RESEARCH ARTICLE

Echocardiographic based cardiac evaluation in children with severe acute malnutrition

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Abstract

Objective: To identify echocardiography-based myocardial changes in children with severe acute malnutrition.

Method: The prospective study was conducted from January to November 2020 at a territory care paediatric hospital in Multan, Pakistan, and comprised severe acute malnutrition patients of either gender aged 1-60 months and an equal number of matching healthy controls. Malnutrition was categorised using the World Health Organisation criteria. Echocardiographic evaluation was done by expert cardiologists. Values for ejection fraction shortening, left ventricular mass, E/A wave ratio as well as mitral and tricuspid annular plane systolic excursions were noted. Data was analysed using SPSS 21.

Result: Of the 150 subjects, 75(50%) each were cases and controls. Age and gender were not significantly different between the groups ($p>0.05$). Left ventricular mass and left ventricular mass index with body surface area were significantly reduced in the cases compared to the controls, and the same was the case with left ventricular ejection fractional shortening ($p<0.05$). There was no significant difference between the groups in terms of E/A wave ratio as well as mitral and tricuspid annular plane systolic excursions ($p>0.05$). Among the cases, cardiac evaluation showed 26(34.6%) were kwashiorkor and 49(65.3%) were marasmic patients.

Conclusion: Left ventricular parameters in malnourished children were found to be reduced. As such, the assessment of these parameters may appear to be a significant indicator for timely identification of cardiac malfunction in severe acute malnutrition cases.

Keywords: Severe acute malnutrition, Myocardial performance index, Ejection fraction, Fractional shortening, Cardiac function. (JPMA 72: 2391; 2022)

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Introduction

Adequate nutritional status is one of the fundamental pillars of child growth and development.[1] Inadequate calory intake and micronutrient deficiency lead to oedematous and non-oedematous severe acute malnutrition (SAM), which mostly effects children aged <5 years in developing countries, and mostly contributes to 60% of paediatric mortality.[2,3] SAM aetiology is highly variable with economic, psychosocial, cultural and geographical factors in the mix.[4-6] According to the National Nutrition Survey of Pakistan (NNS)-2018, 28.9% children were underweight, 40.2% were stunted, and 17.9% were wasted.[7] The mortality rate of SAM is nine times higher compared to normal children aged <5 years.[3]

SAM affects body organs and systems that leads to physiological and metabolic alteration. This process is known as reductive adaptation.[1] Like other systems, major anatomical functional changes occur in the cardiac system. In SAM, impaired cardiac electrical activity, myocardial loss and morphological changes at the cellular level have been reported.[8] In addition to the prolonged repolarisation time reported in SAM, hypotension, cardiac arrhythmias, cardiomyopathy and cardiac failure are common co-morbidities in SAM, and cardiac monitoring must be done to prevent mortality.[9] Malnourished children undergo these changes particularly due to depletion of tissue proteins. Children with oedematous malnutrition are at increased risk of cardiac morbidity. Myocardial dysfunction manifests as cardiac arrythmias or heart failure and it is mostly responsible for death among kwashiorkors.[8-10]

Electrocardiography (ECG), echocardiography (echo), biochemical marker myocardial band (Mb) are the hallmarks of myocardial function. Ration between E and A waves (E/A ratio), tricuspid annular plane systolic excursion (TAPSE), and mitral annular plane systolic excursion (MAPSE) values help to determine the diastolic function. MAPSE and TAPSE help to evaluate the right and left heart functions even when ejection fraction (EF) is normal. Echo also provides detailed depth of cardiac status.[8,9] Data suggests that children

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with SAM have lesser cardiac surface area, and cardiac indicators compared to the surface area. The malfunctioning of cardiac activity in children with SAM is associated with severity and duration of malnutrition. Cardiac troponin is also a sensitive indicator of myocardial insult.[10] There is locally no significant data regarding the cardiac status in SAM children. The current study was planned to fill the gap by identifying echo-based myocardial changes in children with SAM.

Subjects and Methods

This was a prospective study conducted from January 2020 to November 2020 in Children's Hospital and Institute of Child Health Multan (CH&ICH). Non purpose simple selection technique was used to collect samples. All the patients admitted during the study duration, fulfilling the inclusion criteria i.e. identified as Severe Acute Malnourished and admitted to Children's Hospital and Institute of Child Health Multan (CH&ICH) and those who gave consent were included in this study. To ensure maximum samples all patients admitted during study duration which fulfills inclusion criteria were included in this study by simple random sampling technique. The research includes 150 participants from which 75 participants were severely malnourished and 75 participants were healthy controls. Malnutrition was categorised using the World Health Organisation (WHO) guidelines; Weight/Height Z-score <-3 standard deviation (SD) or presence of bilateral pedal oedema or mid-upper arm circumference (MUAC) <11.5cm^2. After taking informed consent from the respective parents, data was collected using a predesigned questionnaire to record demographic details, height, weight, body mass index (BMI) and MUAC, case history, clinical signs and symptoms, and laboratory results of the patients.

Echo evaluation was done for the cases by expert cardiologist (GE Vivid S5 Echocardiography machine). Left ventricular mass (LVM), left ventricular mass index (LVMI), percentage of fractional shortening (FS), ejection fraction (EF) and myocardial performance index (MPI) were calculated.

MPI index was calculated by the equation:

$$MPI = \frac{\text{Total systolic time (TST) - Ejection time (ET)}}{\text{Ejection time (ET)}}$$ [9]

This can also be written as,

$$MPI = \frac{\text{Isovolumetric contraction time (IVCT) + Isovolumetric relaxation time (IVRT)}}{\text{ejection time (ET)}}$$ [9]

E/A ratio, MAPSE and TAPSE were determined to assess the diastolic function. Data was analysed using SPSS 21. All data was checked for normality before applying the tests. Mean ± SD was calculated and t-test was applied for comparison of parametric test values. P<0.05 was considered statistically significant.

Results

Of the 150 subjects, 75(50%) each were cases and controls. Age and gender were not significantly different between the groups (p>0.05). Among the cases, cardiac evaluation showed 26(34.6%) were kwashiorkor and 49(65.3%) were marasmic patients (Table-1).

LVM, LVMI, FS, EF and MPI were significantly reduced in the cases compared to the controls (p<0.05), while the

Table-1: Age, gender and anthropometric data.

Variables	Case n=75	Controls n=75	P-value
Gender			
Male	33	36	0.13
Female	42	39	
Age in months			
1-12	9	13	0.06
13-24	19	22	
25-36	25	27	
37-48	14	08	
49-60	8	05	
MUAC	9.5±1.3	12.9±0.96	0.024
Nutritional status			
Wt/Ht <-3SD	30	Nil	0.001
Wt/Ht <-4SD	45	Nil	
Oedematous SAM	N=26		0.04
Grade-II oedema	06	Nil	
Grade-III oedema	20	Nil	
Non-oedematous SAM	49	Nil	

MUAC: Mid upper arm circumference, Wt: Weight, Ht: Height, SD: Standard deviation, SAM: Severe acute malnutrition.

Table-2: Comparative analysis of echocardiography parameters between the cases and the controls.

Variables	Case (n=75)	Control (n=75)	P-value
LVM(g)	18.23±2.97	32.01±6.09	<0.05
LMI (g/m^2)	37.02±12.92	41.52±8.40	<0.05
EF (%)	63.06±2.71	65.99±1.21	<0.05
FS (%)	32.11±2.82	35.47±1.74	<0.05
MPI	0 .72±0.12	0.45±0.04	<0.05
E/A Ratio	0.8 ± 1.5	0.85 ± 1.45	<0.05
MAPSE	1.15 ± 0.5	1.18 ± 0.4	<0.05
TAPSE	1.2 cm ± 1	1.15 ± 0.8	<0.05

LVM: Left ventricular mass, LVMI: Left ventricular mass index with body surface area, EF: Ejection fraction, FS: Fractional shortening, MPI: Myocardial performance index. E/A ratio: E/A wave ratio, MAPSE: Mitral annular plane systolic excursions, TAPSE: Tricuspid annular plane systolic excursions.

Table-3: Comparative analysis of echocardiography parameters between oedematous and non-oedematous cases.

Variables	Oedematous (n=26)	Non-oedematous (n=49)	P-value
LVM(g)	18.42±3.23	18.02±3.42	0.06
LMI (g/m^2)	36.02±11.81	38.01±16.04	0.59
EF (%)	64.72±2.84	62.92±1.93	0.21
FS (%)	32.01±3.88	30.97±4.02	0.17
MPI	0.69±0.12	0.71±0.05	0.08
E/A RATIO	0.75 ± 1.45	0.85 ±1.5	0.03
MAPSE	1.14 ± 0.5	1.15 ± 0.6	0.045
TAPSE	1.2 ± 0.75	1.1 ± 01	0.052

LVM: Left ventricular mass, LVMI: Left ventricular mass index with body surface area, EF: Ejection fraction, FS: Fractional shortening, MPI: Myocardial performance index. E/A ratio: E/A wave ratio, MAPSE: Mitral annular plane systolic excursions, TAPSE: Tricuspid annular plane systolic excursions.

difference was not significant in terms of E/A ratio, MAPSE and TAPSE (Table-2).

LVM, EF, MPI, and FS values were comparable between children with oedema and those without oedema (p>0.05) (Table-3).

Discussion

Nutritional status, particularly protein energy malnutrition, has direct impact on cardiac status.[2,3] SAM children are at high risk of cardiovascular and related complications, and even mortality.[7] Previous studies have also documented that SAM leads to cardiac manifestations, especially cardiac arrhythmia and cardiac overload during rehabilitation among children.[9] In the current study, cardiac dimensions on echo were reduced in malnourished children compared to the controls.

The present study reported that LVM and LVMI in SAM children were lower compared to the controls. Similar findings have been reported earlier.[11-15]

The current study also suggested that in cardiac malfunctioning, MPI was significantly increased in the cases, but EF and FS remained within acceptable range. Such findings have also been reported earlier.[16,17]

Cardiac parameters were slightly different in oedematous and non-oedematous SAM children in the current study, with FS and EF being lower in oedematous SAM. In another study, LVMI was decreased[15] in SAM, but in the current study there was no significant difference between SAM children and healthy controls in this regard.

Limitation: The sample size for this study was not statistically calculated which could cause a decrease in the power.

Conclusion

Left ventricular parameters in malnourished children were found to be reduced. Therefore, the assessment of these parameters may appear to be a significant indicator for timely identification of cardiac malfunctioning in SAM children.

Disclaimer: None.

Conflict of Interest: One of the authors was also the member of the institutional review board which approved the study.

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