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Study of The Cardiac Function of Children Aged from 6 to 59 Months Suffering from Severe Acute Malnutrition in Yaounde Cameroon

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ABSTRACT

Background: *Malnutrition is a real public health problem in developing countries. The prevalence remains high in Cameroonian.*

Context: *This condition is regularly accompanied by organ failure. One of the most frequent and severe situations is cardiac involvement with implications on the management of patients. Describing the echocardiographic abnormalities of the heart function of children aged 6 to 59 months hospitalized for Severe Acute Malnutrition (SAM) in the hospitals of Yaoundé was the goal of this study. Knowledge of changes in heart function during the management of SAM will contribute to ameliorating the prognosis, which will also depend on the cardiac lesions.*

Methods: *It was a cross sectional descriptive study carried out in healthcare structures in the town of Yaoundé for a period of 5 months, from January to May 2015. Children aged 6 to 59 months suffering from severe acute malnutrition and hospitalized for at least 6 days were included. We excluded those who had a pathology which could influence heart function. Data collected covered the sociodemographic, clinical and echocardiographic characteristics of the study participants.*

Results: *Most of the 78 children recruited were less than 18 months old (81.08%). The sex ratio was 0.6. Marasmus was the most common type of SAM we found (78.38%). Concerning echocardiography, 35.14% of children had a left ventricular shortening fraction (LVSF) and a Left Ventricular Ejection Fraction (LVEF) less than the 3rd percentile. In all the patients, the speed of the E and A waves was less than -2SD of reference means. The ratio of the E/A waves was less than the 5thpercentile in 35.14%. All had a Tricuspid Annular Plane Systolic Excursion (TAPSE) <-2SD of the reference mean. The decrease of the LVEF was significantly linked to the young age of the patients and to the degree of severity of the malnutrition.*

Conclusion: *severe acute malnutrition is associated with both systolic and diastolic heart failure. Functions of the two ventricles are altered. The severity of heart lesion depends on the degree of malnutrition.*

Keywords
Heart function, Severe Acute Malnutrition, Children.

Background

Severe acute malnutrition remains a public health problem in developing countries [1]. Being one of the causes of mortality in Africa, it is one which policy find difficulties in apprehending and halting. Although the global mortality of children below 5 years in Africa has reduced by 14% since 1990, the number of malnourished children has kept increasing in Africa [1]. In Cameroon, the third

health and demographic research in 2004 showed the at 18% of children presented with weight deficiency and 5% suffered from acute malnutrition, of which 1% was severe [2]. In 2011 acute emaciation was present in 6% of children below the age of 5 years with 2% of severe forms. Children below 18 months were the most affected (9%) [3].

Severe malnutrition causes organ, system and even multivisceral failures of nutritional origin and intercurrent pathologies which could affect heart function to varying levels [4]. In view of the structural and functional impacts of cardiac lesions described by Ellis and al up to Amals and al in 2014, the median mortality rate due to SAM which is usually found between 30 and 50% can significantly reduce if the treatment took into account the multi organ physiological and metabolic changes observed during this illness [5].

This rate is particularly increased during the management of complications like severe anemia, dehydration, and during renutrition in the acute phase with the renutrition syndrome due to an acute heart failure. Taking into account the physiological and metabolic changes which occur in SAM implies particular treatments [5]. The goal of our work was to describe the frequencies and the types of echocardiographic abnormalities of heart function in children aged between 6 and 59 months hospitalized for SAM at the onset of the management in hospitals in Yaounde.

Methods

Study type

It was a cross sectional descriptive study.

Study period

The study went on for 5 months, from January 1st to May 31st 2015.

Study location

Patients were recruited in 5 healthcare centers in the town of Yaounde, having a unit for nutritional rehabilitation, and having a pediatrician in charge. They were: The Chantal Biya Foundation (CBF), The Yaounde University Teaching Hospital (YUTH), The Yaounde Gynecological Obstetric and Pediatric Hospital (YGOPH), The Biyem-Assi District Hospital (BDH), The Saint Martin de Porrès Dominican Hospital center at Mvog-Betsi. As for the paraclinical workup, a laboratory for biomedical analyses was the place for the lab tests to be carried out. The cardiac ultrasound examinations (echocardiography) were done in a pediatric cardiology unit at the Chantal Biya Foundation by a pediatric cardiologist.

Study population

It was made of patients aged 6 to 59 months hospitalized for severe acute malnutrition, in the said hospitals for less than six days. They were included in the study after informed consent was obtained from their parents. We excluded children who were in a state of shock, those who presented with a chronic pathology which could have an impact on heart function (Congenital cardiopathies, pericarditis, valvulopathies, sickle cell anemia, HIV infection) as well as those having severe anemia.

Recruitment procedure

The recruitment of participants was consecutive during a random sampling. The size of the study population was limited to the number of patients who fulfilled our inclusion criteria. We pre-selected patients aged 6 to 59 months on the basis of anthropometric parameters and according to the criteria of the WHO defining Severe Acute Malnutrition [6].

The children went through complete clinical examination after written or verbal informed consent of the parents. In these children who were retained as study participants, a 5 ml sample of blood was taken from them and sent to the BETHANIE laboratory for hemoglobin electrophoresis and full blood counts to be done. Two HIV rapid diagnostic tests were equality done; Polymerase Chain Reaction couldn't be done since it was on such short notice. All the participants exposed to HIV, as well as the Sicklers and those who had severe anemia were excluded from the rest of the study.

Cardiac ultrasounds were done only on the eligible study participants. A device of the mark Accuson Cypress, Siemens with two multi-frequency cardiac probes: 3V2c(3.5/3.0/2.5/2.0 MHz) and 7V3c(7.0/6.0/5.0/3.5 MHz) was used. The same technician did all the heart ultrasounds which were all transthoracic in the TM, dimensional, pulse Doppler, continuous and color. The following incidences were systematically done on each eligible participant: sub-costal, para-sternal, large axis, para-sternal, small axis, 4 cavities apical, 5 cavities apical, and finally supra-sternal. Depending on the appropriate incidence, the examination was done on patients in both the dorsal decubitus and the left lateral decubitus positions.

All the cardiac ultrasound measurements were done following the American Society of Echocardiography recommendations [7]. The systolic function of the left ventricle was evaluated by the Left Ventricular Shortening Fraction (LVSF), as well as the Left Ventricular Ejection Fraction (LVEF). It was the same thing for the diastolic function by the speed of the Mitral E and A waves and the E/A ratio.

As for the right ventricle, only its systolic function was evaluated by TAPSE. The echocardiographic parameters of each patient were compared to the reference central tendency values. The LVEF and the LVSF were considered as abnormal when they were out of the 3rd and 97th percentile (P3 and P97).

As for the values of the E and A waves, they were considered abnormal when they were out of the 5th and the 95thpercentiles (P5 and P95). The TAPSE was considered to be abnormal when it was less than the mean minus 2 standard deviations [8-10].

Statistical Analysis

The Epi Info version 3.5.3 was used to analyze the data. Quantitative variables were described using means ± standard deviation and

were compared using the Student's test. Qualitative variables were expressed in the form of proportions. The comparison between different sub groups of variables was done using the Fisher test for categorical data. Probability values P<0.05 were considered to be statistically significant.

The analyses concerned sociodemographic (age in months, gender), clinical (vital parameters: heart rate, respiratory rate, blood pressure as well as the nutritional status: Weight for Height (W/H expressed in Z scores), the type of Severe Acute Malnutrition especially marasmus, kwashiorkor and kwashiorkor-marasmus). Anthropometric parameters were interpreted with the help of the WHO-Anthro software version 3.2.2. Concerning the heart function, the variables studied included: LVEF, LVSF, E wave, A wave, E/A ratio, TAPSE. The mean values of these variables were compared to vital parameters, to anthropometric indices W/H as well as to the type of malnutrition.

Ethical considerations

Our study obtained ethical clearance from the ethical committee of the Faculty of Medicine and Biomedical Sciences of the University of Yaoundé I. Informed consent of the parents was first of all obtained before any clinical or biological investigations were carried out on the children.

Results

During the period of study, 78 children aged 6 to 59 months and suffering from SAM were recruited. We excluded 41 of them who didn't meet up with our criteria (30 for positive HIV serology, 01 for sickle cell, 07 for severe anemia with hemoglobin less than 4 g/dl and 03 for state of shock. Only 37 children were retained.

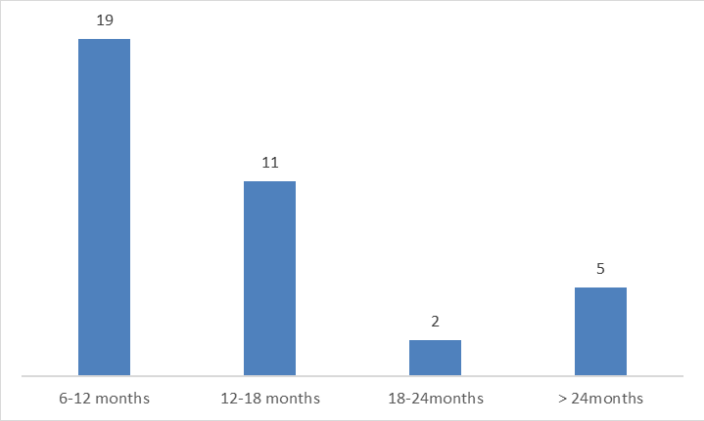

Figure 1: Distribution of patients by age in months.

General characteristics of the study population

More than half (51.4%) of the patients were less than a year old (Figure 1) and 81.1% of children were less than 18 months old. Boys were 14 in number (37.8%) while girls were 23 in number (62.2%), giving a sex ratio of 0.6.

Clinical presentation

Marasmus was the more common type of SAM we came across in our study population, as it was found in 29 (78.4%) children. Kwashiorkor-marasmus followed, as we found it in 5 (13.5%) children and kwashiorkor in 3 (8.1%) others (Figure 2). Fever and loss of appetite were the most common reasons for hospitalization in 27 (73%) and 23 (62.2%) children respectively.

Almost all the patients had abnormal vital parameters. These were: Hypotension which was observed in 36 (97.3%) of children, abnormalities of the heart rate such as tachycardia in 14 (37.8%) patients and bradycardia in 22 (59.5%) children; abnormal respiratory rates which included tachypnea in 20 (54.1%) children and bradypnoea in 8 (21.6%) patients.

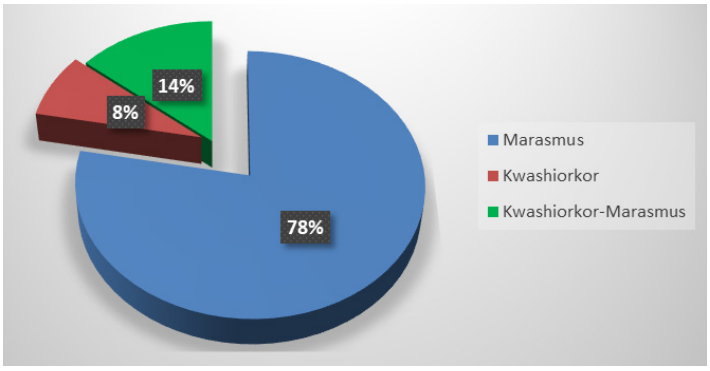

Figure 2: Distribution of patients according to the type of SAM.

The distribution of anthropometric parameters according to the weight for height (W/H) (Z-score) enabled us to identify and distinguish 3 levels of severity of SAM: 16(43,3%) patients had -4 ≤ W/H<-3; 12 (32,4%) had -5≤W/H<-4 and 9(24,3%) had -9≤W/H<-5.

Cardiac function

The LVSF was altered in 13 (35, 14%) patients (Table 1). As for the diastolic function, we noticed abnormalities with the relaxation and filling of the left ventricles in all patients (E waves and A waves of low amplitude in all the eligible study participants). But the E/A ratio enabled us to detect a real and significant relaxation disorder in 13 (35.14%) patients (E/A < 5th percentile) and a restrictive disorder in 01 (2.7%) patient (E/A>95th percentile). We didn't notice any significant change in the systolic function of the left ventricle depending on the type of SAM (Table 2).

However, the filling of the left ventricle appeared to be altered more in those suffering from kwashiorkor than in others (p=0.04). Whatever the type of malnutrition, the systolic and diastolic functions of the left ventricle were more altered as the degree of malnutrition evaluated by the Z-score was advanced (p<0.05) (Table 3).

Likewise, both systolic and diastolic heart function was more impaired when the patient was less than one year (Table 4). Only the systolic function of the right ventricle was evaluated, using the TAPSE. It was altered in all the patients (100%) whatever the type of SAM. The degree of alteration of this function was not a function of the type of SAM.

Parameters	Mean value ± SD	Total	Reference mean values	N	Values compared to percentiles	P-value
LVEF (%)	65,95 ± 11,25	37	81,1 ± 0,69	13	35,14% < P3	0,000
				24	64,86% between P3 and P97	
LVSF (%)	39 ± 0,12	37	42,27 ± 0,65	13	35,14% < P3	0,000
				24	64,86% between P3 and P97	
Speed of the A wave (m/s)	0,58 ± 0,18	37	3,25 ± 0,09	37	100% < P5	0,000
Speed of the E wave (m/s)	0,92 ± 0,24	37	6,84 ± 0,82	37	100% < P5	0,000
E/A Ratio	1,69 ± 0,7	37	2,05 ± 0,21	13	35,14% < P5	0,000
				23	62,16% between P5 and P95	
				1	2,7% > P95	
TAPSE (cm)	1,19 ± 0,35	37	3,38 ± 0,39	37	100% < mean-2SD	0,000

Table 1: Echocardiographic variables.
LVEF: Left Ventricular Ejection Fraction, SV: Stroke Volume, LVSF: Left Ventricluar Shortening Fraction, TAPSE: Tricupsid Annular Plane Sytolic Excursion, SD: Standard Deviation, P50: 50th percentile, P5: 5th percentile, P3: 3rd percentile, P95: 95th percentile, P97: 97thpercentile, Reference mean: Reference value of central tendency.
The p-value is obtained from the student's t test.

Parameters		6-11 months		12-17 months		18-23months		24-60 months	
		N	%	N	%	N	%	N	%
LVEF	<P3	5	13,5	3	8,1	2	5,4	3	8,1
LVSF	< P3	10	27,03	2	5,4	2	5,4	4	10,8
Speed of E wave	<P5	19	51,3	11	29,7	2	5,4	5	13,5
Speed of A wave	< P5	19	51,3	11	29,7	2	5,4	5	13,5
E/A Ratio	< P5	14	37,84	6	16,2	0	0,0	3	8,1

Table 2: Comparison between echocardiographic parameters and age.

Parameters		-9 ≤ W/H < -5 (n=12)		-5 ≤ W/H < -4 (n=9)		-4 ≤ W/H < -3 (n=16)	
		N	%	N	%	N	%
LVEF	<P3	05	41,67*	01	11,11	07	43,75
LVSF	<P3	05	41,67*	02	22,22	06	37,50
Speed of the E wave	<P5	12	100	09	100	16	100
Speed of the A wave	<P5	12	100	09	100	16	100
E/A Ratio	<P5	05	41,67	01	11,11	07	43,75
TAPSE	< moy-2ET	12	100	09	100	16	100

Table 3: Comparison between echocardiographic parameters and the W/H index (z-score). * : P<0,05.

Parameters	Kwashiorkor	Marasmus	Kwashiorkor-Marasmus			
	Mean ± SD	Mean ± SD	Mean ± SD	P*	P**	P***
LVEF (%)	2,67 9,61	64,86 11,69	68,20 9,44	0,29	0,55	0,51
LVSF (%)	43 0,06	36 0,09	50 0,26	0,18	0,60	0,32
Speed of the E wave (m/s)	1,14 0,48	0,92 0.23	0,81 0,14	0,5	0,35	0,19
Speed of the A wave (m/s)	0,49 0,04	0,59 0,2	0,58 0,11	0,04	0,16	0,88
E/A Ratio	1,39 1,09	1,65 0,72	1,51 0,2	0,72	0,87	0,40
TAPSE (mm)	1,22 0,02	1,17 0,38	1,24 0,27	0,52	0,90	0,67

Table 4: Association between the type of malnutrition and echocardiographic parameters.
P*: P-value comparing patients with kwashiorkor and those with marasmus.
P**: P-value comparing patients with kwashiorkor and those with kwashiorkor-marasmus.
P***: P-value comparing patients with marasmus and those with kwashiorkor-marasmus.

Discussion

The goal of our work was to describe the echocardiographic abnormalities of heart function in children 6 to 59 months old suffering from SAM in Yaoundé. Our patients were generally young (81.1% were less than 18 months old). The majority of the children in our sample were suffering from marasmus. Marasmus generally occurs early in life, usually in the first year of life [11]. The female sex were more represented. This female predominance however seemed to have occurred by chance. In fact, there wasn't supposed to be any difference in the occurrence of malnutrition according to the gender [12]. Whatever the gender, it is in poor homes that children run the highest risk of suffering from malnutrition. In Cameroon moreover, the male sex are slightly more affected by SAM [13].

Our study population was largely dominated by children suffering from marasmus. Marasmus is in fact the most common type of SAM [14]. We found hypotension in almost all our study participants. Severely malnourished children are generally dehydrated, which causes a significant decrease in the circulating blood volume, which results in hypotension. Keerpelfronius and col, in a study on the circulatory dynamics of malnourished children, found a decrease of up to 25 mm Hg of blood pressure in 40% of study participants in function of the severity of malnutrition [15]. Abnormalities of the heart rate and respiratory rate were also frequent findings. In addition to the acceleration of cardiac rhythm to restore the cardiac output in situations of hypovolemia, patients suffering from SAM experience a significant autonomic nervous system changes, as a function of the type and the severity of the illness [16]. Srivastava and col in India found a sympathetic hyperactivity in children with SAM which was clinically reflected by tachycardia [17]. But Srivastava's team had as study population patients suffering from mild and moderate acute malnutrition. Ocal and col found a predominance of bradycardia in marasmic patients, which ties with our results in which 59.5% of patients presented with bradycardia [18]. In fact, in our study marasmus represented 78.38% of cases of SAM. Other authors have in the past reported in other case series a combination of bradycardia and tachycardia [19].

The mean of the LV systolic function was generally lower than the reference mean. Over a third of patients (35.14%) had LV systolic function frankly to below normal. In addition, the alteration of the LV systolic function was associated with the severity of the SAM. The SAM is responsible for disturbances in body composition including the loss of skeletal and cardiac muscle causing heart failure [18, 20]. All patients of our study had speed of the mitral E and A waves less than the 5th percentile. In 35.14%, the E/A ratio was below the 5th percentile. The speeds of the E and A waves and the E/A ratio have presented a significant difference with the mean of the values of central tendencies of the reference tables for each variable ($p<0.05$).

These results are in favor of a reference diastolic function for each variable $p<0.05$).These results are in favor of a diastolic function which indicates a change in ventricular relaxation [21]. Relaxation abnormalities encountered during malnutrition are due to disorders of energetic metabolism and tachycardia. This finding is also encountered in coronary syndromes by Kontos and col who declared that 54.5% of acute severely malnourished children had a high level of troponin, which significantly correlated to a very high mortality 30 days following admission [22]. Our results are similar to those of Schoken and col in 1989 who found echocardiographic parameters evaluating the diastolic function of the left ventricle less than standard reference values, and without significant association [22].

On the other hand Ocal and col (2001) in Turkey didn't find any index of disturbance of the left ventricle in their study [18]. That would be explained by the presence in their case series of hemodynamic parameters which were so unstable, which of course could influence the interpretation of indices which explore the function of the left ventricle. Our work shows that there was a significant ($p<0.05$) difference between children suffering from kwashiorkor and those who had marasmus concerning the decrease in the speed of the A wave (Table 2). Concerning other echocardiographic parameters of cardiac function, there was no significant difference according to the type of malnutrition. This corroborates the study of Ahmed and col in 2008 who found that there existed structural and functional lesions of the heart with no statistically significant difference between kwashiorkor and marasmus [23].

All malnourished children of our study presented with a Tricuspid Annular Plane Surface Excursion less than -2 SD, statistically significant ($p<0.05$), testifying to the alteration of right ventricular function. Evaluation of cardiac function is, according to daily practice, extrapolated relative to measures taken to the left [21]. Echocardiographic examination of the right ventricle is impinged by many difficulties, the main ones being its size and its position in the thorax and most especially its unique geometry, having the shape of a deformed prism [24]. This explains the difficulties encountered in studying the function of the right ventricle in everyday practice, as well as the fact that not many studies have been carried out on the subject matter to whose results, we could compare ours.

Conclusion

In view of the results of our study, heart functions were significantly more changed in younger subjects. Systolic as well as diastolic function of LV were altered in 1/3 of patients. The severity of heart changes was significantly associated to those of SAM. RV function was altered in all patients. These abnormalities testify of the necessity of their consideration during nutritional rehabilitation so that the vital prognosis of the patients will not be aggravated. Like patients suffering from kwashiorkor, those suffering from marasmus also need careful surveillance of their vital parameters given the high frequency of alteration of their diastolic function.

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