Malnutrition in Children with Congenital Heart Disease (CHD): Determinants and Short-term Impact of Corrective Intervention

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ABSTRACT

Objective: *To identify determinants of malnutrition in children with congenital heart disease (CHD) and examine the short-term effects of corrective intervention.* ***Methods:*** *Patients with CHD admitted for corrective intervention were evaluated for nutritional status before and 3 months after surgery. Detailed anthropometry was performed and z-scores calculated. Malnutrition was defined as weight, height and weight/height z-score ≤–2. Determinants of malnutrition were entered into a multivariate logistic regression analysis model.* ***Results:*** *476 consecutive patients undergoing corrective intervention were included. There were 16 deaths (3.4%; 13 in-hospital, 3 follow-up). The 3-month follow-up data of 358 (77.8%) of remaining 460 patients were analyzed. Predictors of malnutrition at presentation are as summarized: weight z-score ≤ –2 (59%): congestive heart failure (CHF), age at correction, lower birth weight and fat intake, previous hospitalizations , ≥ 2 children; height z-score ≤–2 (26.3%): small for gestation, lower maternal height and fat intake, genetic syndromes; and weight/height z-score ≤–2 (55.9%): CHF, age at correction, lower birth weight and maternal weight, previous hospitalizations, religion (Hindu) and level of education of father. Comparison of z-scores on 3-month follow-up showed a significant improvement from baseline, irrespective of the cardiac diagnosis.* ***Conclusions:*** *Malnutrition is common in children with CHD. Corrective intervention results in significant improvement in nutritional status on short-term follow-up.*

Key words: *Congenital heart disease, Corrective cardiac intervention, Malnutrition.*

INTRODUCTION

Malnutrition is a common cause of morbidity in children with congenital heart disease (CHD)(1-6). Studies from developed countries have documented normalization of somatic growth when corrective surgery for CHD is performed early(7-12). In developing countries, due to resource limitations, corrective interventions for CHD are performed late, leading to a vicious cycle of congestive heart failure (CHF) and respiratory infections(13,14). This results in a high prevalence of pre-operative malnutrition in patients with CHD(15). The implications of pre-operative malnutrition for future somatic growth are unknown and the role of different ethnic, socio-economic and cultural factors (very common in India) on the nutritional status of patients with CHD have not been hitherto studied.

We previously reported that pre-operative

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malnutrition and respiratory infection do not impact immediate outcomes after surgery for infants with large VSD(15,16). However, on five year follow-up, a significant proportion of these patients continued to have suboptimal growth compared to normal population(17). This study reports the prevalence and determinants of malnutrition at presentation for corrective intervention in a large number of patients with various CHD and analyzes the impact of correction on the nutritional status on short-term follow-up.

METHODS

This is a prospective study conducted in a tertiary referral hospital. All children <5 years undergoing surgical or catheter-based corrective intervention at our center from June 2005-June 2006 were included. Patients undergoing palliative procedures were excluded.

A comprehensive evaluation of determinants of malnutrition was performed at admission for corrective intervention. These included demographic, birth-related, cardiac, socio-economic and cultural factors as well as feeding practices (***Table* I**). Socioeconomic status was graded using the modified Kuppuswamy scale(18).

All patients underwent an anthropometric evaluation at presentation; *z*-scores for weight, height and weight/height were calculated using CDC-2000 reference values(19). The weight and height of parents were recorded and mid-parental height was estimated.

A nutritionist obtained a detailed dietary history by interviewing the child's mother using a 24-hour recall method. Dietary intake on a typical day's diet at home was evaluated for 3 consecutive days; average intake was calculated. The relative proportions of total calorie, protein, carbohydrate and fat intake were estimated by using standard charts of nutritive values of common dietary items. Dietary intake of calories and proteins were expressed as percentage of recommended daily allowance for age and sex. Details of feeding like breast feeding, age at weaning, type and adequacy of weaning foods were recorded.

Follow-up evaluations were scheduled at 3 months and then at 6 monthly intervals. Follow-up evaluations included assessment of growth, dietary intake and cardiac evaluation for any significant residual abnormalities. This report is limited to analysis of 3-month follow-up.

Malnutrition was defined as *z*-scores of <–2 for weight (low weight-for-age), height (low height-for-age) and weight/height (low weight-for-height). *z*-scores of <–3 was classified as having severe malnutrition(20).

To test the statistical significance of the association between nutritional status and risk variables, univariate analysis was done applying

TABLE I DETERMINANTS OF MALNUTRITION IN CONGENITAL HEART DISEASE AT PRESENTATION

Demographic factors	Age, sex, birth weight, order of birth; weight for gestational age (categorized as AGA, SGA or LGA)
Cardiac and clinical factors	Cardiac diagnosis and physiology; presence of congestive heart failure, pulmonary hypertension; oxygen saturation; previous hospitalizations and presence of associated genetic syndromes.
Socioeconomic factors	Details of family - nuclear/joint, number of family members and children; religion, consanguinity; age and level of education of parents; occupation of father, employment status of mother and monthly income.
Growth potential	Weight and height of parents and mid-parental height.
Dietary factors	Intake of calories, protein, carbohydrate, fat (expressed as percentage of RDA); breastfeeding, age at weaning, type of weaning foods and adequacy of weaning.

AGA – appropriate for gestational age, SGA – small for gestational age, LGA – large for gestational age, RDA – recommended daily allowance.

Chi-square test (discrete variables) and independent samples *t*-test (continuous variables). All variables significant at 20% level (80% Confidence) were included in the stepwise multivariate logistic regression analysis. Odds ratios with 95% confidence intervals and *P* values were computed for the statistically significant variables using standard formulae. Comparison of three-month follow up data with baseline values was done using the paired '*t*' test. The study was approved by the review board of the Institution and the funding agency.

RESULTS

476 consecutive patients undergoing corrective intervention for CHD were included. Mean age was 15.2 ± 16.2 months. There were 296 (62.2%) infants (≤1 year) and 45 (9.5%) neonates. 233 (48.9%) patients were male. The most common cardiac diagnosis was left-right shunts (64.3%). Of 431 children older than 4 weeks of age, 320 were acyanotic and 111 were cyanotic. 344 patients (72.3%) underwent surgery while the remaining were catheter-based interventions. 194 patients (40.8%) had congestive heart failure. 30 (6.3%) had associated genetic syndromes. ***Table*** **II** lists the cardiac diagnoses of patients included in the study.

There were 16 deaths (3.4%; 13 in-hospital, 3 on follow-up). Three-month follow-up data of 358 survivors was analyzed. 59% (weight), 26.3% (height) and 55.9% (weight/height) of patients had *z*-scores of ≤ –2 at presentation, *z*-scores of ≤–3 for weight, height and weight/height were observed in 27.7%, 10.1% and 24.2% patients, respectively.

On univariate analysis, age at intervention, lower birthweight, previous hospitalizations, presence of congestive heart failure and pulmonary hypertension, education of parents, lower socio-economic scale, parental anthropometry and lower fat intake were associated with *z*-score ≤-2 for all three parameters. Presence of associated genetic syndrome was predictive of lower weight and height *z*-score, small for gestation was associated with lower height and weight/height *z*-scores. While presence of > 2 children in family was predictive of weight *z*-score ≤–2, religion (Hindus had lower values) had an impact on weight/height *z*-score. Factors like sex, cardiac diagnosis, oxygen saturation, dietary intake of calories, weaning practices, type of family (nuclear vs joint), consanguinity, age of parents and employment status of the mother did not influence the nutritional status.

The results of multivariate logistic regression analysis of predictors of malnutrition are summarized in ***Table*** **III.**

TABLE II CARDIAC DIAGNOSES OF PATIENTS (*N*=476) INCLUDED IN THE STUDY

Cardiac diagnosis	Number (%)
Patent ductus arteriosus	118 (24.8)
Ventricular septal defect	112 (23.5)
Tetralogy of Fallot	63 (13.2)
Atrial septal defect	58 (12.2)
D-transposition of great arteries	39 (8.2)
Total anomalous pulmonary venous connection	33 (6.9)
Pulmonic stenosis	15 (3.2)
Coarctation of aorta	12 (2.5)
Atrioventricular septal defect	11 (2.3)
Anomalous left coronary from pulmonary artery	5 (1.1)
Aortopulmonary window	3 (0.6)
Truncus arteriosus	3 (0.6)
Aortic stenosis	2 (0.4)
Coronary arteriovenous fistula	1 (0.2)
Congenital mitral regurgitation	1 (0.2)

On 3-month follow-up, there was significant improvement of *z*-scores of all 3 parameters compared to baseline values (***Fig.*** **1**). There was no

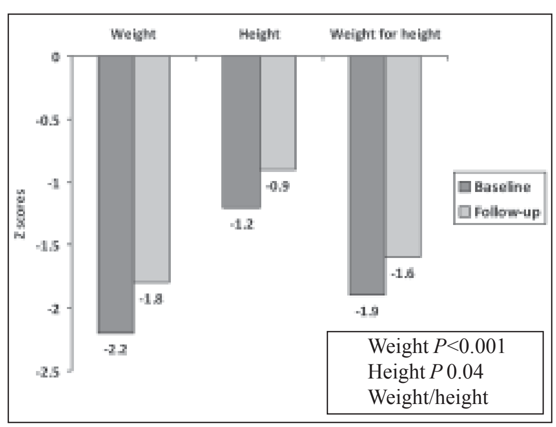

Fig. 1. Comparison of z-scores at presentation (baseline) and 3-month follow-up (data of 358 patients analyzed).

difference in the baseline characteristics between patients with follow-up and those who have not yet completed the 3-month follow-up evaluation.

DISCUSSION

This study reports a very high prevalence of malnutrition at presentation in a large cohort of patients with various CHD undergoing corrective intervention. However, there was significant catch-up growth on 3-month follow-up (***Fig.* 1**), suggesting that correction of the cardiac anomaly favorably influences the nutritional status.

Hemodynamic factors (presence of CHF), older age at corrective intervention and lower growth potential (lower birth weight, small for gestation, lower parental anthropometry and associated genetic syndrome) emerged as significant predictors of malnutrition at presentation on multivariate analysis (***Table* III**). Factors like sex, cardiac diagnosis, dietary intake (except that of fat) and socio-economic scale had no significant impact on nutritional status.

The adverse impact of CHF on growth has been

TABLE III MULTIVARIATE LOGISTIC REGRESSION ANALYSIS OF PREDICTORS OF WEIGHT, HEIGHT AND WEIGHT/HEIGHT *Z*- SCORE < –2

Variable		Odd's ratio (95 % CI)		*P* value
Weight *z*-score <–2				
Congestive heart failure		3.92	(1.86 -8.29)	<0.001
Age at correction	6.1-12 months	6.31	(1.64-24.38)	0.008
	12.1-24 months	8.62	(2.79-26.70)	<0.001
Birth weight	< 2.5 Kg	20.24	(6.15-66.56)	<0.001
	2.51-3 Kg	7.67	(2.59-22.68)	<0.001
Previous hospitalizations		4.05	(1.55-10.64)	0.004
Fat intake	<25g/day	10.31	(2.02-52.63)	0.005
	25-50 g/day	4.22	(1.39-12.87)	0.011
Number of children (>2)		2.05	(1.12-3.77)	0.021
Height *z*-score < –2				
Small for gestational age		6.51	(2.97-14.26)	<0.001
Height of mother (< 150 cm)		2.84	(1.27-6.37)	0.01
Fat intake (< 25 g/day)		3.46	(1.24-9.69)	0.02
Associated syndrome		3.02	(1.26-7.22)	0.013
Order of birth (> 3)		2.67	(1.22-5.81)	0.014
Weight/Height *z*-score < –2				
Congestive heart failure		4.31	(2.41-7.74)	<0.001
Age at correction	6.1-12 months	3.35	(1.56-7.20)	0.002
	12.1-24 months	3.24	(1.47-7.13)	0.004
Birth weight	< 2.5 Kg	4.25	(1.77-10.20)	0.001
	2.51-3Kg	2.53	(1.07-5.99)	0.034
Weight of mother	< 50 Kg	4.15	(1.50-11.46)	0.006
Previous hospitalizations		2.76	(1.38-5.56)	0.004
Education of father (below graduation)		3.18	(1.55-6.54)	0.002
Order of birth (>3)		2.94	(1.21-7.13)	0.017
Religion (Hindu)		2.20	(1.25-3.88)	0.006

WHAT IS ALREADY KNOWN?

- Malnutrition is common in children with congenital heart disease.

WHAT THIS STUDY ADDS?

- Corrective intervention for congenital heart disease results in significant improvement in the nutritional status.

hitherto reported(3, 6-8,11-12,15) and is attributed to the effects of increased total energy expenditure in these patients(4). Age at corrective intervention had a significant impact on weight and weight/height *z*-score (***Table* III**). The risk of weight *z*-score ≤-2 was significantly higher in patients with age above 6 months at intervention compared to younger patients, suggesting the adverse impact of the persisting hemodyanamic abnormality on growth. The other determinants of malnutrition all point towards a role for reduced growth potential. The adverse impact of low birthweight on nutritional recovery after correction has been reported in other studies(7-9,16).

We have used the CDC- 2000 reference values for estimation of *z*-scores as recommended by the World Health Organization(19). Though separate reference standards do exist for Indian Children(21), previous studies from India have reported the reproducibility of the NCHS-CDC 2000 reference standards in Indian setting(22).

The results of this study could have significant implications for physicians caring for children with heart disease in developing countries. Presence of CHF and age at correction were the only modifiable determinants of malnutrition. The results of the study underline the importance of referring patients with CHD and CHF for early corrective intervention (≤6 months) before significant malnutrition sets in. We have previously reported the adverse impact of severe pre-operative malnutrition on somatic growth recovery in infants undergoing VSD closure(17).

The dietary intake of calories did not impact nutritional status and hence the practice of attempting aggressive calorie supplementation to improve nutrition should be replaced by early referral for corrective intervention. The significant catch-up growth on short-term follow-up after correction reinforces the importance of this approach. The study underlines the importance of identifying patients with reduced growth potential and target them for a more aggressive nutritional surveillance after correction of CHD.

This study has certain limitations. We excluded patients undergoing palliative interventions (for purpose of uniformity) and it is possible that these patients have more complex forms of CHD and more severe malnutrition. Also, a longer follow-up (presently ongoing) will provide more details regarding long-term somatic growth and factors associated with sub-optimal nutritional recovery.

In conclusion, malnutrition is very common in children with CHD and is predicted by presence of congestive heart failure, older age at correction and lower growth potential. Corrective intervention significantly improves nutritional status on short-term follow-up.

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Contributors: BV designed, coordinated and supervised the study, interpreted the results, drafted the manuscript and will act as the guarantor for the paper. SBN and UKB collected the data and were involved in analysis. SKR analyzed the data and reviewed the manuscript. SK and SGR performed surgery. RKK supervised the study and critically reviewed the manuscript.

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