Original Article

Assessment of dietary nutrient intake and its relationship to the nutritional status of children with congenital heart disease in Guangdong province of China

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Background and Objectives: Congenital heart disease (CHD) is the common congenital malformations in children and cause malnutrition. We determine the association between dietary nutrient intake and nutritional status of children with CHD. **Methods and Study Design:** 428 children of age 1–10 years with CHD admitted. The dietary nutrient intake was recorded after 3 days of 24-h recall. The growth and nutritional status of children were evaluated using anthropometric measurements and z-scores. **Results:** The prevalence of malnutrition was 37.6% in CHD. 57.8%, 12.6%, 43.8%, and 40.6% of children did not meet their requirements for energy, protein, fat, and carbohydrate, respectively. The prevalence of insufficient intake was 88.3% for calcium, 35.9% for magnesium, 21.9% for iron, and 12.5% for zinc. 15%–86% of children did not meet vitamin requirements. 85.2% and 53.9% of children did not meet their requirements for vitamin A and vitamin C. The prevalence of insufficient intake was 39.1% for thiamin, 24.2% for riboflavin, 15.6% for niacin and 28.1% for vitamin E. Compared with the normal nutrition group, malnutrition group had a relatively lower intake of proteins, iron, zinc and vitamin E. **Conclusions:** An obvious deficiency of dietary nutrient intake was found among children with CHD, especially CHD with malnutrition. Dietary intake related to the nutritional status of children with CHD. The gap between actual consumption and recommendation indicates a need for improved nutritional counseling and monitoring. Early interventions targeting the dietary intakes of children with CHD may be a benefit for long-term effects associated with nutritional status.

Key Words: congenital heart disease, z-score, malnutrition, dietary nutrient intake, 24-h recall

INTRODUCTION

Congenital heart disease (CHD) is one of the most common congenital malformations with an incidence of about 9 per 1000 live births.[1,2] According to reports, the detection rate of CHD in China is between 2.4% and 10.4%. About 160,000 children with CHD are born every year, and around 2 million children are born with CHD in China.[3,4] Although mortality rates and outcomes have been improved because of the optimization of surgical techniques, the nutritional status of children with CHD is a challenge[5,6] because of increased metabolic demands, inadequate nutritional support, and inefficient nutrient absorption.[7,8] In China, the incidence of malnutrition in hospitalized children is 15% to 30%,[9,10] whereas the incidence of malnutrition in hospitalized children with CHD is 30% to 50%,[11-13] which is higher than the average number of children hospitalized in pediatrics. The severity of malnutrition can range from mild under-nutrition to failure to thrive, and it is associated with negative outcomes, more hospitalization costs, growth failure, and increased mortality.[14,15] Studies have shown that compared with children with normal nutrition, children with malnutrition have significantly longer hospital stays and higher mortality rates.[16,17] Children with CHD need to improve their nutritional status to achieve normal growth

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and development. Several studies have shown that malnutrition and growth restriction are common features in children with CHD.[18,19] Adequate nutrition is essential for growth and immune function, which can improve the nutritional status of children. The normal energy and nutrient intake cannot meet the requirement of children with CHD because of the increased metabolic demands.[20] Some children are fed on special diets because of fluid restriction, reduced gastric capacity, or recurrent vomiting. These factors interfere with dietary nutrient intake, which remains below normal nutritional requirements.[21] Assessing the dietary nutrient intake of children with CHD is essential. Furthermore, providing intense support to children and dietary guidance to their parents may improve the nutritional status of children with CHD. The actual macro- and micronutrient intake of children with CHD have not been evaluated in China, and the relationship between nutrient intake and nutritional status is unclear. This study aims to assess the dietary nutrient intake of children with CHD and to explore the association between dietary nutrient intake and nutritional status to provide evidence for proper nutritional support.

METHODS

Study subjects

This cross-sectional study was performed on 428 children of age 1–10 years with congenital heart disease admitted at the Guangdong Provincial People's Hospital during May 2019–October 2021. Ethical approval for the study was obtained from the Guangdong Provincial People's Hospital, Guangdong Academy of Medical Sciences (NO. GDREC2018303H). The clinical trial registration number was ChiCTR2100046328. The parents or the guardians of all children enrolled provided their written informed consent before data collection.

Anthropometry measures and nutrition assessment

The nutritional status of the children with CHD was evaluated based on anthropometric measurements and z-scores. On admission, the children's weight and height were determined in a standard way. For children of age <2 years, the length and weight were measured in their lying position without clothes. For other children, the height and weight were determined with them wearing minimum clothing and with bare feet in the standing position. 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 considered as the final value. Height for age z-score (HAZ) and BMI for age z-score (BAZ) were calculated using the WHO AnthroPlus software (version 3.01). Z-scores <-2 for BMI for age and height were considered to indicate acute and chronic malnutrition, respectively.[22,23]

Dietary intake

Dietary recall (3-days of 24 h) was performed to record the nutrient intake of each child via face-to-face interviews with the respective parents. The parent was asked to describe the time, type, and amount of all foods and beverages consumed by the children in the past 72-h. The interviewer used the food models to help the interviewee estimate the amount of each food and beverage. The dietary information was recorded using a 24-h dietary review questionnaire. The date at the time of each food composition was entered into the Nccw2006 Nutrient Analysis Software program. Macro- and micronutrients were calculated using the software, and the result was compared with the Chinese dietary reference intakes (DRIs). For energy, protein, zinc, vitamin A, thiamine, riboflavin, vitamin C, and niacin, intakes values <80% of the recommended nutrient intake (RNI) were considered as not meeting the requirement. For calcium, phosphorus, magnesium, iron, and vitamin E, intakes value less than the adequate intake (AI) value were considered to not meet the requirement. The dietary nutrient intake of the children was calculated and expressed as a percent of their age-appropriate RNIs or AIs to eliminate the influence of age.

Statistical analyses

The Kolmogorov–Smirnov test for normality was applied to verify the numerical data, while the Levene test was applied to assess the homogeneity of variance. Normally distributed variables were presented as mean SD and the non-normally distributed variables were presented as median and interquartile ranges (IQR). The Pearson's correlation coefficient was applied to estimate the association of dietary nutrient intake and z-scores. Independent-Samples T-test was performed to compare the dietary nutrient intake between the two groups with different nutritional statuses. $p<0.05$ was considered to indicate statistical significance. Statistical analysis was performed using the SPSS (version 25; IBM).

RESULTS

A total of 428 children were included in the study. The mean age was 39.50 (26.0, 69.5) months (range: 13-120 months). Of these, 211 (49.2%) were male and 217 (50.8%) were female. Mean anthropometry measures and z-scores of the 428 children are shown in Table 1. The mean height was 101±19.5 cm and the mean weight was 16.1±8.41 kg. The mean z-scores of height for age and BMI for age were -0.35±1.62 and -0.57±1.47, respectively. Overall, 19.9% (85/428) of the children were categorized as chronic malnutrition and 17.8% (76/428) as acute undernutrition. The prevalence of malnutrition was 37.6% (161/428).

The dietary nutrient intake of children with CHD is shown in Table 2. A total of 57.8% of children did not meet the requirement for energy. Furthermore, 12.6%, 43.8%, and 40.6% of children did not meet their requirements for protein, fat, and carbohydrate, respectively. The prevalence of insufficient intake was 88.3% for calcium, 35.9% for magnesium, 21.9% for iron, and 12.5% for zinc. 85.2% and 53.9% of children did not meet the requirement for vitamin A and vitamin C. The prevalence of insufficient intake was 39.1% for thiamin, 24.2% for riboflavin, 15.6% for niacin and 28.1% for vitamin E.

The association between dietary intake and nutritional status are shown in Table 3. A positive correlation was found between HAZ with energy (r=0.213, p=0.016), magnesium (r=0.216, p=0.014), and zinc (r=0.178, p=0.044). BAZ was positively correlated with iron

Table 1. General characteristics of children with CHD (n=428)

	Result
Male/Female, n (%)	211 (49.2)/217 (50.8)
Age (month)	
M (P25, P75)	39.5 (26.0, 69.5)
Range	13–120
Anthropometrics	
Length/Height (cm)	101±19.5
Weight (kg)	16.1±8.41
Z-score	
HAZ, mean±SD	-0.35±1.62
BAZ, mean±SD	-0.57±1.47
HAZ<-2 (chronic undernutrition)	85 (19.9)
BAZ<-2 (acute undernutrition)	76 (17.8)

CHD: congenital heart disease; HAZ: Height for age z-score; BAZ: BMI for age z-score.

Table 2. The energy and nutrient intakes of children with CHD

	Average intake (mean±SD)	Number of cases of insufficient intake (n)	Percent not meeting requirements (%)
Energy (kcal/d)	1140±387	247	57.8
Protein (g/d)	43.2±19.4	53	12.6
Fat (g/d)	40.6±20.1	187	43.8
Carbohydrate (g/d)	149±55.4	174	40.6
Calcium (mg/d)	320±193	378	88.3
Magnesium (mg/d)	146±58.0	154	35.9
Iron (mg/d)	12.0±387	94	21.9
Zinc (mg/d)	6.95±2.96	54	12.5
Vitamin A (ugRAE/d)	172±113	365	85.2
Thiamin (mg/d)	0.69 ±0.30	167	39.1
Riboflavin (mg/d)	0.78 ±0.38	104	24.2
Vitamin C (mg/d)	45.8±35.8	231	53.9
Vitamin E (mg-αTE/d)	8.58±4.32	120	28.1
Niacin (mg NE/d)	50.6±53.5	67	15.6

CHD: congenital heart disease.

Table 3. Association between nutrient intakes and z-score (HAZ and BAZ) of children with CHD

	HAZ		BAZ	
	r	*p*	r	*p*
Energy	0.213	0.016	0.105	0.239
Protein	0.166	0.062	0.163	0.066
Carbohydrate	0.114	0.199	-0.062	0.483
Calcium	-0.043	0.634	0.062	0.487
Fat	0.033	0.715	0.021	0.815
Magnesium	0.216	0.014	0.079	0.373
Iron	0.081	0.366	0.188	0.033
Zinc	0.178	0.044	0.134	0.130
Vitamin A	-0.065	0.466	0.102	0.251
Thiamin	0.079	0.375	0.151	0.089
Riboflavin	-0.113	0.206	0.068	0.447
Vitamin C	0.019	0.828	0.107	0.229
Vitamin E	0.167	0.060	0.126	0.156
Niacin	0.082	0.358	0.118	0.186

CHD: congenital heart disease; HAZ: Height for age z-score; BAZ: BMI for age z-score.

(r=0.188, p=0.033).

As shown in Table 4, the dietary nutrient intakes of the children were calculated and expressed as a percent of their age-appropriate RNIs or AIs to eliminate the influence of age. Compared with the normal nutrition group, the malnutrition group （with no differences between age and sex) had a relatively lower intake of protein (114±53.3% versus 151±58.2%, p<0.05), iron (102±44.0% versus 129±57.3%, p<0.01), zinc (116±51.3% versus 155±64.0%, p<0.05), and vitamin E (99.2±58.8% versus 135±58.4%, p<0.05).

DISCUSSION

In this cross-sectional study, we assessed the nutritional and growth status of children with CHD. The incidence of low HAZ and BAZ is 19.9% and 17.8%, respectively. A

Table 4. Comparison of the dietary nutrition intakes of children with CHD in different nutritional status†

	Malnutrition (n=150)	Normal nutrition (n=278)	*p*
Energy, %	87.0±26.2	98.7±28.9	0.059
Protein, %	114±53.3	151±58.2	0.004
Carbohydrate, %	103±28.3	106±18.4	0.333
Fat, %	123±66.1	120±53.3	0.792
Calcium, %	38.7±25.2	48.2±28.3	0.116
Magnesium, %	83.1±35.2	97.8±38.2	0.073
Iron, %	102±44.0	129±57.3	0.028
Zinc, %	116±51.3	155±64.0	0.024
Vitamin A, %	52.4±43.6	58.6±36.0	0.449
Thiamin, %	85.7±48.8	102±42.5	0.089
Riboflavin, %	110±70.3	120±61.8	0.444
Vitamin C, %	79.7±62.2	105±78.7	0.121
Vitamin E, %	99.2±58.8	135±58.4	0.006
Niacin, %	489±443	780±846	0.088

CHD: congenital heart disease; RNI: recommended nutrient intake; AI: adequate intake.
†The dietary nutrient intakes of the children was calculated and expressed as a percent of their age-appropriate RNIs or AIs to eliminate the influence of age.

study indicated that lower HAZ is associated with higher mortality and other adverse outcomes after cardiac surgery in infants and young children.[24] Ratanachu-Ek S et al[25] investigated the nutritional status of 161 children with CHD and found that the malnutrition rate was 40% in Thailand of Asia. A foreign case-control observational study reported that 61.2% of children with CHD had severe malnutrition.[6] In our study, the prevalence of malnutrition was 37.6%. A Chinese study reported that the malnutrition rate of congenital heart disease was 27.4%, low weight rate was 24.4%.[26] Altogether, malnutrition is a prevalent problem in children with CHD in China.

We assessed dietary nutrient intake including energy, protein, carbohydrate, vitamin, and minerals. The result indicated that nutrient deficiency was extremely high in children with CHD. About half of the children did not meet their requirements for energy in our study, which is similar to the study of Vieira et al.[27] Another study that investigated the nutritional status of 125 children with CHD showed that 20%–30% of the children have insufficient energy intake, which is the main reason for the high incidence of malnutrition in children.[28] Meanwhile, insufficient energy intake would affect the intensive care time of children.[29] Proteins may mediate the effects of growth hormones and affect skeletal muscle and other tissues.[30] When children have inadequate intake of protein, it may have an adverse effect on their growth and development. Vieirl et al[27] conducted a dietary survey of 38 children with CHD and found that 30% had insufficient protein intake. In our study, 12.6% of children did not meet their protein requirements. Increasing the intake of high-quality proteins can improve the immunity and nutritional status of children. Carbohydrates and fats are the main energy sources of the human body, and inadequate intake leads to energy deficiency. Energy deficiency cannot maintain the body's normal metabolic needs, thus leading to abnormal growth and development of children. An insufficient intake of carbohydrates and fats in our study (40.6% and 43.8%) were not meeting the requirements and are the reason for energy deficiency. Severe insufficient micronutrient intake was found in children with CHD, including calcium, magnesium, vitamin A, and Vitamin E, and this finding is supported by several studies.[27,31-33] In our study, the prevalence of insufficient intake was 88.3% for calcium, 35.9% for magnesium, 21.9% for iron, and 12.5% for zinc. Furthermore, 15%–86% of children did not meet their vitamin requirements. Insufficient supply of minerals and vitamins affects cardiac dysfunction and hinders the growth and development of children with CHD. For example, vitamin A is associated with immune function, vision, reproduction, and cell differentiation, and it is essential for child growth and development. In a cross-sectional study conducted by Zhang et al, a total of 277,064 children aged 0-14 years were enrolled in a cross-sectional survey conducted in 26 Chinese provinces. The results showed that 10.4% were at risk for subclinical vitamin A deficiency (SVAD) as vitamin A concentrations <0.2 mg/L. Sick children, especially those with recurrent respiratory infections (21.3%, 95% CI: 20.5%-22.2%), were susceptible to SVAD.[34] A study by Khan CN et al. found a significant difference between SVAD and prevalence of anemia.[35] In a randomized controlled trial, 826 children were randomly assigned to receive daily zinc or vitamin A supplementation and showed that zinc supplementation increased IFN-γ (cellular immune response) and improved the effect of vitamin A supplementation on salivary immune responses in young and immunoglobulin A mucosa.[36] Hence, it is necessary to supplement sufficient micronutrients through diet.

We found a positive correlation between HAZ and the intake of energy, magnesium, and zinc. We also found that BAZ was positively correlated with the intake of iron. Some studies showed that energy intake was significantly associated with HAZ.[37,38] Hebestreit A et al[39] found that energy intake and daily food intake were significantly positively associated with BAZ. These results indicated that stunted and macilent children had a lower energy intake. Sufficient macro- and micronutrient intake are essential for growth and development. Kim K et al[40] reported that HAZ was positively associated with energy, protein, carbohydrate, fat, calcium, and iron intake. We found that dietary intake and nutritional status are correlated; hence, the intake of various nutrients should be focused on to ensure good nutritional status.

Compared with the normal nutrition group with CHD, the malnutrition group had a relatively lower intake of proteins, iron, zinc, and vitamin E. This result suggests that children in this study were had a deficiency of important nutrients, which may have contributed to malnutrition. Proteins are an important part of human tissues and organs and play an important role in human growth and metabolism. Protein deficit in children may lead to growth retardation and malnutrition.[40] Iron and zinc deficiency is found in children with acute malnutrition, which are crucial for nutritional recovery.[41] Ibrahim SA et al[42] reported that malnourished children have limited intakes of both energy and micronutrients and lack important nutritional factors, including vitamin E.

Although the growth and nutritional status of some children with CHD were in good condition as assessed by anthropometry measures and z-scores, the dietary assessment showed obvious defects in dietary nutrient intake of children with CHD. However, the long-term lack of dietary nutrient intake may have long-term adverse effects on children with CDH who are currently in good nutritional status. An adequate dietary nutrient intake is essential for growth, wound healing, and immune function. Parental feeding behavior plays a critical role in children's nutritional status. Lack of knowledge about nutrient intake can lead to unhealthy diet habits, which lead to malnutrition. Based on diet assessment results, providing proper dietary advice for parents could help children achieve an adequate dietary nutrient intake and improve their nutrition status.

Conclusion

Malnutrition and growth restriction are prevalent problems in children with CHD. An obvious deficiency of dietary nutrient intake was found among children with CHD, especially in the malnutrition group. Parents should be provided with nutritional guidance on how to supplement adequate macro- and macronutrients to improve the growth and nutritional status of children with CHD. Furthermore, regular assessment of the nutritional and dietary intake status and performing nutritional interventions are necessary.

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AUTHOR DISCLOSURES

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