Alqalam Journal of Medical and Applied Sciences. 2025;8(1):198-206
https://doi.org/10.54361/ajmas.258131

Original article

Nutritional Screening and Assessment of Children with Congenital Heart Diseases: A Cross-Sectional Study in a Tertiary Level Hospital in Libya

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Abstract
Congenital heart disease (CHD) is prevalent in Libyan children who are referred to a cardiac clinic tertiary center. These patients may experience mild malnutrition, which can progress to failure to thrive (FTT). Therefore, the aim of this paper is to determine the frequency of malnutrition and evaluate the nutritional status of children with congenital heart disease. The study adopted a descriptive cross-sectional design. It involved pediatric patients aged from 2 months to 18 years presented to the pediatric department at Ibn Sina Teaching Hospital with CHD. Data were collected over the period between April 2024 and September 2024. Subsequently, data was analyzed using the Statistical a Package for Social Science (Rstudio) version 2.3.2. Results showed that, 53.3% were males and 46.7% were females. The participants' age ranged between (2.8-180) months with mean ± SD (29.5 ± 38.1) months. A total of 130 participants were found to have low weight-for-age or a low Body Mass Index (BMI). The prevalence of malnutrition among the participants was 32.8% additionally, 24.7% of the participants were wasted, and 38.6% were stunted. Conversely, 14.1% of children were classified as overweight, and obesity was observed in 5.1% of the participants. Malnutrition is remains highly prevalent among children with CHD. However, the management of nutritional status can be improved by providing patients with early nutritional counseling and conducting periodic nutritional status assessments.
Keywords: CHD, Malnutrition, Underweight, Stunting, Wasting.

Introduction

Congenital heart disease (CHD) is primary etiology of congenital abnormalities. In 2019, approximately Around 3.12 million infants were born with CHD, resulting in 217,000 deaths attributed to this condition. Among these mortalities, 150,000 were in children under the age of one year [1,2]. CHD is prevalent in Libyan children who are referred to the cardiac clinic tertiary center [3]. The majority of infants with CHD have normal birth weights for their gestational age, however, around 60% of these infant's experience FTT and under nutrition before the age of six months [4-6]. Cardiac-related malnutrition is a prevalent issue among children in underdeveloped countries with symptomatic CHD, affecting a substantial proportion ranging from 50 to 90% [7].

In their first year of life, 30% of patients with CHD require cardiac surgery, cardiac catheterization, or experience hospitalization due to heart failure [8]. These patients may experience mild malnutrition, which can progress to FTT [9]. Both cyanotic and cyanotic congenital cardiac disorders were present [10]. Despite advancements in children's cardiac care, early prenatal and postnatal diagnosis, and early correctional therapies for heart defects, malnutrition continues to be a persistent issue in industrialized countries [11]. Children's heart surgery is frequently postponed in developing countries due to a lack of funding, resources, and personnel. Complications arise during the prolonged duration of waiting for surgery [8]. The severity of CHD can have a detrimental impact on the growth of children, even in high-income countries, which causes a significant number of this population to be undernourished [12,13]. During the newborn period, growth retardation becomes more evident, and nutritional difficulties may arise at delivery or shortly after birth [14]. The etiology of growth failure in CHD is multifaceted and involves hereditary factors, persistent cyanosis, pulmonary hypertension (PH), and heart failure. It also involves improper feeding, which leads to inadequate nutrient intake [15–18]. Studies have demonstrated that teenagers with CHD have a tendency to develop excessive weight and obesity [19]. Infants with CHD have a similar risk of stunting as the general population [20,21].

CHD morbidity is primarily correlated with stunted growth, developmental delays, and malnutrition in children. The final prognosis of children with CHD commonly depends on the correlation with the primary deformity additionally; it depends on the degree of catch-up development achieved and the nutritional status of the patient prior to and following surgery [22]. Following cardiac surgery, newborns and young children who experience a decrease in height for age (HAZ) and weight for age (WAZ), potentially indicating malnutrition, are associated with increased fatality rates and other negative outcomes. In addition, negative outcomes are linked to higher weight for height (WHZ), which is indicative of obesity [23]. Early detection and treatment of FTT in CHD during routine pediatric practice may improve their prognosis; therefore, individuals with severe CHD have a greater likelihood of improving their quality of life, development, and

Received*: 03-12-2024 -* ***Accepted****: 26-01-2025 -* ***Published****: 02-02-2025*

survival with dietary optimization [24]. There is a paucity of data on the malnutrition pattern of congenital heart diseases in Libyan children. Therefore, the present study aimed to evaluate the malnutrition status in children with congenital heart disease. The initial stage involved assessing the patients' growth impairment and malnourishment to determine their prevalence and severity.

Methods

Study design

A descriptive cross-sectional study. The study was carried out at the indoor and outdoor Department of Pediatrics of Ibn Sina Teaching Hospital, Sirte, Libya, from April 2024 to September 2024.

Sample size

A purposive sampling was done and the sample size was calculated using the epi- info CDC calculator [25]. Since there are no previous studies regarding this topic in Libya, the prevalence was considered to be 50 % at 95% confidence. The required sample size was determined to be 383 patients.

Inclusion and exclusion criteria

The inclusion criteria for the participants were as follows: Age between 2 months and 18 years, a diagnosis of congenital heart disease confirmed by an echocardiogram, and patients or legal guardians provided written informed consent. The exclusion criteria were as follows: Children who underwent cardiac surgery or acquired heart diseases, children with other chronic diseases or genetic disorders, and premature births or low birth weight babies.

Data collection

Prior to data collection, approval was obtained from the Pediatric Department. In order to protect the privacy of the patients, the survey was completely anonymous. Data was retrieved from patients' medical records, as well as interviews with patients and family members. Types of cardiac lesions were determined via transthoracic echocardiography. Infants were weighed using a calibrated electric scale (weight < 20 kg using Fazzini (precision 0.001 kg) and > 20 kg using RAZ-160 column scale (precision 0.1 kg) naked and without diaper or wearing minimal clothing (light underwear and without socks or shoes). For children under the age of two, height was measured using a standard measuring tape. For children over the age of two, a stadiometer was used, namely the RAZ-160 column scale (precision 0.1 cm), with the child barefoot. Their weights were recorded to the nearest 0.1 kg, and the length or height was recorded to the nearest 0.1 cm. The measurements were performed twice, and the average was taken as the final value.
Anthropometric measures were recorded, and anthropometric data were compared with reference values for (HFA), (WFH), and body mass index (BMI) defined by the World Health Organization (WHO). Malnutrition was defined according to the WHO guidelines as if < -2 SD of WFA or BMI for ages under five years and from five to 18 years, respectively. With regards to severity, underweight was defined as; WFA <-2 to -3 SD; and severe malnutrition if HFA < -3 SD. stunting as HAZ <-2, and wasting as WHZ <-2 low. Z scores for weight for age (WAZ), weight for height (WHZ), and height for age (HAZ) were calculated using the z-scores for anthropometric indices were calculated using the software WHO Anthro and WHO AnthroPlus, for the age group 0-5 and 5-19 years, respectively [26,27].

Ethical approval

Ethical approval for this study was obtained from the ethics Committee at the Sirte university in Libya (Reference number: 02.2024). All patients or their legal guardians provided informed consent.

Statistical Analysis

Data were collected, coded, revised, and entered into the Statistical Package for Social Science (Rstudio) version 2.3.2. The data were presented as numbers and percentages for the qualitative data, mean, standard deviations, and ranges for the quantitative data with parametric distribution. For the quantitative data with non-parametric distribution, the median with inter-quartile range (IQR). The Shapiro test was used to verify the normality of distribution. The chi-square test was used in the comparison between two groups with qualitative data, and the Fisher exact test was used when the expected count in any cell <5. An independent t-test was used to compare two groups with quantitative data and parametric distribution. The Wilcoxon Mann-Whitney test was used to compare the two groups with quantitative data and non-parametric distribution. The confidence interval was set to 95%, and the margin of error accepted was set to 5%. Hence, the p-value was considered significant as P < 0.05.

Results

This study was carried out on 396 participants; 53.3% were males and 46.7% were females. Their age ranged between (2.8-180) months with mean ± SD (29.5 ± 38.1) months. Out of the total participants, 79.8% (316) were under the age of 5, 18.2% (72) were categorized as children, and 2% (8) fell into the adolescent age

***Received**: 03-12-2024 - **Accepted**: 26-01-2025 - **Published**: 02-02-2025*

range. Their weight ranged between (3.5 – 51) Kg with mean ± SD (11.9 ± 10) Kg. Their height ranged between (50-158) cm with mean ± SD (80.1 ± 26.8) cm. Their BMI ranged between (10.3 -23.1) Kg/m2 with mean ± SD (16.1 ± 2.3) Kg/m2. The prevalence of severe malnutrition, defined as weight-for-age Z score (WAZ) less than -3, was observed in 34 participants (8.6%), while 91.4% (362 participants) did not exhibit severe malnutrition (Table 1 & Figure 1).

Table 1. Distribution of all studied cases according to Demographic and Clinical characteristics.

General characteristics	All patients (n=396)	Frequency and Percent
Gender	Male	211 (53.3%)
	Female	185 (46.7%)
Age in months	Min. - Max.	2.8 – 180.0
	Mean ± SD	29.5 ± 38.1
	Median (IQR)	10.0 (6.0 – 42.0)
Weight in Kg	Min.-Max.	3.5 – 51.0
	Mean ± SD	11.9 ± 10.0
	Median (IQR)	8.1 (5.5- 14.0)
Length \height in cm	Min.-Max.	50.0 – 158.0
	Mean ± SD	80.1 ± 26.8
	Median (IQR)	70.0 (60.0-95.75)
BMI (Kg/m2)	Min.-Max.	10.3 – 23.1
	Mean ± SD	16.1 ± 2.3
	Median (IQR)	15.6 (14.6-17.5)
Severe malnutrition (WAZ < 3)	Yes	34 (8.6%)
	No	362 (91.4%)

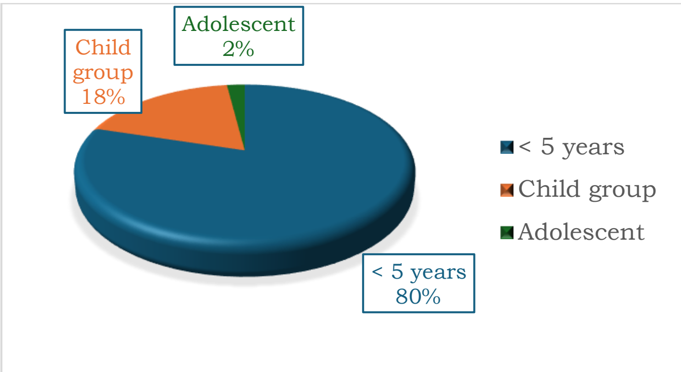

Figure 1. Distribution of age group among all participants.

Regarding the congenital heart disease type (CHD), 90.2% (357 participants) were diagnosed with acyanotic CHD, and 9.8% (39 participants) were diagnosed with cyanotic CHD (Figure 2).

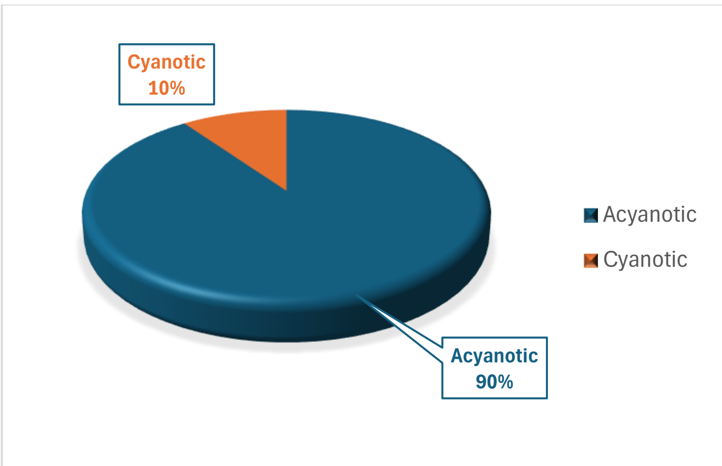

Figure 2. Distribution of CHD type

***Received**: 03-12-2024 - **Accepted**: 26-01-2025 - **Published**: 02-02-2025*

In terms of the clinical presentation, 28.8% of participants were diagnosed with PH, whereas anemia was found in 21.2% of patients, as shown in figure 3.

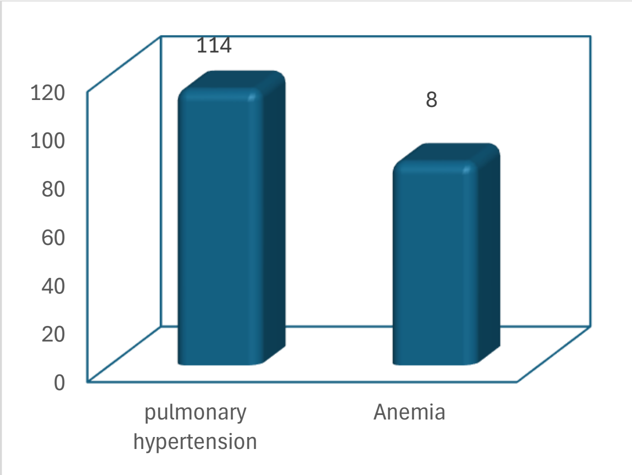

Figure 3. Distribution of clinical presentation among all participants

According to types of CHD, 49.2% (195 participants) were classified as a ventricular septal defect, transposition of the great arteries was diagnosed in 1.5% (6 participants), and tetralogy of Fallot was found in 5.6% (22 participants). 1.5% (5 participants) were classified as Tricuspid atresia, 1% (4 participants) as double outlet right ventricle, 0.5% (2 participants) as total anomalous pulmonary venous return, 1.5% (6 participants) as atrioventricular canal, 1.3% (5 participants) as truncus arteriosus. The Atrial septal defect was detected in 24.7% (98 participants), valves abnormalities in 15.7% (62 participants), patent ductus arteriosus in 16.4% (65 participants), and single ventricle in 0.8% (3 participants), as shown in table 2.

Table 2. Distribution of all studied cases according to type of CHD.

Type of CHD	**N (%)**
Ventricular septal defect	195(49.2%)
Atrial septal defect	98 (24.7%)
Patent ductus arteriosus	65 (16.4%)
Valves abnormalities	62 (15.7%)
Others	40 (10.1%)
Tetralogy of Fallot	22 (5.6%)
Transposition of the great arteries	6 (1.5%)
Atrioventricular canal	6 (1.5%)
Tricuspid atresia	5 (1.3%)
Truncus arteriosus	5 (1.3%)
Double outlet right ventricle	4 (1.0%)
Single ventricle	3(0.8%)
Total anomalous pulmonary venous return	2(0.5%)

Among 34 participants with severe malnutrition, 58.8% (20 participants) were a cyanotic CHD, and 41.2% (14 participants) were cyanotic CHD. There was a highly statistically significant difference in CHD type distribution in relation to the presence of severe malnutrition at (p<0.001), as shown in table 3.

Table 3. Association between gender, type of CHD and severe malnutrition in all studied cases.

Variable	**No severe malnutrition (n=362)**	**Severe malnutrition (n=34)**	**P-value**
Gender			
Male	196 (54.1%)	19 (55.9%)	0.347
Female	166 (45.9%)	15 (44.1%)	
CHD type			
Acyanotic	337 (93.1%)	20 (58.8%)	<0.001*
Cyanotic	25 (6.9%)	14 (41.2%)	

***Received**: 03-12-2024 - **Accepted**: 26-01-2025 - **Published**: 02-02-2025*

In terms of nutritional status, 32.8% of the participants were found to be underweight, as determined by weight for age (WFA) or a BMI less than -2. The remaining 67.2% were not underweight. Out of the total number of participants, 98 individuals (24.7%) were categorized as wasted based on their weight for height (WFH) being less than -2.

In contrast, 298 participants (75.3%) did not show any signs of wasting. Stunting, indicated by a height for age (HAZ) < -2, was observed in 153 participants (38.6%), while 243 patients (61.4%) did not exhibit stunting. In terms of overweight status, which is determined by a BMI for age Z score (BMIZ) >1, 56 participants (14.1%) were categorized as overweight, while 340 participants (85.9%) were not overweight. Finally, a total of 20 participants (5.1%) were found to be obese, as indicated by a BMIZ or WFA > 3. The remaining majority of participants, 376 individuals (94.9%), did not match the criteria for obesity, as depicted in Figure 4.

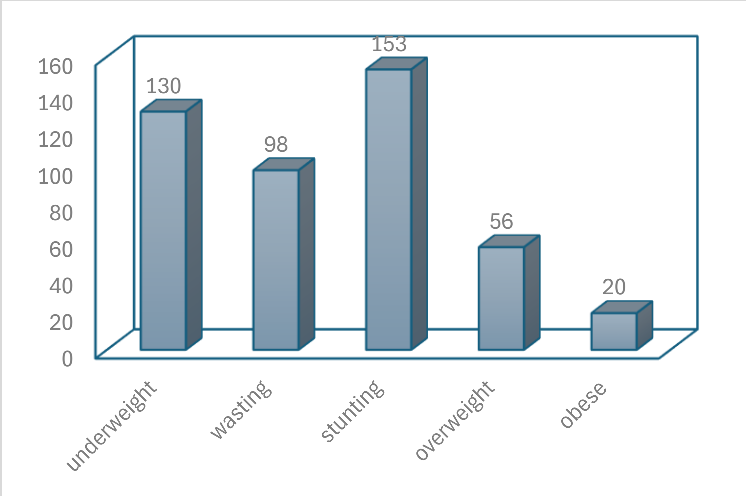

Figure 4. Distribution of nutritional status among participants.

Regarding anthropometric measurements, participants aged less than five years had significantly lower median values for height in cm, weight in kg, BMI (kg/m²), WHZ, height for age z score, weight for age z score, and BMI for age z score compared to those older than five years old, (p<0.001). Various anthropometric measurements between participants aged less than five years and those more than five years old is depicted in table 4.

Table 4. Comparison of various anthropometric measurements between participants aged less than five years and those more than five years old.

Anthropometric measurements	**more than 5 years (n=80)**	**Less than 5 years (n=316)**	**p-value**
Length\ height in cm. Median (IQR)	120.0 (115.0 to 131.0)	66.0 (59.0 to 73.0)	<0.001*
Weight\ Kg Median (IQR)	26.0 (21.5 to 33.5)	7.0 (4.9 to 9.0)	<0.001*
BMI (kg/m2) Median (IQR)	17.3 (15.4 to 19.8)	15.4 (14.6 to 17.2)	<0.001*
Weight height Z value (WHZ) Median (IQR)	0.4 (-0.1 to 1.2)	-0.4 (-1.3 to 0.5)	<0.001*
Height for age z score Median (IQR)	-1.2 (-1.8 to -0.2)	-1.8 (-2.8 to -0.9)	<0.001*
Weight for age z score Median (IQR)	-0.2 (-1.0 to 1.0)	-1.9 (-2.3 to -	<0.001*
BMI for age z score Median (IQR)	0.4 (-0.2 to 1.1)	-0.6 (-1.5 to 0.6)	<0.001*

Regarding the nutritional status, for 316 participants aged less than five years, the prevalence of underweight (WFA or BMI < -2), wasting (WFH < -2), and stunting (HAZ < -2) was significantly higher compared to 80 participants who were older than five years old, (p< 0.001). 32.8% of the participants were found to be underweight, as determined by weight for age (WFA) or a BMI less than -2. The remaining 67.2% were not underweight. The comparison of nutritional status between participants aged less than five years and those more than five years old is depicted in table 5.

***Received**: 03-12-2024 - **Accepted**: 26-01-2025 - **Published**: 02-02-2025*

https://doi.org/10.54361/ajmas.258131

Table 5. Comparison of nutritional status between participants aged less than five years and those more than five years old.

Nutritional status	All patients (%) n =396	more than 5 years (n=80)	Less than 5 years (n=316)	p-value
Underweight WFA or BMI < -2 Yes No	130 (32.8%) 266 (67.2%)	10 (12.5%) 70 (87.5%)	120 (38.0%) 196 (62.0%)	<0.001*
Wasting WFH < -2 Yes No	98 (24.7%) 298 (75.3%)	5 (6.2%) 75 (93.8%)	93 (29.4%) 223 (70.6%)	<0.001*
Stunting HAZ < -2 Yes No	153 (38.6%) 243 (61.4%)	15 (18.8%) 65 (81.2%)	138 (43.7%) 178 (56.3%)	<0.001*
Overweight BMIZ >1 Yes No	56 (14.1%) 340 (85.9%)	22 (27.5%) 58 (72.5%)	12 (3.8%) 304 (96.2%)	0.048*

The study demonstrated a correlation between PH and various indicators of malnutrition among participants as depicted in Table (6). The occurrence of underweight (WFA or BMI < -2), wasting (WFH < -2), and stunting (HAZ < -2) was substantially less common in those without PH compared to those with PH (p <0.001). Similarly, the prevalence of overweight (BMIZ >1) was significantly higher among without PH compared to those with PH patients, with (p< 0.001). None of the participants with PH were classified as obese. Nevertheless, 7.1% (20 participants) of those without PH fell into the obese category. Moreover, the study found a significant correlation between obesity (BMIZ or WFA > 3) and the absence of PH (p= 0.008), as shown in Table 6.

Table 6. Association between patients with pulmonary hypertension and their nutritional status.

Nutritional status	No pulmonary hypertension (n=282)	Pulmonary hypertension (n=114)	P-value
Underweight WFA or BMI < -2 No Yes	236 (83.7%) 46 (16.3%)	30 (26.3%) 84 (73.7%)	<0.001*
Wasting WFH < -2 No Yes	246 (87.2%) 36 (12.8%)	52 (45.6%) 62 (54.4%)	<0.001*
Stunting HAZ < -2 No Yes	226 (80.1%) 56 (19.9%)	17 (14.9%) 97 (85.1%)	<0.001*
Overweight BMIZ >1 No Yes	231 (81.9%) 51 (18.1%)	109 (95.6%) 5 (4.4%)	0.001*
Obese BMIZ or WFA > 3 No Yes	262 (92.9%) 20 (7.1%)	114 (100.0%) 0 (0.0%)	0.008*

Discussion

In this cross-sectional study, we evaluated the nutritional status of Libyan children with CHD. A total of 130 participants exhibited either low WFA or low BMI. The prevalence of malnutrition among the participants was found to be 32.8%. In addition, 24.7% of the participants were wasted and 38.6% were stunted. This finding is consistent with the report Zheng Y et al., who investigated the nutritional status of 428 children with CHD and found that the malnutrition rate was 37.6% in China [28]. A Chinese study reported that the malnutrition rate of congenital heart disease was 23.3% [22]. The findings of this study contradict the results of Okoromah CA et al., who reported a malnutrition prevalence of 90.4% [29]. Additionally, other study has reported rate of 68 % [30]. While further studies have reported even lower rates [31,32]. Overall, malnutrition is a prevalent issue among children with CHD.

Wasting is a condition that indicates acute malnutrition, while stunting, represents chronic malnutrition [33]. The prevalence of stunting was higher than that of wasting in our study, which aligns with the findings

***Received**: 03-12-2024 - **Accepted**: 26-01-2025 - **Published**: 02-02-2025*

of numerous studies that have reported a greater occurrence of stunting [31, 32]. In He et al and Batte A et al studies, wasting was detected in 36.9% and 31.5% of the children with CHD, respectively [24,34]. The most common type of malnutrition among the general pediatric population in the Eastern Mediterranean was determined to be stunting rather than wasting [35]. However, a comparative study conducted in Africa observed a higher prevalence of wasting (38.5%) compared to stunting (37.8%) [36]. Therefore, it can be concluded that children with CHD display varying levels of malnutrition when compared to children without CHD [37]. When comparing the acyanotic and cyanotic groups, it was found that the acyanotic group had a higher percentage (58.8%) of severe malnutrition compared to the cyanotic group (41.2%). These findings contradict the results of Amelia et al., who also observed that Acyanotic CHD patients tended to be underweight, whereas cyanotic patients were severely underweight [38]. Zhang et al and Chinawa et al. reported that children with cyanotic CHD are more likely to be stunted [22,37]. Murni K et al. reported that both [31]. However, several studies reported different results [10.31].

In the present study, children with PH had a higher proportion of being wasted and stunted than children without PH who had a higher proportion of being overweight and obese. These results were consistent with the study of Tsega *et al.* which found that PH is associated with an increased risk of wasting and stunting [32]. This finding is consistent with our research. In addition to persistent hypoxia and CHF, PH can result in undernutrition in cyanotic congestive heart failure due to inefficient cellular metabolism of food [30]. The primary factor contributing to malnourishment and stunted growth in children with CHF is the presence of PH. In addition, PH has an impact on nutrition and growth in both cyanotic and acyanotic CHD. Patients with cyanotic and PH exhibited a greater number of symptoms than those with a cyanotic and PH [32,30]. Interestingly, 14.1% of children in this study were classified as overweight. Conversely, Chinawa et al discovered that 3.8% of children with CHD were overweight, while 1.4% were obese respectively [36].

A similar prevalence of obesity has been reported in Italian comparative retrospective cross-sectional study [10]. This finding exhibited a lower prevalence compared to the 12–15% prevalence of obesity among children with CHD in the United States [38]. In the Jeremy et al. study, the prevalence of overweight was 31.5%, and the prevalence of obesity was 16.4%, which is a lower percentage compared to other studies [19]. Nevertheless, the prevalence observed in each study could be attributed to the methodology and the sample size utilized. In this study, a total of 316 children, which accounts for 79.79% of the sample, were under the age of five. Among these children, 38.0% were identified as underweight, 29.4% were wasted, and 43.7% were stunted. A study conducted in Nigeria revealed that 42.9% (96/224) of subjects under the age of five were wasted compared to the controls of the same age group [36]. A previous study that collected anthropometric data of pediatric patients with CHD and a control group of healthy individuals revealed that children with CHD under the age of two exhibit an increased risk for inadequate weight gain when compared to their healthy counterparts [10]. This finding suggests that the infants were prone to malnutrition. Similarly, a previous study showed that patients younger than one year old exhibited higher rates of malnutrition with WAZ < -2 (73.4%) [22]. In contrast to our findings, a previous study by Tsega and his colleagues found that children between the ages of one and three were 2.3 times less likely to be underweight compared to those aged 5-10 [32]. FTT has been associated with younger age groups, particularly infants, who pose the greatest challenge in terms of treatment [24]. When considering age, it is clear that older children have a lower occurrence of low WAZ and low HAZ compared to infants. Infants in this stage of rapid physical growth may be particularly susceptible to nutritional deficiencies [23].

Conclusion

Malnutrition remains highly prevalent among children with CHD. Approximately 32.8% of children were malnourished, 38.6% were stunted, and 24.7% were wasted, However, the management of nutritional status can be improved by offering patients early nutritional counseling. In addition, periodic nutritional status assessments should be an integral part of cardiology clinic visits of children scheduled for surgical correction.

Conflicts of Interest

The authors declare no conflict of interest.

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***Received**: 03-12-2024 - **Accepted**: 26-01-2025 - **Published**: 02-02-2025*

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Received*: 03-12-2024 -* ***Accepted****: 26-01-2025 -* ***Published****: 02-02-2025*

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المستخلص

ينتشر مرض القلب الخلقي بين الأطفال الليبيين الذين يتم إحالتهم إلى المركز الثالث لعيادة القلب. قد يعاني هؤلاء المرضى من سوء التغذية الخفيف، والذي. يمكن أن يتطور إلى فشل النمو ولذلك فإن الهدف من هذه الورقة هو تحديد مدى أنتشار سوء التغذية وتقييم الحالة التغذوية للأطفال المصابين بأمراض القلب الخلقية. واعتمدت الدراسة التصميم الوصفي المقطعي. وقد شملت مرضى الأطفال الذين تتراوح أعمارهم بين شهرين إلى 18 عامًا والذين تم تقديمهم إلى قسم الأطفال في مستشفى ابن سينا التعليمي مصابين بأمراض القلب الخلقية. تم جمع البيانات خلال الفترة ما بين أبريل 2024 وسبتمبر 2024. وبعد ذلك، تم تحليل البيانات باستخدام الحزمة الإحصائية للعلوم الاجتماعية الإصدار 2.3.2. وأظهرت النتائج أن 53.3% ذكور و46.7% إناث. تراوحت أعمار المشاركين بين (2.8-180) شهرًا. تم العثور على إجمالي 130 مشاركًا لديهم انخفاض الوزن بالنسبة للعمر أو انخفاض مؤشر كتلة . كما بلغ معدل انتشار سوء التغذية بين المشاركين 32.8%، بالإضافة إلى ذلك، كان 24.7% من المشاركين يعانون من الهزال، و38.6% من التقزم. وعلى العكس من ذلك، تم تصنيف 14.1% من الأطفال على أنهم يعانون من زيادة الوزن، ولوحظت السمنة لدى 5.1% من المشاركين. لا يزال سوء التغذية منتشراً بشكل كبير بين الأطفال المصابين بأمراض القلب التاجية. ومع ذلك، يمكن تحسين إدارة الحالة التغذوية من خلال تزويد المرضى بالمشورة التغذوية المبكرة وإجراء تقييمات دورية للحالة التغذوية.

***Received**: 03-12-2024 - **Accepted**: 26-01-2025 - **Published**: 02-02-2025*