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Research Article

Nutritional Assessment of Children with Congenital Heart Disease – A Comparative Study in Relation to Type, Operative Intervention and Complications

Nevin Mamdouh Habeeb[1], Marwa Moustapha Al-Fahham[2]*, Afaf Abdel Fattah Tawfik[3] and Maha Mawad Abd Ellatif Mohammed[4]

[1]*Professor of Pediatrics, Pediatric Cardiology, Faculty of Medicine, Ain Shams University, Cairo, Egypt*

[2]*Lecturer of Pediatrics, Pediatric cardiology, Faculty of Medicine, Ain Shams University, Cairo, Egypt*

[3]*Professor of Child Health and Head of Field Studies and Surveys Department at the National Nutrition Institute, Cairo, Egypt*

[4]*General practitioner, Ministry of Health, Egypt*

***Corresponding Author:** Marwa Moustapha Al-Fahham, Lecturer of Pediatrics, Pediatric cardiology, Faculty of medicine, Ain Shams University, Cairo, Egypt.

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Abstract

Objectives: Children with congenital heart disease (CHD) often experience growth delay. This study was designed to evaluate the nutritional status of CHD patients in the pediatric cardiology clinic, Children's Hospital, Ain Shams University.

Methods: This cross sectional study included 152 patients with CHD. The population was classified according to the type of CHD, presence or absence of complications and operative intervention. Detailed dietetic history was taken; collected data was analyzed into macro- and micro-nutrients and referred to as a percentage from the recommended daily allowance (RDA). Anthropometric measurements were interpreted using Z scores.

Results: Malnutrition, stunting and wasting were detected in 65.8%, 66.4% and 62.5% of patients respectively. Their prevalence rates were significantly higher among cyanotics (62.8%, 74.4% and 25.6%) when compared to acyanotics (49.5%, 63.3% and 18.3%) respectively ($p < 0.05$), among complicated acyanotics (54.1%, 76.47% and 21.2%) when compared to uncomplicated acyanotics (33.3%, 62.5% and 8.3%) respectively ($p < 0.05$), and among complicated cyanotics (74%, 92.6% and 70.4%) when compared to uncomplicated cyanotics (50%, 62.5% and 18.8%) respectively ($p < 0.05$). Prevalence of malnutrition and stunting was significantly higher among non-operated (56.2% and 77.4%) when compared to operated (41.9% and 63.6%) respectively ($p < 0.05$).

Decreased daily dietary intake of macro- and micro -nutrients was observed in the studied population. The dietary intake of calories was unsafe in (53.9%) of patients. The mean value of daily caloric intake was significantly lower among cyanotics (404.6 ± 96.06 Kcal) and complicated cyanotics (127.2 ± 38.6 Kcal) when compared to acyanotics (442.3 ± 106.8 Kcal) and uncomplicated cyanotics (326.9 ± 47 Kcal) respectively ($p < 0.05$).

Conclusion: Cyanotic, complicated and non-operated patients with CHD are more vulnerable to nutritional complications. Structured feeding program including micronutrient supplementation as well as parental education strategy should be established for those children.

Keywords: *Recommended Daily Allowance; Congenital Heart Disease; Z Scores; Micro-Nutrient; Macro-Nutrient; Nutrition*

Introduction

Growth delay in children with CHD is a common complication [1]. Failure to thrive can be mild or severe that ends in permanent physical or developmental deterioration [2]. Malnutrition in those children results in frequent hospitalization, poor surgical outcomes and increased death [3], thus CHD is considered a real challenge because of the complex interplay between medical, surgical, dietetic and socio-economic factors [4]. Success in managing those children is no longer solely dependent on the post-surgical survival alone; as nowadays operative interventions have a higher success rate, hence the focus of management has turned to minimizing malnutrition, approaching age-appropriate growth parameters and improving quality of life for patient and family [5].

Objectives

This study was designed to evaluate the nutritional status of CHD patients in the pediatric cardiology clinic, Children's Hospital, Ain Shams University.

Patients and Methods

This is a Cross-sectional observational study that included 152 patients (77 boys and 75 girls). Based on the presence or absence of cyanosis, complications and surgical intervention, the study population was categorized into groups and subgroups. Patients below 3 month and above 5 years of age and those with congenital anomalies that could have interfered with feeding were excluded. The study protocol was conducted according to principles of the Declaration of Helsinki as well as approved by the ethics committee of the Pediatric department, Ain Shams University and an informed consent was obtained from the caregivers before enrollment in the study. All patients were subjected to full history taking stressing on symptoms of cardiac disease, feeding difficulties, weight gain and anti-failure treatment given. Detailed dietetic history was taken from the caregiver using two types of Questionnaires (24 hour dietary recall and food frequency questionnaire). In the 24 hour dietary recall, the caregiver was asked about the approximate amount of every food and beverage taken in the previous 24 hours (before breakfast, at breakfast, before dinner, at dinner, before lunch, at lunch and at bed-time). In the food frequency questionnaire, the caregiver was asked to indicate the frequency of consumption of specific quantities of food items commonly used in Egypt and to assess their usual portion size based on household measures. The frequency of food consumption was assessed by a multiple response grid in which the respondents were asked to estimate how often a particular food or beverage was consumed. Categories used ranged from 'never' or 'less than 6 a week' to '4 per month'. The collected data was analyzed into macronutrients (calories, carbohydrates, proteins and fat) and micronutrients (vitamins and minerals) and was referred to as a percentage from the recommended daily allowance (RDA) using the Egyptian food composition tables according to the National Nutrition Institute protocol, 2nd edition, May 2006, Cairo, Egypt. Dietary intake was considered unsafe (< 50% RDA), unacceptable (50 - 70% RDA), acceptable (75 - 100% RDA), adequate (100 - 120% RDA) and overconsumption (> 120% RDA).

Clinical examination was done for signs of heart failure, pulmonary hypertension and anthropometric measurements. Interpretation of measures was done using the Z score [6]. Malnutrition was considered when weight for age (WAZ) score ≤ 2, stunting when height for age (HAZ) score ≤ 2 and wasting when weight for height(WHZ) score ≤ 2 [7].

Statistical analysis of the results was performed via the standard computer programs (SPSS 15.0.1 for windows; SPSS Inc, Chicago, IL, 2001). Student t-test was used for parametric quantitative data. Chi-Square test was used to detect the relationship between two qualitative variables; Fisher's exact test was used to detect the relationship between two qualitative variables when the expected count was less than 5 in more than 20% of cells. The numerical data was represented in mean ± SD for parametric data and median (IQR) for non-parametric data. Non-numerical data was represented in terms of frequency and percentage. The differences were considered significant if the probability (p) values were less than 0.05.

Results

The study included 152 patients with CHD, 77 (50.6%) were males and 75 (49.3%) were females. Their ages ranged from 3 month to 5 years with a mean of (22.2 ± 17.8) month. Their weights ranged from 2.3 kg to 18 kg with a median and IQR of 8.5 (5.5 - 11.5 kg) and a

mean and SD of (8.4 ± 3.5 kg). Based on the type of CHD, patients were assigned to either an acyanotic or cyanotic group. They were 109 acyanotics (71.7%) and 43 cyanotics (28.3%). Of the total population, 31 (20.4%) were operated and 121 (79.6%) were not, 112 (73.7%) were complicated and 40 (26.3%) were not. Of the acyanotic group, 85 (78%) were complicated and 15 (13.8%) were operated, while of the cyanotic group; 27 (62.8%) were complicated and 16 (37.2%) were operated.

The table 1 shows the distribution of daily dietary intake of calories, macro- and micro-nutrients in relation to the RDA where the dietary intake of calories, carbohydrates, proteins and fat was unsafe in (53.9%, 42.1%, 63.8% and 22.4% respectively) of the studied population. Comparisons between the studied groups and subgroups as regards to the mean values of the daily intake of macro- and micro-nutrients are shown in tables 2-5.

	< 50% unsafe	50 - 75% unacceptable	75 - 100% acceptable	100 – 120% adequate	> 120% Over-consumption
Calories (Kcal)	82 (53.9%)	70 (46.1%)	-	-	-
Carbohydrates (gm)	64 (42.1%)	44 (28.9%)	43 (28.3%)	1 (0.7%)	-
Proteins (gm)	97 (63.8%)	10 (6.6%)	13 (8.6%)	7 (4.6%)	25 (16.4%)
Fats (gm)	34 (22.4%)	18 (11.8%)	100 (65.8%)	-	-
Iron (mg)	61 (40.1%)	11 (7.2%)	73 (48%)	3 (2%)	4 (2.6%)
Magnesium (mg)	32 (21%)	21 (13.8%)	15 (9.8%)	32 (21.1%)	52 (34.2%)
Sodium (mg)	45 (29.6%)	39 (25.7%)	34 (22.3%)	21 (13.8%)	13 (8.6%)
Potassium (mg)	107 (70.4%)	40 (26.3%)	5 (3.3%)	-	-
Selenium (mcg)	130 (85.5%)	22 (14.5%)	-	-	-
Zinc (mg)	16 (10.5%)	31 (20.4%)	12 (7.9%)	14 (9.2%)	79 (52%)
Vitamin B1 (mg)	32 (21%)	109 (71.7%)	8 (5.3%)	2 (1.3%)	1 (0.6%)
Vitamin B2 (mg)	51 (33.6%)	84 (55.2%)	9 (5.9%)	4 (2.6%)	4 (2.6%)
Vitamin C (mg)	43 (28.3%)	76 (50%)	2 (1.3%)	3 (2%)	28 (18.4%)
Vitamin A (IU)	50 (32.9%)	2 (1.3%)	4 (2.6%)	96 (63.1%)	-

Table 1: *Distribution of daily dietary intake of calories, macro- and micro-nutrients in relation to the RDA.*

	Acyanotic (n=109)	Cyanotic (n=43)	Student t	P value
Calories (Kcal)	442.3 ± 106.8	404.6 ± 96.06	1.995	0.04 *
Carbohydrate (gm)	55.0 ± 24.1	49.5 ± 22.10	0.818	0.414
Protein (gm)	16.6 ± 13.2	14.8 ± 11.90	1.966	0.05*
Fat (gm)	18.0 ± 6.7	15.52 ± 8.10	0.682	0.496
Calcium (mg)	249.96 ± 162.36	254.38 ± 164.13	- 0.148	0.882
Iron (mg)	2.83 ± 2.23	3.69 ± 2.10	- 2.112	0.036*
Zinc (mg)	3.21 ± 1.75	3.03 ± 1.69	0.561	0.576
Magnesium (mg)	36.29 ± 22.23	33.01 ± 21.36	0.939	0.34
Sodium (mg)	258.22 ± 195.05	319.05 ± 287.74	-1.486	0.139
Potassium (mg)	447.00 ± 208.78	494.41 ± 280.15	-1.126	0.262
Selenium (mcg)	6.363 ± 4.14	5.51 ± 5.21	1.777	0.048*
Vitamin B1 (mg)	0.192 ± 0.16	0.224 ± 0.168	-1.073	0.285
Vitamin B2 (mg)	0.33 ± 0.8	0.33 ± 0.21	0.496	0.621
Vitamin C (mg)	21.72 ± 13.01	18.67 ± 16.21	1.199	0.05*
Vitamin A (IU)	372.27 ± 215.76	308.98 ± 216.7	1.601	0.111

Table 2: *Comparison between cyanotics and acyanotics as regards to the mean values of daily dietary intake of calories, macro- and micro-nutrients.*

** P < 0.05 is Significant*

	Operated (n = 31)	Non-operated (n = 121)	Student t	P value
Calories (Kcal)	479.62 ± 121.17	449.12 ± 168.22	0.906	0.36
Carbohydrate (mg)	68.87 ± 31.15	64.90 ± 32.31	0.892	0.55
Protein (mg)	18.64 ± 12.36	18.62 ± 11.04	0.008	0.99
Fat (mg)	14.39 ± 9.04	12.75 ± 9.52	0.830	0.40
Calcium (mg)	275.86 ± 143.54	245.54 ± 166.3	-0.892	0.37
Iron (mg)	2.73 ± 1.9	3.14 ± 2.31	0.863	0.38
Zinc (mg)	3.37 ± 1.44	3.11 ± 1.79	-1.882	0.03*
Magnesium (mg)	39.8 ± 19.58	34.39 ± 22.438	2.373	0.005**
Sodium (mg)	268.71 ± 192.87	276.1 ± 231.95	0.157	0.87
Potassium (mg)	508.13 ± 254.47	448.88 ± 224.15	-1.231	0.22
Selenium (mcg)	6.66 ± 4.24	6.01 ± 4.51	0.699	0.48
Vitamin B1 (mg)	0.232 ± 0.15	0.19 ± 0.16	-1.113	0.26
Vitamin B2 (mg)	0.339 ± 0.20	0.38 ± 0.76	0.344	0.73
Vitamin A (IU)	418.25 ± 175.31	340.7 ± 223.7	-1.999	0.05
Vitamin C (mg)	24.09 ± 14.97	20.16 ± 13.68	-1.346	0.18

Table 3: *Comparison between operated and non-operated as regards to the mean values of daily dietary intake of calories, macro- and micro-nutrients.*

** P < 0.05 is Significant, **p < 0.01 is highly significant*

	Complicated acyanotics (n = 85)	Un-complicated acyanotics (n = 24)	Student t test (t)	P value
Calories (Kcal)	322.56 ± 97.5	326.94 ± 119.4	0.186	0.853
Carbohydrate (mg)	47.02 ± 18.9	47.07 ± 23.94	0.011	0.992
Protein (mg)	12.76 ± 7.86	15.05 ± 8.58	-2.222	0.028*
Fat (mg)	7.94 ± 5.92	13.54 ± 9.66	3.046	0.003**
Calcium (mg)	158.66 ± 92.49	121.30 ± 89.23	1.127	0.261
Iron (mg)	2.4 ± 1.69	2.14 ± 1.58	-0.780	0.437
Zinc (mg)	2.0 ± 1.0	2.3 ± 1.27	1.224	0.223
Magnesium (mg)	22.57 ± 16.36	26 ± 15.55	1.091	0.277
Sodium (mg)	233.5 ± 175.5	187.8 ± 156.6	-2.133	0.035*
Potassium (mg)	327.4 ± 140	330.2 ± 171.2	0.084	0.933
Selenium (mcg)	3.355 ± 2.68	4.65 ± 3.26	2.880	0.004**
Vitamin B1(mg)	0.13 ± 0.12	0.15 ± 0.1	-2.841	0.005**
Vitamin B2 (mg)	0.21 ± 0.15	0.27 ± 0.54	0.676	0.500
Viamin C (mg)	11.15 ± 9.8	15.9 ± 9.8	2.618	0.010*
Vitamin A (IU)	204.2 ± 163	267 ± 151.9	2.320	0.047*

Table 4*: Comparison between the complicated and uncomplicated acyanotics as regards to the mean values of daily intake of calories, macro- and micro-nutrients.*

** P < 0.05 is Significant, **p < 0.01 is highly significant*

	Complicated cyanotics (n = 27)	Uncomplicated cyanotics (n = 16)	Student t test (t)	P value
Calories (kcal)	127.2 ± 38.6	326.9 ± 47	1.850	0.04*
Carbohydrate (mg)	14.5 ± 7.46	18.57 ± 9.44	1.876	0.050*
Protein (mg)	5 ± 3.1	6.2 ± 3.2	-2.266	0.023*
Fat (mg)	3.1 ± 2.3	3.8 ± 2.7	3.046	0.002**
Calcium (mg)	62.59 ± 36.5	73.17 ± 47.85	0.599	0.510
Iron (mg)	0.94 ± 0.66	0.84 ± 0.6	0.681	0.437
Zinc (mg)	0.79 ± 0.42	0.9 ± 0.49	0.226	0.083
Magnesium (mg)	8.9 ± 6.45	10.27 ± 6.14	0.935	0.259
Sodium (mg)	92.16 ± 69.32	74.17 ± 61.8	0.972	0.357
Potassium (mg)	129.2 ± 55.18	130.3 ± 67.6	0.176	0.995
Selenium (mcg)	1.32 ± 1	1.83 ± 1.28	0.972	0.386
Vitamin B1 (mg)	0.04 ± 0.3	0.05 ± 0.04	-1.768	0.035*
Vitamin B2 (mg)	0.08 ± 0.05	0.11 ± 0.2	0.558	0.605
Vitamin C (mg)	4.4 ± 3.88	6.28 ± 3.87	0.980	0.310
Vitamin A (IU)	80.59 ± 64.34	105.4 ± 59.96	2.618	0.010*

Table 5: *Comparison between complicated and uncomplicated cyanotics as regards to the mean values of daily intake of calories, macro- and micro-nutrients.*

**P < 0.05 is Significant, **p < 0.01 is highly significant*

Malnutrition, stunting and wasting were detected in (100, 65.8%), (101, 66.4%) and (95, 62.5%) respectively of the studied population. Table 6 shows the Comparison between the studied groups as regards to anthropometric measurements based on Z-scores.

		Acyanotic (n = 109)	Cyanotic (n = 43)	Test	P value
HAZ	<-2SD	69 (63.3%)	32 (74.4%)	** 1.92	0.0464
	-2SD to 2SD	39 (35.8%)	11 (25.6%)		
	> 2SD	1 (0.9%)	_ _		
WAZ	<-2SD	54 (49.5%)	27 (62.8%)	** 2.17	0.04
	-2SD to 2SD	55 (50.5%)	16 (37.2%)		
	> 2SD	_ _	_ _		
WHZ	<-2SD	20 (18.3%)	11 (25.6%)	** 1.16	0.05
	-2SD to 2SD	86 (78.9%)	31 (72.1%)		
	> 2SD	3 (2.8%)	1 (2.3%)		
		Operated (n = 31)	**Non-operated (n = 121)**		
HAZ	<-2SD	24 (63.6%)	77 (77.4%)	*** 2.33	0.049
	-2SD to 2SD	7 (22.6%)	43 (35.5%)		
	> 2SD	-	1 (0.8%)		
WAZ	<-2SD	13 (41.9%)	68 (56.2%)	***2.017	0.05
	-2SD to 2SD	18 (58.1%)	53 (43.8%)		
	> 2SD	-	-		
WHZ	<-2SD	6 (19.4%)	25 (20.7%)	***0.044	1.0
	-2SD to 2SD	24 (77.4%)	93 (76.9%)		
	> 2SD	1 (3.2%)	3 (2.5%)		
		Complicated acyanotics (n = 85)	**Uncomplicated acyanotics (n = 24)**		
HAZ	<-2SD	65 (76.47%)	15 (62.5%)	**0.498	0.05
	-2SD to 2SD	20 (23.5%)	9 (37.5%)		
	> 2SD	-	-		
WAZ	<-2SD	46 (54.1%)	8 (33.3%)	***3.23	0.05
	2SD to 2SD	39 (45.9%)	16 (66.7%)		
	> 2SD	-	-		
WHZ	<-2SD	18 (21.2%)	2 (8.3%)	**2.47	0.028
	2SD to 2SD	64 (75.3%)	22 (91.7%)		
	> 2SD	3 (3.5%)	-		
		Complicated cyanotics (n = 27)	**Uncomplicated cyanotics (n = 16)**		
HAZ	<-2SD	25 (92.6%)	10 (62.5%)	**0.498	0.05
	2SD to 2SD	2 (7.4%)	6 (37.5%)		
	> 2SD	-	-		
WAZ	<-2SD	20 (74 %)	8 (50%)	*** 3.23	0.05
	2SD to 2SD	7 (25.9%)	8 (50%)		
	> 2SD	-	-		
WHZ	<-2SD	19 (70.4%)	3 (18.8%)	**2.47	0.028
	2SD to 2SD	8 (29.6%)	12 (75%)		
	> 2SD	-	1 (6.3%)		

Table 6: *Comparison between the studied groups as regards to anthropometric measurements based on Z-scores.*

***Fisher's Exact; ***Chi-Square Test*

P > 0.05 is not significant, P< 0.05 is Significant, p < 0.01 is highly significant

HAZ: Height for age Z-score; WAZ: Weight for age Z-score; WHZ: Weight for height Z-score

Discussion

The WHO recommends the use of standard definitions and classifications for malnutrition (under nutrition) based on the calculated Z scores for anthropometric indices [8]. The WHO global database on child growth and malnutrition (under nutrition) recommends a cut-off Z score of ≤ −2 to classify low WAZ (underweight), low HAZ (stunting) and low WHZ (wasting). The overall prevalence of malnutrition (diagnosed as WAZ score ≤ 2) was present in 65.8% of patients. This goes with Vaidyanathan., *et al*. [9] who used the Z score in defining malnutrition and reported a prevalence of malnutrition of 66% in a population of 460 Indians with CHD. Also, Hassan., *et al*. [10] reported a prevalence of 84% in 100 symptomatic CHD patients compared to 20% for the control group. On the other hand, Okoromah., *et al*. [5] found that 90.4% of 73 patients with CHDs had malnutrition. This may be because they studied only hospitalized patients who had more severe illnesses and consequently were at higher risk for malnutrition. In an early study, Mehrizi and Drash [11] reported a lower overall malnutrition prevalence of 27% of Turkish children with CHD who were below the 3rd percentile for both weight and height but they used a different method to define malnutrition.

Stunting (HAZ score ≤ 2) was found in 66.4% of patients. This matches with the usual distribution of growth deficiency in the general pediatric population in Egypt and agrees with Hassan., *et al*. [10] who reported stunting in 61.9% of patients and also in agreement with El-Zanaty and Way [12]. Okoromah., *et al*. [5] reported stunting in 28.8% while, Ratanachu and Pongdara [13] reported stunting in 16% of 161 Thailand children with CHD.

Wasting (WHZ score ≤ 2) was present in 62.5% of patients. Ratanachu and Pongdara [13] and Okoromah., *et al*. [5] reported wasting in 22% and 41.1% of patients respectively. This shows that CHD- related nutritional problems are particularly more common in the developing countries.

The prevalence rates of malnutrition, wasting and stunting were significantly higher among cyanotics when compared to acyanotics. This can be explained by the chronic hypoxemia which causes poor growth. This is in agreement with Varan., *et al*. [14] who found higher prevalence of malnutrition, wasting and stunting among cyanotics. Hassan., *et al*. [10] found that stunting was proportionately higher among the cyanotic subgroup while wasting was predominant among them. On the other hand, Okoromah., *et al*. [5] reported that wasting was associated with acyanotics while stunting was linked to cyanotics. Also, Swan., *et al*. [15] studied the prevalence of malnutrition (expressed as percentiles as well as in Z scores) among 32 children with TGA and found that 22 (96%) of the patients were below the 3rd percentile for weight (the mean Z scores ≤ -2) and 21 (91%) were below the 3rd percentile for height and head circumference. Halliolgu., *et al*. [16] reported that cyanotic lesions usually result in reduced height and weight as children with cyanotic lesions are considered to have chronic malnutrition based on their height and the degree of growth impairment was found to be closely associated with the severity of the hemodynamic impairment.

There are wide variations in the patterns of malnutrition in acyanotic and cyanotic CHD in the reported studies [5]. This could be related to the heterogeneous nature of the methodologies used to assess the nutritional status in CHD that limited accurate comparison of their results. Studies varied in their designs, sizes, and eligibility criteria as well as in the clinical characteristics of the enrolled patients (symptomatic and asymptomatic), classification of malnutrition, and the reference growth standards used for interpretation of the anthropometric indicators. Also, regional variations in the prevalence and distribution of undernutrition contributed to the differences [17].

In the present study, there was a statistically significant higher prevalence of malnutrition and stunting among the non-operated when compared to the operated. This can be explained by the prolonged exposure to the hemodynamic derangements due to delay in the corrective interventions among those patients. This agrees with Cheung., *et al*. [18] who used the z score to compare the anthropometric data of 45 children with tetralogy of Fallot pre- and post-operatively and found a highly significant improvement in the somatic growth of the operated patients. Also, Ratanachu and Pongdara [13] detected a significant decrease in the prevalence of underweight and wasting postoperatively. Furthermore, in patients with ASD, Rhee., *et al*. [19] detected improvement of weight and height by + 0.5 SD after surgical repair.

Complicated patients showed statistically significant higher prevalence of malnutrition, wasting and stunting when compared to the uncomplicated. This is mostly due to the relative increased nutrient requirements caused by increased metabolism, tissue hypoxia, peripheral acidosis, cardiac insufficiency and intestinal malabsorption in complicated patients. This is in agreement with Okoromah., *et al.* [5] who detected a statistically significant higher prevalence of malnutrition, wasting and stunting in complicated patients and Ross., *et al*. [20] who found a highly statistically significant higher prevalence of malnutrition among patients complicated with congestive heart failure when compared to the uncomplicated patients. Moreover, Varan., *et al*. [14] found that patient with pulmonary hypertension were more prone to malnutrition than those without pulmonary hypertension and found that patients with cyanotic lesions with increased pulmonary flow are possibly the most malnourished because both their weight and height have been affected since the first months of life. Moreover, those without pulmonary hypertension were of normal weight for their length or were mildly malnourished.

This study revealed that cyanotics had statistically significant lower mean values of caloric intake when compared to the acyanotics. Similarly Linde., *et al.* [26], Litch., *et al.* [27] and Varan., *et al.* [14] found that cyanotic infants had a lower daily caloric intake when compared to the age-matched cyanotics. This can be attributed to the hazardous effect of hypoxia, cyanosis, pulmonary hypertension and heart failure on the caloric intake and growth of those children. Moreover, the delay in surgical repair of CHD can lead to worsening of nutrition and the growth status [5].

Decrease intake of several micronutrients was reported in this study. Benzercy., *et al*. [28] reported that iron, zinc, thiamin, folic acid, calcium, magnesium, phosphorus and vitamin A, C and E were below RDA in infants with complex CHD. Also, Vieira., *et al*. [29] found that the intake of' sodium, potassium, iron and vitamin A was below the RDA for age among CHD infants. Hansson., *et al*. [23] found that the intake of potassium, phosphorous, zinc, selenium and vitamin D was lower compared to the RDA in both CHD and controls whereas, magnesium and iron intake was lower than recommended in CHD infants. Unfortunately these studies -as well as ours-had suggested insufficient intake but did not confirm using biomarkers to indicate deficiencies.

Conclusion

Deficient intake of macro- and micro- nutrients is observed in patients with CHD. Complicated, cyanotic and non-operated groups are more prone to nutritional complications.

Recommendations

- Early detection of malnutrition in patients with CHD and early corrective interventions should be done.
- Further research into the mechanisms of growth failure in CHD from a biochemical level is needed to guide the possible management options.
- Micronutrient deficiencies in CHD should be studied thoroughly so that this population of children can be given comprehensive nutrition supplementation.
- Family counseling is important to know the magnitude and aspects of malnutrition.
- A systematic approach must be used to identify specific reasons for failure to thrive, to develop a strategy for a structured feeding program, and to educate parents as to the best ways to feed their children.
- There must be a concerted effort between parents, physicians, nurses and other healthcare professionals to develop a plan that will be appropriate on an individual basis.

Ethics

All Authors of this study deny any conflicts of interests. They deny any financial or personal relationship that might be a potential cause of conflicts. No funding was received. Informed consent was obtained from all caregivers of the participant children and the study protocol was approved by the ethics committee of the Pediatric department, Ain Shams University. The authors warrant that the article is

original, does not infringe upon any copyright or other proprietary right of any third party, is not under consideration by another journal, has not been previously published and will not be published elsewhere except the abstract form. The authors confirm that they have reviewed and approved the final version of the manuscript.

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