Original Research

Left ventricular function and cardiac valvar annular dimensions among children with sickle cell anemia compared to those with hemoglobin AA type in Enugu, Nigeria

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Abstract

Background

Enumerating the relationship between cardiac structures, function and chamber sizes in children with sickle cell anemia would help in delineating some cardiovascular abnormalities which will aid the Pediatric cardiologist and the cardiac surgeons in a number of decision-making situations.

Objectives

The objectives of this study are to assess the dimension of cardiac structures and left ventricular function in children with sickle cell anemia in steady state and controls using echocardiography.

Methods

A cross-sectional prospective study that assessed cardiac structures and left ventricular function among fifty-one children with sickle cell anemia (HBSS) and compared with fifty children with HB AA type serving as controls.

Results

A significant high proportion of children with sickle cell anemia had abnormal Valvar dimension and left ventricular function above two standard deviations (2-SD) from the mean of the standard population compared to the control group, showing a statistically significant difference ($\chi 2 = 10.42$, $p= 0.001$).

All the mean annular valves diameter, left ventricular internal dimension in systole and diastole, inter-sinus distance diameter and sinu-tubular junction diameter are higher in children with sickle cell anemia than controls and this is statistically significant. ($p<0.005$).

Conclusion

This result shows that children with sickle cell anemia have increased valvar size diameter compared with those with normal hemoglobin type. A significantly higher proportion of respondents in type SS group had abnormal left ventricular systolic and diastolic dysfunction when compared with those in type AA group.

Key Words: cardiac structures; children; sickle cell anemia; echocardiography

Introduction

Echocardiography has remained the leading technique for evaluating cardiovascular anatomy and physiological function in children[1]. In this regard, accurate diagnosis and surgical intervention of congenital abnormalities are constantly made on the basis of quantitative echocardiographic measurements[1-3]. Predicting the cardiac valve size using echocardiography measurements among children with sickle cell anemia and their counterparts with normal hemoglobin type, would benefit pediatric cardiologists, adult cardiologists, and cardiac surgeons in a number of decision-making situations especially in children with congenital heart disease who have sickle cell anemia as what is seen as normal for children with haemoglobin AA type might not be the same for them.

The validity in measurement of valve annular diameter remains an issue since the decisions about the care of children depend on normal measurements, it therefore becomes necessary to know what is actually the normal range in children with sickle cell anemia[4-8]. This is best done by correlating this measurement with body surface area.

Previous studies[9-11] had reported normal left ventricular (LV) function in patients with severe chronic anaemia, while others[12-14] document varying degrees of left ventricular (LV) dysfunction with significantly decreased fractional shortening or abnormal systolic time[15-16].

To date, no consensus exists as to whether myocardial contractility is inherently affected by long-standing severe anaemia or is simply altered by chronic anaemia[17,18].

The evaluation of left ventricular systolic function in sickle cell anaemia has yielded inconsistent results, probably due to the differences in patient's selection criteria and the indices of systolic function employed in the studies. However, it has been observed that alterations in the loading characteristics of the heart in patients with chronic anaemia affect the ejection performance of the heart[18-20]. Patients with sickle cell anaemia have similar load-dependent but lower load-independent measures of left ventricular systolic function

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than control subjects.

Appropriate screening of left ventricular function among children with sickle cell anaemia using echocardiography can lead to early detection of left ventricular dysfunction and pulmonary hypertension. Treatment that may reduce these cardiac anomalies could potentially reverse the disease process as well as preventing the increased morbidity and mortality associated with it[15]. Assessment of left ventricular function in children with sickle cell anaemia is very uncommon in our setting as only three studies were undertaken on this subject in a large population like Nigeria. Therefore, more studies are needed to bridge this gap. It is not known if children with sickle anemia had a different cardiac size and function compared with those with normal hemoglobin type. Thus, a number of decision making may be stalled if surgeons don't know the exact dimension of the structure and function (especially the z scores) of children with sickle cell anemia as the value may not be the same with their counterpart with HB AA type.

This study is therefore aimed at determining the dimension of cardiac structures in children with sickle cell anaemia in steady state and controls using echocardiography and to compare left ventricular function of children with sickle cell anaemia and their counterparts with HB AA type. There had been no known normative values of cardiac valves dimension among children with sickle cell anemia and it is not known if these values are the same with that of their counterpart with HB AA type.

Careful search on literature showed that studies on cardiac valve sizes and left ventricular function in sickle cell anemia compared with normal children with normal hemoglobin type is very rare, thus necessitating the need for this study.

Methods

Study Area/Population

This study was carried out at the out-patient clinic of UNTH, Ituku-Ozalla, Enugu among children who were between 3 years and 18 years. This is because confounders such as increase biventricular pressure which is seen in children with sickle cell anaemia below the age of three years will affect the results[15-17].

The control population was children who are healthy with HbAA type and matched for age and gender.

Subjects and controls who gave consent or ascent (especially those below 7 years) are included in the study. Subjects and controls who have congenital or acquired heart disease and who present with very severe anemia as causing heart failure were excluded. Heart failure on its own can cause chamber dilatation. Subjects who were in crises, those on hydroxyurea and who were on regular blood transfusion were excluded from the study.

Hemoglobin type of the cases were determined by hemoglobin electrophoresis using cellulose acetate at a PH of 8.6. Children with sickle cell anemia were recruited consecutively from sickle cell clinic who already had their hemoglobin electrophoresis done in the course of their visit and repeated during follow up[18].

Steady state HB SS type

Children with hemoglobin SS type are those who are clinically stable for a minimum of 4 weeks and who were not transfused before recruitment[18].

Case Selection

Children with sickle cell anaemia in steady state, and not in regular blood transfusion or hydroxy urea and who attended the sickle cell clinic or presented at the children outpatient and who fulfilled the inclusion criteria were consecutively recruited into the study.

The control group were children with HBAA type and who were apparently healthy and who came to the hospital for follow up for common illnesses.

Study Duration

The study was done over a three-month period.

Methods of assessing cardiac chambers

Transthoracic 2D Echo was used by experienced pediatric cardiologists in all the reviews. This they do by using a digital commercial harmonic imaging system with an S3 3MHz phased-array transducer. Each child had trans-thoracic studies done in the supine and left lateral decubitus positions.

Images of the parasternal long axis (PLAX), parasternal short axis (PSAX) (at mitral leaflet level), apical 4-chamber (A4C), apical 5-chamber view, suprasternal short and coronal view, and subcostal views were obtained. Image acquisition and measurement of LV function using M mode, were performed according to the guideline recommendations of the European Society of Echocardiography and the American Society of Echocardiography (ASE)[13].

With respect to recommendations for standardizing measurements from M mode echocardiograms, measurements were obtained of the following: right ventricular anterior wall thickness at end diastole, right ventricular end diastolic dimension, thickness of interventricular septum at end diastole and systole, thickness of posterior wall of the left ventricle at end diastole and systole, left ventricular dimension at end diastole and systole.

Left ventricular systolic function was studied using M Mode. The left heart chambers were measure in diastole. Left ventricular diastolic function was assessed by pulsed Doppler of the mitral inflow and by tissue Doppler obtained at the lateral and medial border of the mitral and tricuspid annulus in the apical four-chamber view. E and A waves velocities and E/A ratio in mitral flow were recorded.

Measurements of cardiac valves were all taken in end diastole. To avoid inter- and intra-observer bias, all variables were measured by the cardiologists. The inter-and intra-observer variability was calculated as (mean percentage errors)[13].

All measurements were compared with that of the standard population by calculating their z-scores[16-18].

Ethical Consideration

Ethical clearance for the study was obtained from the Research and Ethical Committee of the University of Nigeria Teaching Hospital Ituku- Ozalla Enugu.

Sample Size Estimation

The minimum sample size used in this study was calculated using the formular[19].

$N = Z2P (I - P)/D2$

Using the above formula, the minimum sample size is 30.

20% attrition rate was considered, this brought the final value to 36, this was however rounded off to 50 (i.e., 50 patients with sickle cell anemia in steady state, 50 children with HB AA type.

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Consent

An oral consent was obtained from each parent/ caregiver of the subjects and controls. This was obtained after details of echocardiographic procedure were explained to them.

Child Assent

This was obtained from children older than seven years.

Data Analysis

All measurements were converted to their z-score values based on normal values from the standard population. Cardiac annular diameter was compared using student T test while correlation between annular diameter and surface area were compared using Pearson correlation. Correlation between annular diameter and function and age were also compared using Pearson correlation. Proportions were compared using Chi-square test.

Results

Demography

There were 101 participants, including 50.5% subjects with type SS and 49.5% with type AA. The type SS group included 54.9% males while the type AA group had 52% of the participants as males.

Comparison of dimensions of cardiac structures

The z-scores for the mitral, aortic, tricuspid, and pulmonic valves of subjects and controls were determined using cardiac valve z-score calculator based on their height and weight.

It was observed that the z-scores for cardiac valves were generally lower in participants with type AA than those with type SS (Table 1). The mean z-score for AV of respondents in type AA group, (-0.12±0.61) was lower than that in type SS group (0.74±0.69) and the difference was found to be statistically significant, (t=6.67, p<0.001). The mean z-score for MV of respondents in type AA group (0.88±0.65) was also lower than that in type SS group (1.50±0.65) and the difference in mean was found to be statistically significant, (t=4.78, p<0.001).

Table 1: Comparison of z-score for cardiac structures between subjects and controls z-score values were derived from deviations from mean of the standard population

Variable	AA (n=50)	SS (n=51)	Student t p value
AV	-0.12±0.61	0.74±0.69	6.67<0.001
TV	0.86±0.62	1.34±0.89	3.17<0.002
MV	0.88±0.65	1.50±0.65	4.78 <0.001
PV	-0.80±0.60	-0.09±0.67	5.46 <0.001
RPA	-0.06±0.86	0.56±0.66	4.10 <0.001
LPA	0.88±0.90	1.30±0.66	2.54 <0.01
IVSD	4.96±0.67	5.78±0.59	6.51<0.001
IVSS	-0.11±1.28	-0.70±1.26	-2.32 <0.02
STJ	0.36±1.04	1.51±1.00	5.67<0.001
AA	1.71±1.15	3.49±1.22	7.50 <0.001
RV area	0.19±1.02	-0.17±1.42	-1.43 < 0.16
LV area	-0.91±1.20	-0.99±1.10	-0.23< 0.74
LA area	-0.91±1.20	1.56±1.10	6.72<0.001
RA Area	-0.07±1.06	1.37±1.40	5.83<0.001

We compared cardiac valve dimensions between males and females. The values were comparable in both subjects and controls. The mean z-score for AV, TV, MV and PV for male subjects were 0.60, 1.50, 1.61 and -0.20 respectively while that for females were 0.91, 1.15, 1.14 and -0.05 respectively. The difference in means were not significant male (p= 0.70, 0.33, 0.92, 23 respectively). For the male controls, the mean z-score for AV, TV, MV and PV were -0.20, 0.85, 0.85 and -0.84 while that for female controls were -0.03, 0.86, 0.91, -0.76 respectively. The difference in mean z-score were also not significant (p= 0.92, 0.23, 0.29, 0.63 respectively).

27.5% of subjects had MV above two standard deviations (2-SD) from the mean of the standard population compared with 4% of the control group, showing a statistically significant difference ($\chi 2$ = 10.42, p= 0.001). 25.5% of the type SS group had their TV more than 2_SD above the mean of the standard population compared with 2% of those in type group AA, which was also statistically significant ($\chi 2$= 11.67, p= 0.001). 5.9% of participants in type SS group had AV above 2-SD from the mean of standard population compared with non from the control with type AA. None of the participants had PV above or below 2-SD from the mean for standard population.

The mean z-score for IVSd for respondents in type AA group (4.96±0.67) was lower than that for type SS group (5.78±0.59) and the difference in mean was found to be statistically significant, (t=6.51, p<0.001). The mean z-score for IVSs for respondents in type AA group, 18.05±3.84 (-0.11±1.28) was higher than that for type SS group (-0.70±1.26) and the difference in mean was found to be statistically significant, (t=-2.32, p=0.02). Also, the mean z-score for LV area for respondents in type AA group, (-0.91±1.20) was higher than that in type SS group (-0.99±1.10), although the difference was not statistically significant, (t= -0.23, p=0.74). The mean z-score for RV area for respondents in type AA group, (0.19±1.02) was higher than that in type SS group (-0.17±1.42) but the difference was not statistically significant, (t= -1.43, p=0.16). The mean z-score for LA area for respondents in type AA, (0.04±1.17) was significantly lower than that in type SS group (1.56±1.10), (t= 6.72, p<0.001). 9.8% and 8% of subjects and controls respectively had abnormal RV area while 19.6% and 22% of subjects and controls respectively also had abnormal LV area. 48.8% of the subjects had LA area below 2SD from the mean of standard population, compared with 96% of the control group ($\chi 2$= 21.05, p<0.001). 66.7% of subjects had RA area below 2SD, compared 94% of the controls ($\chi 2$= 13.32, p= 0.001).

The mean z-score for Left Ventricular Internal Diameter in diastole (LVIDd), for respondents in type AA group (-0.58±1.26) was lower than that in type SS, (1.33±1.10) and the difference in mean was statistically significant, (t=5.42, p<0.001). The mean z-score for Left Ventricular Internal Diameter in systole (LVIDs) for respondents in type AA, (0.13±1.41) was lower than that in type SS, (1.61±1.66) and the difference in mean was statistically significant, (t=4.80, p<0.001).

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Table II: Correlation of BSA with cardiac structures among the subjects and controls

Variable	Pearson correlation coefficient (r)			
	AA (n=50)		SS (n=51)	
	r	p	r	p
AV	0.85	<0.001	0.83	<0.001
TV	0.81	<0.001	0.61	<0.001
PV	0.81	<0.001	0.82	<0.001
MV	0.81	<0.001	0.74	<0.001
RV area	0.39	0.006	0.69	<0.001
LV area	0.39	0.007	0.79	<0.001
RA area	0.41	0.003	0.67	<0.001
LA area	0.61	0.001	0.83	<0.001
LVIDd	0.30	0.04	0.57	<0.001
LVIDs	0.30	0.04	0.30	0.04
LVPWd	0.01	0.93	0.47	0.001
LVPWs	0.30	0.04	0.47	<0.001
IVSd	0.46	<0.001	0.71	<0.001
IVSs	0.20	0.2	0.22	0.14
STJ	0.46	0.001	0.75	<0.001
AA	0.41	0.003	0.72	<0.001
EF	-0.15	0.32	0.02	0.32
FS	-0.14	0.34	0.12	0.40

Table III: Correlation between age and cardiac structures in subjects and controls

Variable	Pearson correlation coefficient (r)			
	AA(n=50)		SS (n=51)	
	r	p	r	p
AV	0.83	<0.001	0.81	<0.001
TV	0.83	<0.001	0.56	<0.001
PV	0.44	0.002	0.77	<0.001
MV	0.82	<0.001	0.59	<0.001
RV area	0.72	<0.001	0.63	<0.001
LV area	0.72	<0.001	0.72	<0.001
RA area	0.68	<0.001	0.62	<0.001
LA area	0.74	<0.001	0.74	<0.001
LVIDd	0.75	<0.001	0.60	<0.001
LVIDs	0.76	<0.001	0.34	0.02
LVPWd	-0.08	0.58	0.46	0.001
LVPWs	0.05	0.76	0.46	0.001
IVSd	0.81	<0.001	0.74	<0.001
IVSs	0.18	0.21	0.25	0.08
STJ	0.80	<0.001	0.75	<0.001
AA	0.78	<0.001	0.74	<0.001

49% of sickle cell anemia group had LVIDs above 2SD, which was significantly higher than 8% of the controls ($\chi2$= 21.88, p<0.001). The subjects also had higher proportion (31.4%) of children with LVIDd above 2SD, compared with 2% of the controls ($\chi2$= 22.07, p<0.001). In fact, 12% of the control group had LVIDd below 2SD and none of the subjects.

The mean z-score for Left Ventricular ejection fraction (LVEF) and Fraction shortening (FS) for respondents in type AA group (0.135±0.91 and 0.058±0.95) were higher than that in type SS (-0.127±1.07 and -0.055±1.05), but the difference was not statistically significant. (t=-1.30, p=0.196) and (t=-0.56, p=0.557) respectively. However, 15.7% and 2% of the subjects and controls respectively had left ventricular dysfunction.

The mean z-score for Mitral valve inflow velocities (MVE/A) for respondents in type AA group (-0.247±0.81) was lower than that of respondents in type SS group (0.252±1.11) and the difference in proportions was statistically significant, (t=2.55, p=0.012).

Association between cardiac structures and body surface area (BSA)

In children with sickle cell anemia, there was a very strong positive correlation between BSA and age, increases in BSA correlates with increases in age and this was found to be statistically significant, (n=51, r=0.93, p<0.001). Likewise, there was a very strong positive correlation between BSA and weight, which was found to be statistically significant, (n=51, r=0.98, p<0.001). Table 2 shows the correlation between BSA and cardiac structures among children with sickle cell anemia and those with type AA. There was generally strong positive correlation between the body surface area and cardiac valve dimensions. Positive correlation was also observed between BSA and STJ as well as with AA. These correlations were statistically significant, (n=51, r=0.76, p<0.001) and (n=51, r=0.72, p<0.001) respectively.

There was statistically significant positive correlation between BSA and TV, PV, MV and AV among the control group. Likewise, there was positive correlation between BSA and LVIDs, LVIDd. Although the correlation between BSA and LVPWs was positive, it was a weak correlation (n=50, r=0.29, p=0.05). There was a fairly strong positive and significant correlation between BSA and LVIDs (n=50, r=0.50, p=0.003).

Association between cardiac structures and age

In both subjects and controls, we observed positive correlation between age and cardiac valve dimensions (Table 3). There was significant positive correlation between age and AV, TV, PV and MV among the sickle cell anemia group (n=50, r= 0.81, 0.56, 0.77, 0.59; p= <0.001 for each respectively). For the controls, n=50, rt= 0.83, 0.83, 0.44, 0.82; p= <0.001, <0.001, 0.002, <0.001 respectively for AV, TV, PV and MV. Positive correlation was also

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observed between age of participants and RV area, LV area, RA area and LA area. Among the children with sickle cell anemia, Pearson correlation coefficients and p values were 0.63, 0.72, 0.62, 0.74 and <0.001 for each for RV area, LV area, RA area, LA area respectively.

Discussion

It is important to note that dilatation of the mitral valve (MV) or tricuspid valve (TV) often contributes to primary (organic) and secondary (functional) regurgitation and knowledge of the extent of dilatation especially in sickle cell anemia may assist the surgeon in identifying those valves amenable to repair[1,21-23].

From this study, we noted that all cardiac valve annuli are higher in children with sickle cell anemia when compared with those with normal haemoglobin type. It is important to note that when we look at the normal reference ranges for all the valves dimension, almost a third of subjects with SCA had their mitral valves above normal range compared to 4% of the control group. In addition, a quarter of subjects with type SS had their tricuspid valves above normal reference range compared with 2% of those in type AA. However, 5.9% of participants in type SS group had their aortic valves more than normal range compared with non from the control with type AA. This simply means that children with sickle cell anemia have higher tendency of presenting with chamber dilatation, volume abnormality and heart failure when compared with their normal counterparts[24].

Similarly, Batra et al[25] noted that children with sickle cell anemia had chamber dilatation from volume-overload with a significant increase in LV dimensions and mass.

We also noted that cardiac valve parameters and ascending aorta tend to increase as age and body surface area increase. The increase of these cardiac valves with body surface area may be explained by the fact that after birth, mitotic division of cells ensue especially in the ventricularis and spongiosa. [26] With age and maturation, the matrix shows an increasing amount of collagen and collagen cross-links and a reduction in glycosaminoglycans[26,27].

It is pertinent to note from this study, that of all the variables, only body surface area had a strong correlation with cardiac valves and dimension both in subjects and control. For example, Capps et al[28] noted that cardiac valves especially aortic and pulmonary valve diameters are closely related to body size. Thus, body surface area, when used in conjunction with other clinically accepted evaluations, is a useful tool for estimating normal aortic and pulmonary valve size[28,29].

Hanséus et al maintained the fact that the best predictor of aortic and pulmonary valve size is body surface area[22]. Among 120 healthy infants, children, and teenagers who were examined by cross-sectional echocardiography, they noted inter observer reproducibility and good correlation with body surface area with annular diameter was demonstrated for all measurements. This however is high in parasternal long axis than any other views.

Yan[30] et al in his study noted that body surface area still remains the best index for annular diameter and not valvar area.

We noted in this study, that there is no difference in chamber dimension among children with sickle cell anemia when compared with those with normal hemoglobin type except for left atrial chamber where almost half of the subjects had LA dilatation. It has been documented in the literature that sickle cell anemia leads to a chamber enlargement of the left atrium and ventricle[31-33].

We noted that a higher percentage of children with sickle cell anemia had left ventricular area higher than that of the right ventricle. The enlargement of the right ventricle, when analyzed in absolute values, is considered controversial. It is a known fact[33] that the enlargement of the right ventricle occurs later than that of the left ventricle. Some factors might affect more specifically the left side of the heart, such as chronic ischemia acting upon the hypertrophied ventricular wall[33].

It is important to point out from this study that the only indices of left ventricular systolic function that was affected in this study, when subjects were compared with controls is the left ventricular internal diameter in systole and that in diastole and these parameters tend to increase with age. These changes in left ventricular diameter show a reflection of increase in the left ventricular area observed in our study.

This was also observed by Mohammad et al[34] in Saudi Arabia where he noted the left ventricular internal dimensions, wall thicknesses, volumes and mass indexes were significantly increased in SCD patients, though the left ventricular ejection fraction was similar in both groups. These alterations in cardiac dimensions in sickle cell anaemia acts as a negative feedback mechanism especially among children with chronic anaemia to increase the cardiac output with little increase in heart rate[34].

The impact of sickle cell anaemia on left ventricular dimensions and function has been extensively studied; however, there were no consensus as to the long-term effects on myocardial contractility. Lester et al in their study among sixty-four children with sickle cell anaemia found significantly increased left ventricular dimensions and mass compared with healthy AA control patients but noted that this increase correlated strongly with severity of anaemia[35]. The increase in left ventricular dimension with advancing age seen in this study was also corroborated by other studies[36-38]. They noted that with anaemia especially those related to thalassemia, there is abnormal loading condition which leads to chamber dilation and myocardial remodelling. This in a long run can progress to ventricular dysfunction. In contrast, Balfour et al and San et al documented varying degrees of left ventricular dimension and advancing age[39, 40].

Children with sickle cell anaemia had higher mitral inflow velocities indices compare to their normal counterpart. This can simply be explained by the fact that they are prone to more cardiac dilatation, poor left ventricular filling, and poor myocardial index fibre shortening, and poor contractility when compared with their counterpart with normal haemoglobin type. These findings were supported by San et al who noted markedly significant difference in left ventricular diastolic function in children with sickle cell anaemia[40].

Though there were no significant difference in left ventricular ejection fraction and left ventricular fractionating shortening in both subjects and controls, however about 15.7% of children with sickle cell anaemia had left ventricular systolic dysfunction compared to 2% of the subjects denoting a higher tendency of presenting with Left ventricular systolic dysfunction. San et al[41] found systolic function and contractility to be preserved, while a study[42] used a slightly different method as well as matched controls and found a significant decrease in contractility in these patients. It is very important to note that LVEF and LEFS are not the

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best method of assessing Left ventricular function because these measurements are highly dependent on and influenced by myocardial loading conditions as well as heart rate, both of which are abnormal in sickle cell anaemia patients. Some authors have assessed LV function in SCA patients where contractility was evaluated using the ejection phase indexes such as fractional shortening, ejection fraction, velocity of circumferential shortening, or systolic time intervals[1–7] and noted better sensitivities and specificities.

The preservation of left ventricular systolic function in children with sickle cell anaemia has been seen in a recent large screening echocardiographic studies where left ventricular systolic function is preserved in the majority of SCD patients studied in a steady state[43,44].

It is important however to note that none of these parameters are true indices of contractility since they are known to be affected by heart rate, preload, and afterload[44].

A number of studies have examined the use of the end systolic force-length relationship to characterize myocardial contractility[43-45].

We noted a significant increase of left ventricular diastolic function of children with sickle cell anaemia compared with those with normal haemoglobin type. This simply means that children with sickle cell anaemia have a higher tendency of presenting with left ventricular diastolic dysfunction. These alterations in left ventricular diastolic dysfunction may be as a result of myocardial ischemia, fibrosis, iron deposition, and ventricular hypertrophy[8,41-43].

This study also showed increase in diastolic dysfunction with age especially among children with sickle cell anaemia. As expected, diastolic abnormalities are associated with older age, increases in blood pressure, increased left ventricular mass and higher creatinine levels.

We noted from this study the prevalence of diastolic dysfunction among children with sickle cell anaemia as 12% compared with 3% in those with normal haemoglobin type. This finding is lower than that obtained in a study where a prevalence of 24% was found[38,46]. This simply means that children with sickle cell anaemia have Doppler filling abnormalities especially impairment of ventricular relaxation when compared with their counterparts with normal haemoglobin type[38, 46].

It is necessary to highlight that LV diastolic dysfunction was not the only hemodynamic confounder of the significant left atrial dilatation among these patients, other factors such as chronic anaemia, chronic ischemia-perfusion injury of the atrial walls, and possible iron overload secondary to recurrent haemolytic episodes and frequent blood transfusions [38] could be implicated.

Conclusion

A reasonable fraction of children with sickle cell anaemia have high tendency of developing ventricular dilatation due to increase chamber size when compared with their counterparts with HB AA type. A significantly higher proportion of respondents in type SS group had abnormal left ventricular systolic and diastolic dysfunction when compared with those in type AA group.

Recommendations

A fraction of children has increased chamber size and are at risk of ventricular dilatation. It is therefore recommended that ventricular function should be added in the routine screening of these patients. Furthermore, a high index of suspicion is needed when managing these children to avert any complication that may arise from chamber dilatation. This cardiac size values will also help surgeons during decision making especially in valvar surgery since valvar size of the children with sickle cell anaemia is not the same with normal children.

Strength of the study

This is a prospective study carried out for the first time in this locale. The normative values of Z scores of chamber size and left ventricular function of children with sickle cell anemia has provided baseline values that could be useful in future studies.

Limitations

A cohort study in a larger community to follow up the sizes and function of the heart of children with sickle cell anemia will make this study worthwhile.

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Ethical approval and Consent:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standard. Subjects (or their parents or guardians) have given their informed consent and the study protocol was approved by the ethical and research committee of the university of Nigeria.

Disclosure Statement

The authors declare that they have no competing interests.

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Authors' contribution

JMC contributed to the conception, writing and proof reading of this manuscript. OEN and CBF contributed in data and statistical analysis of this work, while CBF, CAT, IA, NIK, and AIN contributed in proofreading the manuscript.

List of Abbreviation

AV: aortic valve annulus

PV: Pulmonary valve annulus

TV: Tricuspid valve annulus

MV: Mitral valve annulus

PA: Pulmonary artery

RPA: Right pulmonary artery

LPA: Left pulmonary artery

MPA: Main pulmonary artery

IVSd : Inter ventricular septum diameter in diastole

LVIDd: Left ventricular internal diameter in diastole

LVPWd: Left ventricular posterior wall diameter in diastole

IVSs: Inter ventricular septum diameter in systole

LVIDs: Left ventricular internal diameter in systole

EF: Ejection Fraction

FS: Fractionating shortening

RV: Right ventricle

LV: Left ventricle

RA: Right atrium

LA: Left atrium

HBSS: Hemoglobin SS

HBAA: Hemoglobin AA

SCA: Sickle cell anemia

BSA: Body surface area

ISD : inter-sinus distance

STJ : Sino- tubular junction

AA : Ascending aorta

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