https://doi.org/10.29309/TPMJ/2025.32.08.9335

The Professional Medical Journal
www.theprofesional.com
2025, Volume, 32 Issue, 08

ORIGINAL ARTICLE

Frequency of cardiac dysfunction in severely malnourished children.

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Article Citation: Mehmood R, Parkash A, Asim S. Frequency of cardiac dysfunction in severely malnourished children. Professional Med J 2025; 32(08):1018-1024. https://doi.org/10.29309/TPMJ/2025.32.08.9335

ABSTRACT… Objective: To determine the frequency of cardiac dysfunction in children having severe acute malnutrition (SAM). **Study Design:** Cross-sectional study. **Setting:** In-patient Department of Pediatric Medicine, National Institute of Child Health (NICH), Karachi, Pakistan. **Period:** May 2024 to October 2024. **Methods:** A total of 188 children aged 6-59 months with severe acute malnutrition (SAM) were analyzed. Demographics, anthropometric data, and vital signs were documented. Echocardiography assessed ejection fraction (EF), right ventricular mass (RVM), and left ventricular mass (LVM). Data were analyzed using IBM-SPSS Statistics, version 26.0. **Results:** In a total of 188 children, 101 (53.7%) were female. Cardiac dysfunction was noted among 45 (23.9%) children. The most common cardiac dysfunction findings were diastolic dysfunction, and left ventricular hypertrophy, identified in 24 (53.3%), and 13 (28.9%) children, respectively. The mean WHZ-score was significantly lower in children with cardiac dysfunction (-3.38±0.52 vs. 3.09±0.30, p<0.001). Bilateral pedal edema (53.3% vs. 17.5%, p<0.001), dyspnea (57.8% vs. 40.6%, p=0.043), abnormal fast breathing (40.0% vs. 20.3%, p=0.008), difficulty in breathing (66.7% vs. 44.8%, p=0.010), weight loss (40.0% vs. 20.3%, p=0.008), and hepatomegaly (40.0% vs. 20.3%, p=0.008) were significantly associated with cardiac dysfunction. Echocardiographic findings showed that children with cardiac dysfunction had a significantly lower mean ejection fraction (58.67±4.82 vs. 62.80 ± 3.87%, p<0.001), higher right ventricular mass (18.27±4.34 vs. 17.10±3.03 g, p=0.045), and lower left ventricular mass (21.09±11.30 vs. 27.45±8.30 g, p<0.001). **Conclusion:** This study highlights the significant burden of cardiac dysfunction in children with SAM.

Key words: Bilateral Pedal Edema, Cardiac Dysfunction, Ejection Fraction, Left Ventricular, Malnutrition.

INTRODUCTION

Malnutrition is defined as the deficiency of one or more macronutrients in body tissues resulting in inability of body to maintain optimal functions followed by numerous micronutrient deficiencies. Malnutrition is one of the major heath related problem of children, significantly associated with a large number of morbidities and mortality. Approximately 3.1 million deaths per year are reported among children from low and middle-income countries.[1,2] In 2020, WHO estimated that 149 million children under 5 were stunted, 45 million wasted, and around 45% of deaths among children under 5 were linked to malnutrition.[3] Severe acute malnutrition (SAM) is most common clinical condition of malnutrition in children especially in countries of low and middle income.[4,5]

Pakistan is among nations with highest burden of child malnutrition especially SAM compared to other developing counties.[6,7] Approximately 1 to 2 million deaths per year are reported among children due to SAM and most of them live in Asia and Sub-Saharan Africa.[8,9] Literature reports many factors associated with SAM, and some researchers have reported the relationship of cardiac dysfunction and SAM especially behind unexplained or sudden deaths.[10-12] Regional data has shown cardiac changes in malnourished child as compared to healthy children, and documented the mean left ventricular mass (LVM) index as 4.76 units higher in children with normal nutritional status compared with those who had malnutrition indicating the reduction of cardiac muscle mass.[12]

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Article received on: 13/02/2025
Accepted for publication: 21/04/2025

Brent B et al., reported cardiac dysfunction in malnourished children associated with low cardiac index with slight difference between marasmus and kwashiorkor.[10] Bebars GM et al., noted that the grade I diastolic dysfunction was present in 40%, and grade II in 30% of severely malnourished children.[11] This study is focused to study cardiac changes in severely malnourished children and the findings can help in better understanding and implementation of fluid management in these children in future. The main aim of this study was to determine the frequency of cardiac dysfunction in children having SAM.

METHODS

This cross-sectional study was conducted at the in-patient department of pediatric medicine, National Institute of Child Health (NICH), Karachi, Pakistan, during May 2024 to October 2024. A sample size of 188 was calculated using Open EPI sample size calculator taking the proportion of grade-I diastolic dysfunction as 40%, at 95% confidence level, and 7% margin of error.[11] Non-probability, consecutive sampling technique was adopted. Inclusion criteria were children aged 6-59 months, and having SAM. Exclusion criteria were children with history of cardiothoracic event, or those born with extreme low birth weight or with congenital defects (as per history and medical record). Severely ill children, or those with metabolic/storage disorders, or having chronic ailments were also excluded. Children whose parents/guardians were not willing to participate in the study were not included. SAM was labeled as a child presenting with severe wasting (weight for height z score (WHZ) < - 3 SD), or mid-upper arm circumference (MUAC) < 11.5 cm and/or bilateral edema.

This study was performed after the permission of Institutional Ethical Review Board, NICH (IERB-70/2023, dated: 18-05-2024). Written and informed consents were obtained from the parents/guardians of children. Demographic characteristics of patients including, gender, and age, along with anthropometric parameters like weight, height, weight to height Z score (as per WHO charts) and middle-upper arm circumference were documented. Vital signs including temperature, blood pressure and respiratory rate were also noted. Presenting complaints of each child regarding cardiac dysfunction were inquired. Blood sample of each child was collected in aseptic environment and sent to institutional laboratory for complete blood count and electrolytes evaluation. Echocardiography was performed and information like ejection fraction (EF), right ventricular mass (RVM), and LVM were recorded. Cardiac dysfunction was named when a child had symptoms of dyspnea, abnormal fast breathing, difficulty in feeding, nausea or weight loss along with physical examination of heart failure including bilateral basal crackles, raised jugular vein pressure (JVP), hepatomegaly and pedal edema, and confirmed on presence of any abnormality on echocardiogram. All echocardiographic evaluations were performed by a consultant pediatric cardiologist with a post-fellowship experience of more than 3 years on 2-D Echo. Abnormal fast breathing was defined as abnormally increased respiratory rate more than the age cut off limit, 1-month till 12 months > 50 breaths/minute, 12 months to 59 months > 40 breaths/minute. All relevant study data were noted on a specially designed proforma.

Data analysis was done using IBM-SPSS Statistics, version 26.0. Mean and standard deviation were calculated for quantitative variable like age, weight, height, weight for height z score, MUAC, temperature, blood pressure, respiratory rate, sodium, chloride and potassium. Frequency and percentages were shown for gender, age groups, presenting complaints, cardiac changes and type. Effect modifier like gender and age were controlled by stratification, and post-stratification analysis was done employing chi-square test taking $p<0.05$ as significant.

RESULTS

In a total of 188 children, 101 (53.7%) were female. The mean age, height, weight, WHZ-score, and MUAC were 37.98±17.29 months, 84.81±1.15 cm, 8.58±2.42 kg, -3.17±0.38, and 11.12±0.69 cm, respectively. Cardiac dysfunction was noted among 45 (23.9%) children. The most common cardiac dysfunction findings were diastolic dysfunction, and left ventricular hypertrophy, identified in 24 (53.3%), and 13 (28.9%) children, respectively, and the details of cardiac dysfunctions are shown in Figure-1.

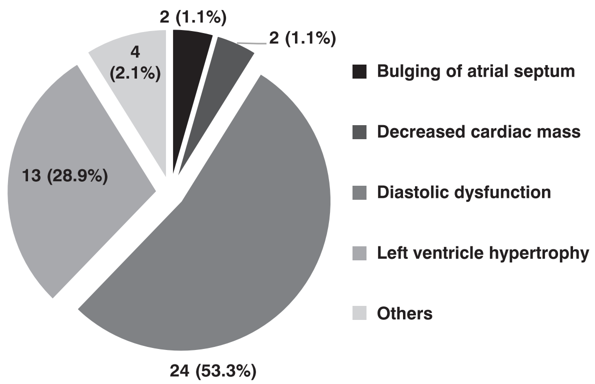

Figure-1. Types of cardiac functions in children with severe acute malnutrition (n=188)

The mean WHZ-score was significantly lower in children with cardiac dysfunction (-3.38±0.52 vs. 3.09±0.30, p<0.001). The mean respiratory rate was significantly higher in children with cardiac dysfunction (41.16±7.27 vs. 37.18±6.56 breath/min, p=0.001). Table-I is showing details about the association of cardiac dysfunction with demographic, anthropometric, and vitals in children with SAM.

In terms of clinical presentation, bilateral pedal edema was significantly more prevalent in children with cardiac dysfunction (53.3% vs. 17.5%, p<0.001). Dyspnea (57.8% vs. 40.6%, p=0.043), abnormal fast breathing (40.0% vs. 20.3%, p=0.008), difficulty in breathing (66.7% vs. 44.8%, p=0.010), weight loss (40.0% vs. 20.3%, p=0.008), and hepatomegaly (40.0% vs. 20.3%, p=0.008) were also significantly associated with cardiac dysfunction, and the details are shown in Table-II.

Laboratory findings revealed that children with cardiac dysfunction had significantly lower hemoglobin levels (8.82±1.96 vs. 10.72±2.22 g/dL, p<0.001). Neutrophil counts were higher in children with cardiac dysfunction (66.82±13.60 vs. 60.64 ± 12.05%, p=0.004), while lymphocyte counts were lower (23.98±10.49 vs. 29.67 ± 10.21%, p=0.001). Chloride levels were significantly elevated in the cardiac dysfunction children (102.93±4.10 vs. 100.69±5.28 mEq/L, p=0.010). Other laboratory parameters, including total leukocyte count, platelet count, sodium, and potassium levels, did not differ significantly between children with or without cardiac dysfunction (Table-III).

Echocardiographic findings showed that children with cardiac dysfunction had a significantly lower mean ejection fraction (58.67±4.82 vs. 62.80 ± 3.87%, p<0.001).

Characteristics Yes (n=45)		Cardiac Dysfunction		P-Value
		No (n=143)		
Gender	Male	18 (40.0%)	59 (48.3%)	0.333
	Female	27 (60.0%)	74 (51.7%)	
Age (months)	6-12	9 (20.0%)	17 (11.9%)	0.217
	13-36	15 (33.3%)	40 (28.0%)	
	37-59	21 (46.7%)	86 (60.1%)	
Weight (kg)		8.02±2.67	8.75±2.32	0.076
Height (cm)		82.16±14.14	85.65±12.76	0.120
WHZ-score		-3.38±0.52	-3.09±0.30	<0.001
Middle-upper arm circumference (cm)		11.28±0.81	11.07±0.65	0.079
Systolic blood pressure (mmHg)		92.62±6.02	91.31±13.23	0.522
Diastolic blood pressure (mmHg)		44.49±5.00	46.64±7.24	0.065
Respiratory rate (breath/min)		41.16±7.27	37.18±6.56	0.001

Table-I. Association of cardiac dysfunction with demographic, anthropometric, and vitals in children with severe acute malnutrition (n=188)

Clinical Presentation	Cardiac Dysfunction		P-Value
	Yes (n=45)	No (n=143)	
Bilateral pedal edema	24 (53.3%)	25 (17.5%)	<0.001
Fever	17 (37.8%)	37 (25.9%)	0.124
Dyspnea	26 (57.8%)	58 (40.6%)	0.043
Abnormal fast breathing	18 (40.0%)	29 (20.3%)	0.008
Fatigue	8 (17.8%)	39 (27.3%)	0.200
Difficulty in breathing	30 (66.7%)	64 (44.8%)	0.010
Weight loss	18 (40.0%)	29 (20.3%)	0.008
Hepatomegaly	18 (40.0%)	29 (20.3%)	0.008
Bilateral lung crackles	12 (26.7%)	35 (24.5%)	0.767
Raised jugular vein pressure	12 (26.7%)	35 (24.5%)	0.767

Table-II. Association of cardiac dysfunction with clinical presentation in children with severe acute malnutrition (n=188)

Presentation	Cardiac Dysfunction		P-Value
	Yes (n=45)	No (n=143)	
Hemoglobin (g/dl)	8.82±1.96	10.72±2.22	<0.001
Total leukocyte count (10^9/L)	13.44±2.86	13.27±4.84	0.823
Neutrophils (%)	66.82±13.60	60.64±12.05	0.004
Lymphocytes (%)	23.98±10.49	29.67±10.21	0.001
Platelets (10^9/L)	274.42±200.65	260.84±118.39	0.577
Sodium (mEq/L)	138.60±5.24	138.30±5.64	0.753
Chloride (mEq/L)	102.93±4.10	100.69±5.28	0.010
Potassium (mEq/L)	3.81±0.54	3.78±0.59	0.718

Table-III. Association of cardiac dysfunction with laboratory parameters in children with severe acute malnutrition (n=188)

Right ventricular mass was significantly higher in children with cardiac dysfunction (18.27±4.34 vs. 17.10±3.03 g, p=0.045). Left ventricular mass was significantly lower in the cardiac dysfunction children (21.09±11.30 vs. 27.45±8.30 g, p<0.001).

DISCUSSION

In this study, 23.9% exhibited cardiac dysfunction, a prevalence that highlights the significant burden of malnutrition on cardiac health. The reduced LVM observed in children with cardiac dysfunction (21.09±11.30 vs. 27.45 ± 8.30 g, p < 0.001) mirrors results by Prajapati and Singh[13], who documented myocardial atrophy in children with SAM. Jain et al.[14], reported significantly lower LVM and increased myocardial performance index in SAM children compared to well-nourished controls (p<0.0001). Kumar et al.[15], demonstrated significant reductions in structural cardiac parameters, including LVM and interventricular septum thickness, among SAM children. These changes are consistent with the catabolic state and protein-energy deficits inherent in SAM, leading to progressive loss of myocardial mass.[16]

In this study, the mean EF in children with cardiac dysfunction was significantly lower than in those without (58.67±4.82 vs. 62.80±3.87%, p<0.001). This is comparable to findings by Prajapati and Singh[13], who observed reduced EF and fractional shortening in malnourished children, suggesting systolic dysfunction. In contrast, Pradhaa and Ramanathan[17] reported preserved systolic function despite reduced cardiac dimensions, with normal EF and fractional shortening in their cohort. This discrepancy may arise from differences in the severity of malnutrition, methodologies, or population characteristics. Among children with cardiac dysfunction, diastolic dysfunction was identified in 53.3% of children. This contrasts with findings from Silverman et al[18], who reported no significant differences in cardiac index or diastolic function between children with and without SAM. However, their study focused on stable hospitalized children. Brent et al.[10], also found no evidence of diastolic dysfunction but noted significant electrolyte disturbances, which may indirectly affect cardiac function. These differences highlight the heterogeneity of cardiac effects in SAM and the influence of clinical status and comorbidities.

Laboratory findings in this study further corroborate the systemic impact of SAM. Children with cardiac dysfunction had significantly lower hemoglobin levels (8.82±1.96 vs. 10.72±2.22 g/dL, p<0.001), and altered leukocyte profiles, with higher neutrophil counts (66.82±13.60 vs. 60.64±12.05%, p=0.004), and lower lymphocyte counts (23.98±10.49 vs. 29.67±10.21%, p=0.001). These findings align with **Silverman et al**[18], who identified anemia and immune dysregulation as common features in malnourished children. Elevated chloride levels in this study (102.93±4.10 vs. 100.69±5.28 mEq/L, p=0.010) further reflect electrolyte imbalances, which are well-documented in SAM and can exacerbate cardiac dysfunction.[19]

The high prevalence of cardiac dysfunction in this study underscores the need for routine cardiac evaluation in children with SAM. Reduced LVM and EF, along with high rates of diastolic dysfunction, highlight the vulnerability of the malnourished heart.[20] Echocardiography should be considered a critical component of the clinical assessment in this population, enabling early detection of structural and functional abnormalities.[21] Nutritional rehabilitation, though essential, must be carefully monitored to prevent complications such as refeeding syndrome, which can worsen cardiac dysfunction.[22] This study also emphasizes the importance of addressing comorbidities that may contribute to cardiac dysfunction. Anemia, electrolyte imbalances, and immune dysregulation are common in SAM and can exacerbate myocardial stress. Multidisciplinary management, including nutritional support, correction of metabolic derangements, and close monitoring of cardiac function, is essential to optimize outcomes.

This study had several limitations. Its cross-sectional design precludes assessment of causality or the temporal progression of cardiac changes in SAM. This study did not include cardiac biomarkers, such as BNP or troponins, which could have provided additional insights into myocardial stress and injury. Potential confounders, such as infections and other comorbidities, were not fully controlled for and may have influenced the prevalence of cardiac dysfunction. The use of 2D echocardiography, though widely available, may lack the precision of advanced imaging modalities, such as cardiac MRI.

CONCLUSION

This study highlights the significant burden of cardiac dysfunction in children with SAM. Reduced left ventricular mass, impaired ejection fraction, and high rates of diastolic dysfunction underscore the impact of malnutrition on cardiac health. These findings emphasize the need for early cardiac evaluation and integrated management strategies in children with SAM. By addressing both nutritional and cardiac health, we can enhance care for malnourished children and reduce the morbidity and mortality associated with SAM.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

SOURCE OF FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Ramsha Mehmood:** Data collection, drafting, responsible for data's integrity, approval for publication.
2	**Arit Parkash:** Study concept, design, methodology, critical revisions, approval for publication,
3	**Sadaf Asim:** Data analysis, methodology, proof reading, approval for publication