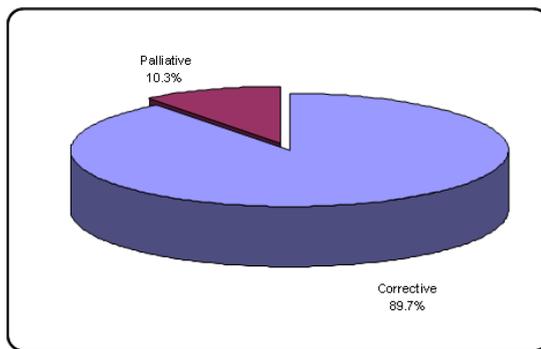

Figure (1): Acyanotic CHD: Cyanotic CHD

Figure (2): Modified Ross Score grades

Figure (4): Cardiac function improvement

Figure (3): Type of operations

Table (3): Preoperative Echocardiography of studied patients

	No.	%
Tetralogy of Fallot	12	17.6%
Atrio-ventricular canal	4	5.9%
Patent ductus arteriosus	22	32.4%
Ventricular septal defect	14	20.6%
Coarctation of aorta	8	11.8%
Pulmonary stenosis	8	11.8%
Pulmonary hypertension	18	26.5%
Cardiac function (Ejection Fraction)%		
✚ EF %	49	72.1%
✚ EF %	19	27.9%

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Table (4): Preoperative and Postoperative evaluation of nutritional status

	Min	Max	Mean	SD
Preoperative evaluation	402	1640	902.07	294.03
Postoperative evaluation	451	1973	1096.40	338.09
Ideal	515	1715	1175.66	324.48

Discussion

Congenital heart disease (CHD) is one of the major problems affecting the public health worldwide. Not only causing high morbidity and mortality in infants, but also affecting the quality of life in childhood and later in adulthood, the incidence of congenital malformation of heart and large vessels ranges from 3.7 to 17.5 per 1000 live births in the world (5).

Malnutrition is a common problem, which represents between 15% to 50%. In developing countries, because of resource limitations, corrective interventions for CHD are performed late, leading to a vicious cycle of congestive heart failure (CHF) and a high prevalence of preoperative malnutrition in patients with CHD(6).

There is a lack of literature regarding nutritional recovery before and after cardiac surgery. Longitudinal studies show that there is a significant weight recovery after surgical intervention 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 (7).

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, parent's height, and age of cardiac surgery have been found to be factors associated with a better nutritional recovery. However, after a year the growth charts show stabilization, which suggests that other factors may play a role in the nutritional status (8).

In Egypt, up to our knowledge, we have not studied what happens from the nutritional point of view in those children who have CHD surgery. Therefore, our study has been performed to evaluate the nutritional status and growth pattern in CHD children after cardiac surgery in Cardiology Unit and Cardiothoracic Surgery Clinic in Elgalaa Military Hospital. The following CHD were included: ventricular septal defect (VSD), atrial septal defect (ASD), Hypoplastic left heart syndrome (HLHS), Tetralogy of Fallot (TOF) or Transposition of great arteries (dTGA).

All patients have been subjected to history taking, examination, laboratory investigations (including haemoglobin, serum proteins, iron status and blood electrolytes), radiological findings (including echocardiography, CXR and pelvi-abdominal U/S) and arterial oxygen saturation (using a digital pulse oximetry).

In our study, 47.1% were females, mean of age was 2.33 months with range from 5 months to 5.8 years and 75% were the birth weight between 2.500 – 4 kg. [4]

Assessed the nutritional status of children with CHD. The mean (SD) age was 19 (28.3) months, with a median of 7 months (range 0-192).

In our study, mean of weight was 10.76 with range from 4.7 to 18.5 kg, mean of length was 84.29 with range from 59 to 112 and mean of BMI was 14.6 with range from 11.6 to 16.9. Mean of weight for age z score was -0.90 with range from -3 to 2, mean of mid arm circumference z score was -1.01 with range from -3 to 1. 51.5% of patients were average BMI and 13.2% were pathologic malnutrition.

In the done 2013 (9) it was found that malnutrition was in 40% of pediatric patients with CHD and cardiac surgery has a significant positive effect on weight gain and nutritional status.

Our study showed that 38.2% were teeth caries (the commonest sign in clinical presentation of studied patients). The percentage of short stature was 11.8%, similar to other children with CHD in Australia and United States, where (10) reported a 16% and 24% of short stature respectively.

Our study showed that 79.4% were acyanotic CHD and 20.6% were cyanotic CHD. In a study done previously it found similar results where they found acyanotic CHD in about 79% of cases and cyanotic CHD in about 21% of cases (11).

In our study, there was statistically significant difference in patient with cyanotic in comparison to patient a cyanotic CHD as regards weight, length, BMI for age (mid arm circumference and weight) Z score but there was no statistically significant difference in HC (height for age and weight for height) Z score.

Nutritional recovery was described in 46 children with CHD and associated factors after surgery (12). It was shown that there was 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, however, six months after, this difference turned out not to be significant. Assessing all study subjects, a recovery of W/HBMI/AZ was found between admission and three months after surgery, with a W/H-BMI/AZ of -0.6 and -0.3, respectively, which remained between admission and after six months (W/HBMI/AZ at 6 months 0.09).

In the former study (12), 39.7% commonest malnutrition was underweight WAZ $\leq$ -2, stunting was found in 8 patients (11.8%), while wasting was found in 12 patients (17.6%).

It was concluded that there is a strong correlation between acute and chronic malnourishment and worse clinical outcomes post-cardiac repair in children undergoing surgery for CHD, specifically the ICU length of stay and the ventilation time (13).

Our study has found that 7.4% of cases with acyanotic CHD and 42.8% of cases with cyanotic CHD had severe malnutrition and 1.9% of cases with acyanotic CHD and 35.7% of cases with cyanotic CHD had moderate malnutrition. Statistically, there was significant difference in nutritional status as regards acyanotic CHD and cyanotic CHD.

Some researchers showed in their study a statistically significant difference between the different CHD, the time of surgery, use of NGT, and to be under

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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 were 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 (12).

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) (12).

In our study, 79.4% were with no clinical heart failure in the studied patients. About 13.2% of our cases with CHD had mild heart failure, 4.4% had moderate heart failure and 2.9% had severe heart failure. The prevalence of HF in other study was higher about 82.2%, may be due to older age of patients group than in our study (14).

In our study, mean value of hemoglobin was 11.16 with range from 8.2 to 14, mean of total proteins was 6.11 with range from 4.02 to 7.95 and mean of serum albumin was 3.96 with range from 2.04 to 5.2 (15). It was found that total serum protein and serum albumin were significantly lower in patient with CHD than controls. But, in a similar study, the serum albumin and protein were similar in cases and controls (14). Other

researchers found that the mean (SD) serum albumin was 39.3 (6.16) mg/dl, with (range 23-63) (4).

In our study, the most common CHD was Patent ductus arteriosus 32.4% and the less common 5.9% was atrio-ventricular canal 5.9%. It was proved that VSD was the most common cardiac lesion (11).

In our study, mean age of operations time was 6.7 with range from 3 to 18 months and 89.7% were corrective operations. Mean of postoperative Calori were 1096.4 with range from 451 to 1973 and mean of ideal were 1175.66 with range from 515 to 1715.

The patients with nutritional intake of < 50 RDA pre-admission (69%) were the cases who had more malnutrition with a *P* value of 0.0001. Patients with severe malnutrition 32.4% were kept NPO longer than the no severe malnutrition patients. Children with CHD were significantly malnourished preoperatively and had further weight loss postoperatively. Preoperative nutritional status and delayed postoperative enteral feeding were associated with a higher infection rate and mortality (4).

Conclusion

- We concluded from this study that malnutrition in children with congenital heart disease is a major problem as the prevalence of malnutrition among those children was high.

- There is a high percentage of malnutrition in children with CHD preoperatively, and they have a further loss in weight postoperatively. There is a high compromise in VSD patients.

- Malnutrition increases ventilation time, pediatric intensive care length of stay, and consequently the cost.

- Adequate preoperative assessment of the nutritional status for pediatric cases with congenital heart diseases, and putting plans to improve it, may help to improve the postoperative outcome.

- Cardiac function improved more in corrective operation rather than the palliative procedures.

- Postoperative caloric data improved when compared to the preoperative caloric data.

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