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Original Article

Study of cardiac changes in children with malnutrition

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ABSTRACT

Background: Children with malnutrition usually exhibit several alterations in the body composition, one of them being a loss of cardiac muscle and its consequences. **Aim:** The aim of this study is to detect the incidence of cardiac involvement among malnourished schoolchildren as shown by clinical examination and corresponding investigations. **Methodology:** This is a prospective case-control study conducted on 15 children between 5 and 15 years of age with malnutrition. Inclusion criteria were children who fall under the definition of moderate malnutrition as per the World Health Organization (WHO) Z-score based on the WHO Child Growth Standards. Children with known congenital/acquired heart diseases were excluded from the study. These children were assessed by echocardiography and estimation of cardiac troponin T (cTn T) levels for cardiac involvement that was compared with 12 healthy controls. **Results:** The mean left ventricular mass (LVM) was 16.74 units higher in children with normal nutritional status compared with malnourished children (p=0.092, 95% confidence interval=2.91-36.40).The mean LVM index was 4.76 units higher in children with normal nutritional status compared with kids with malnutrition indicating the reduction of cardiac muscle mass. **Conclusion:** As cardiac muscle mass is reduced in children with malnutrition leading to various complications, they need early detection, monitoring, and appropriate management.

Key words: *Cardiac, Nutrition, Protein*

Malnutrition is a state of suboptimal (deficient/excessive) supply of nutrients, which is known to interfere with the growth, development, and maintenance of an individual's health [1]. According to the World Health Organization (WHO), malnutrition is defined as "the cellular imbalance between the supply of nutrients and energy and the body's demand for them to ensure growth maintenance and specific function" [2]. Malnutrition is one of the serious public health problems associated with increased risk of morbidity and mortality [3]. Malnutrition affects approximately one-third of the children worldwide and is frequently seen in less developed countries due to inadequate food intake, socioeconomic factors, or sometimes due to natural disaster [4,5]. Inadequate intake of protein and energy results in proportional loss of skeletal and myocardial muscle [6,7]. This is complicated by electrolyte imbalance, mineral, and vitamin deficiencies as an add-on effect contribute to the cardiac abnormalities such as hypotension, cardiac arrhythmias, cardiosympathy, cardiac failure, and sometimes even sudden death [4,8].

Cardiac troponins (cTn) are one of the regulatory proteins of the thin actin filaments of the cardiac muscle [9]. The release of this regulatory protein after a myocardial cell injury serves as a highly sensitive and specific biomarker of the myocardial damage [10]. Therefore, this study was planned to detect the incidence of myocardial damage as indicated by the left ventricular mass (LVM) among children with moderate malnutrition using echocardiography and cTn T levels. This group of children are asymptomatic and as such cardiac involvement goes unnoticed and most of the available studies are done on children in the age group of <5 years and with severe acute malnutrition (SAM) and found significant changes in the cardiac muscle mass; hence, to find out the same in the age group of 5-15 years with moderate malnutrition and to detect cardiac abnormalities as early as possible, thereby paving the way for prevention and early management of the same.

METHODOLOGY

A case-control study was conducted in the outpatient and inpatient Department of Pediatrics of a Teaching Institution of Chennai for 6-month period after obtaining clearance from the Institutional Ethical Committee. A total of 15 children with malnutrition who fulfilled inclusion criteria, i.e., children between 5 and 15 years of age having moderate malnutrition based on the WHO Child Growth Standards were included in the study. Moderate malnutrition was defined as weight for age between -3 and -2 Z-scores below the median of the WHO child growth standard [11]. Those children with known congenital/acquired heart diseases will be excluded from the study. These children were assessed for the cardiac involvement by echocardiography

and estimation of cTn T levels. These were compared with 12 healthy children taken as controls.

After obtaining informed written consent from the parents, patients and control groups were assessed with relevant history, thorough clinical examination with special emphasis on the anthropometric measurements. To find the nutritional status of the child, standing height and weight were taken as per the standard protocols. The children were made to stand erect against a wall on a flat floor with heels closely placed and with the help of stadiometer, height was measured in centimeters. Weight was measured by bathroom weighing scale in kilograms (error of ±50 g). Body mass index (BMI) was calculated, and reference value of height, weight, and BMI was plotted on the WHO growth charts.

All the subjects were assessed with two-dimensional, M-mode, Doppler and echocardiography using mechanical and phased-array sector scanner with 4.5 and 3.0 MHz transducers. The examination was conducted with patient lying in supine position. The parasternal long axis and short axis and apical four chamber views were obtained in all study cases and controls. Following parameters were studied and recorded.

LV Function

LV dimensions were measured from the derived M-mode echocardiography in the parasternal long axis view. All the tracings were recorded using the leading-edge technique. Percentage of LV fractional shortening (FS) was calculated using the following formula: FS=EDD-ESD/EDD×100%. Where, EDD is the end-diastolic diameter of the LV and ESD is the end-systolic diameter of the LV. Ejection fraction (EF) was measured from the "cubed equation, " i.e., EF=(EDD)-(ESD)/(EDD)×100. LV diastolic function was assessed using ratio of the early (E) to late (A) ventricular filling velocities ratio of the mitral flow by pulsed wave Doppler across the mitral valve. LVM was measured and LVM index (LVMI) was calculated using the LVMI calculator.

Under aseptic precautions, 3 ml of venous blood was drawn and allowed to clot and then centrifuged. The serum obtained was used for the assessment of cTn T, by chemiluminescence immunoassay intended for use on the Beckman Coulter immunoassay analyzer. The lower detection limit was 0.010 ng/ml, any value above this is considered positive, and it indicates myocardial cell injury, especially seen in children with SAM. Values below this detection limit are reported as <0.010 ng/ml.

Statistical analysis was performed using SPSS (version 16). The numerical data will be represented as mean ± standard deviation. Student's t-test was used for parametric data. The value was considered significant if $p<0.05$. Linear correlations were performed by Spearman's or Pearson's test.

RESULTS

The study has included 15 children with moderate malnutrition as cases and another 12 healthy children as controls. The mean age of cases and controls was 10.5±2.03 and 11.16±2.20 years, respectively. The male:female ratio was 1.1:1 and 1:1.4 in cases and controls, respectively. The mean BMI among cases was 13.36±2.18 and among controls was 16.43±1.63 which was statistically significant ($p<0.005$), and cTn T was not detectable in any of the cases as in Table 1 because it is usually found to be elevated or positive only with SAM or with associated complications such as sepsis as quoted in the previous studies, but in this study, we had only children with moderate malnutrition that being the limitation of the study also.

Table 2 shows the echocardiographic parameters among both the groups where the EF was 68.07% among the cases as compared to 69.55% among the healthy controls. As shown in Table 3, the mean LVM (g) in controls was 87.06±30.99 in comparison to 70.32±18.6 in malnourished children. The mean LVMI (g/m^2) in controls and cases was 38.66±17.6 and 33.90±13.4, respectively. The mean value of LVM was 16.74 units more in children with normal nutritional status, compared with kids with malnutrition ($p=0.092$, 95% confidence interval=2.91-36.40), and the mean value of LVMI was 4.76 units higher in children with normal nutritional status, compared to kids with malnutrition.

DISCUSSION

Children with malnutrition have been found to exhibit a series of cardiovascular abnormalities, which manifest as hypotension, cardiac arrhythmias, cardiomyopathy, cardiac failure, and sometimes sudden death. The exact pathogenesis for all these cardiovascular changes and abnormalities is still not completely understood, either it could be as a result of malnutrition itself as a primary component or sometimes secondary to sepsis and electrolyte imbalance.Nutritional status of a child and heart disease is found to be strongly related with a great influence on the long-term prognosis. In this study, we included 15 children with moderate malnutrition in the age group of 5-15 years and compared the cardiac mass as represented by LVM and LVMI with 12 healthy controls. The mean LVM and mean LVMI were higher in children with normal nutritional status compared to malnourished children.

Kothari et al. conducted a case-control study with 25 children aged 1-5 years with protein-energy malnutrition (PEM) and 26 healthy children and showed that the mean LVM was lower in cases as compared to controls [12]. Ahmed also studied 54 children aged 2-5 years and showed that LVM was reduced in patients with malnutrition [13]. Furthermore, in a study by Faddan et al., echocardiography evaluation in children with PEM revealed a significantly lower interventricular septal thickness, posterior wall thickness, and LVM as compared to the control group [14]. All the above studies included children with SAM in contrast to this study where we studied children with moderate malnutrition. We included children with moderate malnutrition as most of the previous studies have been done on children with SAM, and we wanted to assess the effects of moderate malnutrition so as to detect cardiac abnormalities at an early stage.

Table 1: Clinical and laboratory data of the studied patients with malnutrition compared with controls

Variant	Sex	Age (years)	Weight (kg)	Height (cm)	BMI (weight/height^2)	cTn T (ng/ml)	Height (g/dl)
Patients (n=15)	Male=7 Female=8	10.5±2.03	25.27±8.62	135.83±14.88	13.36±2.18	Nil	11.18±1.06
Controls (n=12)	Male=5 Female=7	11.16±2.20	32.05±8.82	138±13.40	16.43±1.63	Nil	12.13±0.96
Mean difference		0.633	6.77	2.16	3.053		0.32
p value		0.446	0.056	0.698	0.000		0.425

BMI: Body mass index, SD: Standard deviation

Table 2: Echocardiographic findings of the patients with malnutrition compared with the controls

ECHO	PWD (cm)	LVM (g)	LVMI (g/m^2)	FS (%)	EF (%)	E/A
Patients (15)	0.747	70.32	33.90	36.93	68.07	1.81
Controls (12)	0.745	87.06	38.66	37.36	69.55	2.13
Mean difference	0.012	16.75	4.76	4.30	1.47	0.32
p value	0.97	0.092	0.43	0.82	0.44	0.398

PWD: Pulse wave doppler, LVM: Left ventricular mass, LVMI: Left ventricular mass index, FS: Fractional shortening, EF: Ejection fraction

Table 3: Effect of malnutrition on left ventricular mass

WHO [ZSCAT]	N	Mean±SD	Standard error mean	Unpaired t-test	Mean difference	95% confidence interval of the difference	
						Lower	Upper
LVM				LVM			
No malnutrition	12	87.067±30.9941	8.9472	Equal variances assumed	16.7467	−2.9116	36.4049
Malnutrition	15	70.320±18.1609	4.6891				
LVMI				LVMI			
No malnutrition	12	38.667±17.6097	5.0835	Equal variances assumed	4.7667	−7.4160	16.9494
Malnutrition	15	33.900±13.1492	3.3951				

LVM: Left ventricular mass, LVMI: Left ventricular mass index, SD: Standard deviation

The age group also shows a difference from other studies as most of them included children in the <5 years group and only one study included up to 16-year-old children. Giuseppe et al. studied 313 children of 4-16 years which revealed LVMI was significantly reduced in cases, similar to our study, and also showed that children who were affected with malnutrition of any degree had a lower value of LVMI as compared to children with normal nutritional status [15]. Olivares et al. found that the decrement of LVM and LVMI was proportional to the decrement in the total body mass [4].

As compared to this study, where although there was some difference in the EF between the cases and controls, it was not statistically significant. Some of the previous studies also showed some alterations in systolic function of the LV as in a study by Coal et al. [8], and Bergman et al. [16] showed that there was no difference with reference to LV and FS between the PEM group and control group, similar finding even Giuseppe et al. showed where, even if LV mass is reduced in proportion to the decrease of BMI, LVEF was normal and not affected.

Phornphatkul et al., [17] on the other side, showed that children with PEM were associated with cardiac muscle wasting and LV dysfunction, and also systolic function was found to be further reduced with a loss in bodyweight of more than 40%. In our study, we also estimated CTn levels, but no significant difference was found between the two groups, but this was in contrast with other previous studies which revealed that CTn T levels were higher in malnourished children particularly with severe degree of malnutrition, associated with complications such as anaemia, sepsis, and electrolyte deficiency, and also the mortality at 30 days was significantly higher among patients with elevated Tn levels at presentation than among patients with no biomarkers detected [18,19].

We had some limitations such as small sample size, among confounding factors only anemia was investigated, others such as electrolyte imbalance and infections were not detected as parents were not willing for the same as again our cases were with moderate malnutrition and not SAM as in earlier studies.

CONCLUSIONS

As children with malnutrition have shown to have some cardiac involvement as evidenced by LVM reduction seen in echocardiography which may progress to cardiac dysfunction; therefore, the prevention of malnutrition should be the first priority, and early detection of malnutrition along with appropriate management and regular monitoring of children with malnutrition is needed with special reference to cardiac monitoring with serial echocardiography.

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