Cardiac Findings In Patients 6-60 Months of Age Filipinos with Acute Malnutrition: A Preliminary Study

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Abstract

There is a consensus that cardiac size is reduced in proportion to body mass in malnourished children, but with conflicting findings in cardiac functions. This descriptive-cross sectional study was conducted at a tertiary hospital to evaluate the cardiac findings among patients 6-60 months old with acute malnutrition using chest x-ray, electrocardiogram (ECG), and 2-D echocardiogram (2D-echo). Included in the study were 22 patients. Fourteen (14) of whom had moderate acute malnutrition (MAM) while 8 had severe acute malnutrition (SAM). Both the MAM and SAM groups have cardiothoracic (CT) ratios within normal range but lower than the mean for MAM patients 6-36 months old. ECG studies generally showed low R wave amplitude in both groups and shortened PR interval in the SAM group. Sinus tachycardia appeared to be more common in the SAM group at 50% (4/8) compared to the MAM group at 21% (3/14). 2D-echo measurements of chamber and wall dimensions on both groups were within normal limits; comparison of both groups showed the SAM group had lower left atrial dimensions and left ventricular end-systolic dimensions (LVESD) compared to the MAM group (p values of 0.006 and 0.037 respectively). Pulmonary artery pressure was higher in SAM compared to MAM with a p value of 0.026. In both groups, systolic and diastolic functions were within normal range. MAM patients 6-36 months of age have CT ratios lower than the mean. Low R wave amplitudes are seen in both groups. Those with SAM have more tachycardia and shorter PR interval. There is a trend for the SAM group to have a smaller left atrial

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and left ventricular end-systolic dimensions and higher pulmonary artery pressure. Systolic and diastolic functions are preserved in both groups. These cardiac findings are suggestive of the effects of malnutrition on the heart.

Keywords: acute malnutrition, chest x-ray, electrocardiogram, 2D echocardiogram, moderate malnutrition, severe malnutrition

INTRODUCTION

Malnutrition is still a major cause of global childhood morbidity and mortality. Global overview of child malnutrition estimates that 49 million (7.3% prevalence) are wasted (Safety, 2019). Although in the 2019 WHO report there has been progress in reducing the under-5 mortality rate, nutrition related factors is still a significant factor contributing to about 45% of deaths in children under 5 years of age (World Health Organization: WHO, 2020).

In the Philippines, while the prevalence of malnutrition has decreased over the last two decades, the burden still remains high. The 8th National Nutrition Survey (NNS) in 2013 revealed that the national prevalence of wasting among children 0-60 months increased to 7.9 % from 7.3% in 2011 (Gumaru, n.d.-b). In the latest 2015 NNS survey in Iloilo Province, the prevalence of wasting among children less than 5 years of age is 6.2 % compared to 9.9 % in 2013.The 2015 Philippine Nutrition Anthropometric survey revealed that among children 0-60 months of age in Western Visayas, the percentage distribution of severely wasted is 1% and for moderately wasted is 5.3%(eNutrition - Food and Nutrition Research Institute, n.d.-c). The 2011 Family Health Survey revealed that an estimated 30 children for every 1,000 live births in the Philippines will likely die before reaching age five. The leading causes of death in this age group are still pneumonia and diarrhea. Malnutrition is the underlying contributing factor, making children more vulnerable to severe diseases (Death Among Children Under Five Years of Age Continues to Decline (Results From the 2011 Family Health Survey) | Philippine Statistics Authority, n.d.-c).

Malnutrition-related mortality is often due to infection or dehydration (Ashworth, 2001; Brewster, 2006). One probable reason why children with severe acute malnutrition (SAM) die is that no allowance is made when prescribing treatment for the profound physiologic and metabolic changes that have taken place in almost all of the organ systems including the heart (Ashworth, 2001). Some have proposed that cardiac dysfunction may be associated with some unexplained deaths directly or through decompensation after aggressive fluid resuscitation or because of inadequate correction of volume depletion because of fear of cardiac failure (Brewster, 2003; Smythe,etal, 1962; Bergman et al., 1988; Akecch, et al., 2010). Although there has been a consensus that cardiac size reduces in proportion to body mass in malnourished children, there have been conflicting findings regarding cardiac function.

Malnutrition, regardless of its type, has a definite effect on cardiac volume, muscle mass, as well as the electrical properties of the myocardium. The systolic functions of the heart are affected more than the diastolic functions and this affection becomes manifest only in severe cases and may constitute a bad prognostic parameter, thus necessitating more intense management and strict follow-up of such cases (El-Sayed et al., 2005). A study demonstrated that left ventricular mass and cardiac output were reduced in proportion to decrease in body size in patients with protein energy malnutrition but left ventricular systolic and diastolic functions were preserved in atrophic hearts (Ocal et al., 2001). One study showed that the heart is not spared in malnutrition; however, the decrease in cardiac output in the starved patient is matched by various compensatory mechanisms such that cardiac failure is unusual (Webb et al., 1986). Another study showed that important electrocardiographic and echocardiographic abnormalities have been found in malnourished children associated with their nutritional status. Thus, special precaution must be taken about the possibility of occurrence of arrhythmias and sudden death related with malnutrition (Olivares et al., 2005). However, a more recent study showed no significant difference in the cardiac function between hospitalized children with and without severe acute malnutrition (Silverman et al., 2016).

There is still substantial confusion with respect to the understanding of the complex interaction of myocardial dysfunction and circulatory failure, well recognized in pediatric critical illness, with that of heart failure and circulatory overload. The conflicting findings on the cardiac functions of children with SAM pose a big challenge in the fluid and electrolyte management of these patients. Adding to this confusion is the lack of knowledge about the cardiac function of children with moderate acute malnutrition (MAM). What is known, however, is that if moderate malnutrition is not properly managed, it can lead to severe acute malnutrition (Silverman et al., 2016).

The dearth of local studies on the cardiac functions of this group of patients has resulted in anecdotal assumptions as to the sudden cause of death of children with acute malnutrition while undergoing fluid and nutritional therapy. This prompted the need to conduct this exploratory study. It aimed to describe the cardiac findings of patients 6-60 months of age with moderate to severe acute malnutrition seen at a tertiary medical center using chest x-ray, ECG and 2-D echo. The results of which can lead to more extensive studies on the impact of malnutrition to the heart.

METHODS

Research Design

This was a descriptive cross-sectional study conducted at a tertiary medical center from February 1, 2019 to May 31, 2020.

Setting and samples

Convenience sampling was utilized. All service patients 6- 60 months of age seen at the emergency room/ward /out-patient department of a tertiary medical center identified to have moderate or severe malnutrition using the weight for length/height (Safety, 2008) and/or mid upper arm circumference (Safety (2007)of the WHO growth standards were considered for inclusion in the study. The patients with weight-for-height/length between -3 and -2 Z-scores of the WHO Child Growth Standards and/or mid-upper-arm circumference (MUAC) greater or equal to 115 mm and less than 125 mm were identified as having moderate acute malnutrition. Those with weight-for height/length below -3 SD of the WHO child growth standards and/or MUAC less than 115 mm were labelled as severe acute malnutrition (Lenters et al., 2016).

Excluded were critically ill malnourished patients, delivered preterm or low birth weight, those diagnosed with congenital heart disease by history, physical examination and/or laboratory work up, with hemoglobin levels ≤ to 6 g/dl, on medications that can affect cardiac function such as calcium channel blockers, diuretics, beta-blockers, inotropes, angiotensin receptor blockers, antiarrhythmic drugs and chemotherapeutic drug; diagnosed by history and/or laboratory to have metabolic problems, and with severe skeletal deformity that will affect accurate measurement of the weight, length/height or mid-upper arm circumference as determined by the researcher. Subjects with moderate and severe malnutrition who met at least one exclusion criteria except for the hemoglobin level criterion were immediately excluded from the study.

For those who met the eligibility criteria, written informed consent was obtained from the parents/caregivers after a thorough explanation by any of the four investigators.

The study protocol was approved by the Ethics Committee. All the participants underwent nutritional rehabilitation using WHO protocol. All participants were under the care of the pediatric gastroenterologist and those with significant cardiac dysfunction were evaluated and managed by a pediatric cardiologist, who were all part of the research team. All the participants enrolled with other existing co-morbidities were managed according to established treatment guidelines of the Philippine Pediatric Society.

Measurement and data collection

The enrolled patients had their complete blood count (CBC) taken. Those with hemoglobin level ≤ to 6 g/dl 6 g/dl were then excluded. Those with hemoglobin more than 6 g/dl comprised the final study population and were subjected to the following tests for cardiac evaluation within 48 hours after enrolment.

1. Chest x-ray APL views

Cardiac size was evaluated by obtaining a chest radiograph in antero-posterior/postero-anterior and lateral views with the central ray perpendicular to the plane of film centered on the midpoint of the chest, 40 inches away.

2. 15 lead electrocardiograms (ECG)

A single electrocardiographic machine, Fukuda Cardisunymodel was used in the study. The parameters described were as follows: rate, axis, PR interval, corrected QT interval, p, Q , R and T wave amplitudesas well as ST- T wave appearance. R wave amplitudes were measured in 2 limb leads (I,II), 1 augmented lead (AVF), right precordial leads (V3R, V1, V2) and left precordial leads (V5,V6).

3. 2D-echocardiography

A single echocardiography machine Toshiba Xario 200 model was used throughout the study. Each qualified subject underwent a standard 2-dimensional echocardiography and color flow doppler study procedure. The patient was made to assume right lateral decubitus position and was subjected to the standard echocardiographic views in real-time (B-mode), M-mode, Color and Doppler investigation.

Only one radiologist interpreted the chest x-ray. Likewise, both the ECG reading and the 2D-echocardiography were done by a single pediatric cardiologist. This was done to reduce bias in the interpretation of the results. Both are board certified in their respective specializations. Periodically, the senior pediatric residents were reoriented regarding the proper procedures in obtaining the anthropometric measurements of the subjects

Data analysis

SPSS 20.0 software was used in processing and analyzing the data gathered. The data were described using means, standard deviations, frequency and percentage analysis. The results were presented in tables and graphs. Statistical significance using Pearson chi-square was determined by a p value less than 0.05. Independent Sample t-test was utilized to compare the mean difference between MAM and SAM. A statistical software (Stata) was used to solve for the statistical power which was approximately 0.392 showing that the results of the study may not have a strong ability to detect real differences or effect between the MAM and SAM group. Cohens d was calculated to measure effect size and it was approximately 0.44, interpreted as medium sized effect. However, since this is a preliminary study, the authors would like to focus on the trends.

RESULTS

A total of 22 patients made up the final study population. Fourteen (14) or 64% of whom were moderately malnourished while 8 or 36% were severely malnourished. The majority of patients in both groups belonged to 13-36 months age bracket (50% for MAM and 62.5% for SAM). Ten (10) or 71.4% of patients with MAM were males while patients in SAM group were equally distributed as to gender. Four patients in the MAM group had co-morbidities in the form of pneumonia and bronchial asthma. Meanwhile, only one out of eight patients in the SAM group had co-morbidity (intussusception).

Table 1. Mean Cardiothoracic ratio (CTR) for MAM and SAM

Age Group	Normal Range for Age	Mean CTR	MAM Mean CTR	SAM Mean CTR	p Value
6-12 months	0.39-0.65	0.49	0.47	0.54	
13-36 months	0.39-0.60	0.49	0.48	0.51	0.81
37-60 months	0.40-0.52	0.45	0.47	0.47	

All patients, either with moderate or severe acute malnutrition, have cardiothoracic ratios well within the normal range based on measurements on chest x-rays. However, it is worthy to note that those CTR of MAM patients

6-36 months old were below the mean.

Table 2. Electrocardiographic findings in moderate and severe acute malnutrition

Electrocardiographic parameters	Normal Value	Moderate Acute malnutrition n= 14		Severe acute malnutrition n=8			
		Mean	SD	Mean	SD	*t*	p Value
Heart rate (mean)	-	114.36	22.2360	132.31	17.4682	-1.958	0.064
P amplitude (mV)	<3	1.18	0.3167	1.12	0.3536	0.366	0.718
PR interval (msec)	0.11-0.13	0.11	0.0149	0.10	0.0125	1.514	0.146
R I amplitude (mV)	7-8	5.90	1.9965	5.94	2.2430	-0.041	0.968
R II amplitude (mV)	12-27	11.71	4.8107	12	2.8284	-0.153	0.880
R AVF amplitude (mV)	10-20	10.18	5.5248	10.94	3.3213	-0.352	0.729
R V3R	5-11	6.14	3.0346	7.125	4.9911	-0.578	0.570
R V1 amplitude (mV)	8-10	8.78	3.8611	6.75	3.8822	0.625	0.539
R V2	15-32	15.07	6.4981	13.38	6.5670	0.587	0.64
R V5	20-33	17.57	6.5510	16.75	8.2937	0.257	0.800
R V6 amplitude (mV)	13-15	11.07	4.3050	11.19	5.8306	-0.054	0.958
T amplitude (mV)	-	2.64	1.1837	2.50	1.0690	0.568	0.781
Q wave V6	0.5-3	1.79	1.1387	1.44	1.1160	0.695	0.495
QTc (msec)	0.36-0.44	0.39	0.0182	0.39	0.0182	0.413	0.796
QRS Axis (degrees)	60-120	70.71	13.708	73.12	13.7080	0.394	0.732
QRS duration	0.05-0.075	0.67	0.0127	0.68	0.0149	-0.060	0.953

Based on the normative table of values by Park (2014),electrocardiographic parameters showed shortened PR interval and low R amplitudes in Leads I, V1, V5 and V6 in the SAM group. The MAM group showed normal PR interval and low amplitudes in Leads I, II, V5 and V6. On the other hand, the comparison of the two groups did not show significant difference when scrutinized as to amplitude and duration of electrical activity. SAM group was noted to have faster heart rate than the MAM group but this is not statistically significant.

Other cardiac findings noted were sinus tachycardia in 4 (50%) of the severely malnourished group compared to 3 (21%) in MAM patients. Meanwhile, sinus arrhythmia was seen in 3 MAM patients and 1 in SAM patient. Some subjects have more than one finding on final interpretation. One participant in the severely malnourished group was found to have left ventricular hypertrophy by voltage. Another participant in the severely malnourished group showed low T waves.

Table 3. 2D-echocardiography M-mode cardiac dimensions in MAM and SAM

Cardiac parameters	BSA 0.3-0.6	Moderately malnourished (n =14)		Severely malnourished (n=8)			
	Normal Mean	Mean	SD	Mean	SD	*t*	p Value
Left atrium	1.6-2.0	1.84	0.1692	1.58	0.2252	3.085	0.006
Aorta	1.2-1.5	1.56	0.1790	1.49	0.2232	0.779	0.445
Right ventricular dimension at end diastole (RVDd)	0.9-1.9	0.85	0.1036	0.89	0.1157	-0.783	0.443
Left ventricular dimension at end diastole (LVDd)	2.2-3.0	2.77	0.1863	2.56	0.3105	1.965	0.063
Left ventricular dimension at end systole (LVDs)	1.3-1.9	1.71	0.1895	1.51	0.2159	2.236	0.037
Interventricular septum thickness at end-diastole (IVSd)	0.35-0.45	0.45	0.0464	0.42	0.0674	1.209	0.241
Interventricular septum thickness at end-systole (IVSs)	-	0.64	0.1038	0.60	0.0698	0.993	0.332
Left ventricular posterior wall thickness at end-diastole(LVPWd)	0.35-0.45	0.52	0.0658	0.48	0.0481		0.129
Left ventricular posterior wall thickness at end-systole(LVPWs)	-	0.76	0700	0.71	0.1161	1.585	0.209
Left ventricular mass	-	23.96	5.7355	26.51	5.7477	1.297	0.328
Left ventricular Mass Index by BSA (ASE)	-	56.50	10.3904	56.12	7.5864	-1.002	0.930

M-mode echocardiogram was utilized to measure the various cardiac chamber and wall dimensions. The comparison of the two groups as to the mean values of the dimensions of the following cardiac structural parameters: aorta,LVDd IVSd, IVSs, LVPWd, LVPWs and left ventricular mass index were slightly lower in SAM group than the mean values demonstrated by the MAM group except for the RVDd. Moreover, dimension of the left atrium and LVDS were significantly lower in the SAM group compared to the MAM group with p value of 0.006 and 0.037 respectively.

Table 4. 2D-echocardiography M-mode cardiac functional parameters in MAM and SAM

Cardiac functional parameters	Moderately malnourished (n =14)		Severely malnourished (n=8)			
	Mean	SD	Mean	SD	*t*	p Value
Systolic function LV						
• ejection fraction (%)	69.86	4.88	73.00	4.53	-1.489	0.152
• fractional shortening (%)	38.07	3.62	40.25	3.91	-1.317	0.203
Systolic function RV						
• TAPSE (mm) (Z score)	17.79	1.62	17.60	2.41	0.216	0.831
• FAC (%)	47.79	5.23	50.25	6.58	-0.968	0.345
Diastolic function LV						
• MV E/A ratio	1.57	0.18	1.48	0.10	1.234	0.231
Diastolic function RV						
• TV E/A ratio	1.50	0.253	1.64	0.26	-1.197	0.245
Pulmonary artery pressure						
• By TR Jet	31.8	5.57	38.00	0.0000	-1.487	0.171
• By PAT	36.5	10.35	48.6	13.32	2.397	0.026

*TAPSE – Tricuspid annular plane systolic excursion; FAC – Fractional area change
* TR – tricuspid regurgitation*PAT – pulmonary acceleration time
*LV – left ventricle; RV – Right ventricle; MV – Mitral valve; TV – tricuspid valve

Table 5. Cardiac findings on Chest X-ray, ECG and Echocardiography among children with moderate acute malnutrition and severe acute malnutrition

Cardiac Findings	MAM (n=14)	Percent	SAM (n=8)	Percent
Chest X-ray Normal CT ratio	14	100	8	100
ECG				
Sinus tachycardia	3	21	4	50
Low T waves	0	0	1	12
LVH by voltage	0	0	1	12
Short PR interval	6	42	5	62
Low R wave amplitudes				
I	10	71	5	62
II	4	28	4	50
V1	8	57	5	62
V 5	8	57	6	75
V6	10	71	6	75
2D -echo				
Normal dimensions	14	100	6	75
Normal systolic function	14	100	8	100
Normal diastolic function	14	100	8	100
Tricuspid regurgitation	9	64	2	25
PAP by PAT >40	6	42	6	75

All participants have normal CT ratio. Sinus tachycardia is seen in both groups but more common in SAM. Two participants in the SAM group have tricuspid regurgitation, whereas MAM group had nine. All patients in MAM have normal cardiac chamber and wall dimensions except for 2 participants in the SAM group who have lower left atrium dimension and left ventricular dimension at end systole. Two participants in the SAM group have tricuspid regurgitation whereas MAM group had nine. All patients have no systolic or diastolic dysfunction. Pulmonary artery pressure of >40 mmHg by pulmonary acceleration time was seen more in the SAM group

DISCUSSION

A total of 22 patients with wasting were enrolled in the study, 64% had moderate acute malnutrition while 36% had severe acute malnutrition, non-edematous type.All were seen at the OPD except for 1 patient with SAM who was admitted with a co-morbidity. Recruitment of participants was greatly affected by the Covid 19 pandemic because of a drastic decrease both in OPD consults and hospital admissions.

In this study, the cardiac status of pediatric patients 6-60 months old was assessed using chest x-ray, ECG and 2D-echo, respectively.

Chest x-ray showed cardiothoracic ratios (CTR) well within the normal range. It is notable, however, that all the particpants with MAM and participants 37-60 months of age with SAM have CTR falling below 0.50. A small heart was defined as having a CTR of less than 0.50 (Smythe et al., 1962) others define microcardia as having a CTR of 0.40 (Kothari et al., 1992). The cardiac silhouettes of the participants did not exhibit microcardia radiologically, having cardiothoracic ratios of more than 0.40. Yet, some of the values are also below the mean values underscoring the fact that malnutrition affects tissue protein throughout the body and the probability that the heart muscle is also affected by wasting. A small heart may result from rapid decrease in blood volume as is in the case of dehydration due to reduced fluid intake or extensive fluid loss (Swischuk, 1968). In this study, the p-value for the CT ratio is greater than the 0.05 level of significance; suggesting changes in nutritional status have no significant overall effect on the cardiothoracic ratio.

Electrocardiographic findings have been noted both in MAM and SAM patients. Sinus tachycardia is found in half of the severely malnourished group. Meanwhile, one participant in the severely malnourished group was found to have left ventricular hypertrophy by voltage, most likely due to a thin chest wall resulting in tall QRS complexes. Another participant in the severely malnourished group showed low T waves. Similar ECG findings like sinus tachycardia (91%), were also noted in 90 Nigerian children with edematous SAM (Olowonyo et al., 1993). Increased heart rate is also seen in a study in India involving 100 children with SAM both edematous and non-edematous (Sharma et al., 2017). Low T waves is seen in a study in SAM where 88% of cases had altered (flat to depressed) T wave at the time of admission (Kumar et al., 2015).

Notably, low R wave amplitudes are found in both groups which are similar to the study done in Nigerian children whose ECG showed also low QRS amplitude (Olowonyo et al., 1993). In this study, PR interval in the SAM group was shortened; corrected QT interval was normal in both groups as opposed to prolonged QTc interval in the Nigerian study (Olowonyo, et al., 1993). The study in Indian children likewise showed shortened PR interval, shortened P wave, QT and QTc in their ECG (Sharma et al., 2017).

The conflicting results in the ECG findings could probably be explained by the type of SAM patients enrolled. The present study involved non-edematous SAM unlike in the other two studies who dealt with edematous

SAM in the Nigerian study and mixed edematous and non-edematous in the Indian study. Although, all studies reviewed on the cardiac structure and function in acute malnutrition were done in SAM patients, the group with MAM enrolled in our study already showed significant ECG findings like low R wave amplitudes which may suggest beginning effect of malnutrition on the heart.

M-mode echocardiogram was utilized to measure the various cardiac structural parameters. Comparison of the two groups as to the mean values of the dimensions of the aorta, interventricular septum during diastole (IVSd), left ventricular end diastolic dimension (LVDd), left posterior wall diastolic dimension (LVPWd) and left ventricular mass index were slightly lower in SAM group than the mean values demonstrated by the MAM group except for the right ventricular dimension (RVDd) during diastole but were not statistically significant. There was a significant difference, however, in the measurement value of the left atrium (p value 0.006) and the LVDs (p value 0.037) in the SAM group compared to the MAM group. This decrease in the dimension of the left ventricle at end systole in patients with SAM is seen also in a study involving 32 children with SAM (Agrawal et al., 2016). However, that study also showed significant reduction of other cardiac dimensions like LV end diastolic diameter, LV posterior wall diameter and LV mass. Another study also concluded that LV mass is reduced in malnourished children (Hassan et al., 2010). Although in this study, LV end diastolic diameter, LV posterior wall diameter, and LV mass dimensions were lower in SAM compared to MAM. It was not statistically significant probably because of the small sample size.

In the assessment of the functional parameters, left ventricular systolic function was determined by ejection fraction (EF) and fractional shortening (FS). The SAM group has a slightly higher EF 72% vs 69.7% and FS 40% vs 38% than the MAM group. Right ventricular systolic function was assessed by measuring the tricuspid annular plane systolic excursion (TAPSE) which showed almost similar values in both groups (MAM: 17.7 vs SAM 17.6 mm) and fractional area change (FAC) which showed higher FAC value in SAM than in the MAM group 50.2% vs 47.9%. All values were within normal limits. Diastolic function investigation was limited in this study utilizing only E/A ratio by Doppler as parameter. MAM vs SAM group mean MV E/A was 1.55 vs 1.47 and mean TV E/A was 1.5 vs 1.63. Left ventricular function is preserved similar to other studies (Ocal et al., 2001; Olivares et al., 2005; Agrawal et al., 2016). Left ventricular dysfunction is mostly seen in studies in edematous SAM (Shoukry et al., 1986; Olowonyo et al., 1993).

The pulmonary artery pressure was estimated using the tricuspid regurgitation jet if present and pulmonary artery acceleration time (PAT). The results showed higher pulmonary artery pressure in the SAM group than the MAM group. Pulmonary artery pressure mean values calculated by TR Jet were 38 vs 31.8 mmHg and by PAT 48.6 vs 36.5 mmHg. The analysis showed pulmonary pressure based on the 2 parameters is is higher in the SAM group. Ideally, PAP is measured in a resting patient, preferably sedated to get a more reliable approximation of pulmonary artery pressure. However, in this study, all the participants were not sedated, and younger patients tend to be more uncooperative hence the higher PAP values. Moreover, the patients with respiratory symptoms may also present with slight PA pressure elevation.

Two participants in the SAM group had tricuspid regurgitation, whereas MAM group had nine. Tricuspid regurgitation is generally considered physiologic or functional. It can be utilized to assess right ventricular and/or pulmonary artery pressure. There was no participant with pericardial effusion unlike in another where pericardial effusion is seen in patients with SAM (Sharma et al., 2017).

This study is limited by the small number of subjects which will preclude a more reliable and valid conclusion. Convenience sampling, lack of interobserver reliability, and the skewed number of participants in the 2 groups are inherent sources of bias. Diastolic function was not explored extensively in this study.

CONCLUSION

In this study, moderately and severely undernourished children have cardiothoracic ratios within normal range but lower than the mean. ECG studies generally showed low R wave amplitude in both groups. Those with SAM have more tachycardia and shorter PR interval. There is a trend for the SAM group to have a smaller left atrial and left ventricular end-systolic dimensions and higher pulmonary artery pressure. The systolic and diastolic functions are preserved in both groups

It is recommended that more participants should be enrolled in order to arrive at a more robust conclusion. A similar study with well nourished children serving as a control group can also be done.

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