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Normal values of echocardiographic parameters of apparently healthy adult Nigerians in Zaria

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Summary
The usefulness of echocardiography as a non invasive tool in the assessment of cardiac function is well established. Ninety two (54 males and 38 females) apparently healthy adult Nigerians were assessed echocardiographically to determine the normal values for the commonly measured parameters in our area of clinical practice. The mean age, body mass index (BMI), cardiothoracic ratio (CTR) and electrocardiographic left ventricular hypertrophy (ECG – LVH) were 51.4 ± 11.15 years, 23.85 ± 4.91 kg/m2, 0.49 ± 0.05, and 27.3 ± 7.46mm respectively. The mean systolic blood pressure (SBP), diastolic blood pressure (DBP) and mean arterial pressure ('MAP) were 125.0 ± 9.94, 79.7 ± 6.23 and 94.7 ± 6.54, mmHg respectively. While the results of the echocardiographic measurements followed the same pattern as other published reports from outside Nigeria especially with relation to age, there were still some differences in terms of absolute values. This emphasizes the need to have our own normal reference values. A multicenter study across the country involving much larger number of subjects is required to establish normal reference values for Nigeria.

Keywords: *Echocardiography, normal values.*

Résumé
L'utilité d'echocardiographie comme une outille non envahissant dans l'estimation de fonction cardiaque est bien établi. Quatre-vingt-dix deux (54 hommes et 38 femmes) des adultes Nigérians sains ont été examinés de l'échocardiographie pour déterminer les valeurs normales pour des paramètres mesurés dans notre région a l'entraînement clinique. L'âge moyen, corps index de masse (BMI), proportion du cardiothoracique (CTR) et les eléctrocardiographique, l'hypertrophie ventriculaire de gauche (ECG - LVH) étaient 51.4 ± 11.15 ans, 23.85 ± 4.91 kg/m2, 0.49 ± 0.05, et 27.3 ± 7.46mm respectivement. La tension moyenne du systolique (SBP), la tension du diastolique (DBP) et pression moyenne artérielle ('MAP) était 125.0 ± 9.94, 79.7 ± 6.23 et 94.7 ± 6.54, mmHg. Pendant que les résultats des dimensions de l'échocardiographie ont suivi le même modèle comme les autres rapports publiés hors du Nigeria surtout par rapport à l'âge, il y avait en core des différences en valeurs absolues. Ceci met l'accent sur le besoin d'avoir nos propres valeurs de référence normales. On a besoin de plusieurs centres d'etudes comprennant beaucoup de plus grands nombres de sujets pour établir des valeurs de référence normales pour le Nigeria.

Introduction

Echocardiography has become an established non-invasive tool in cardiac function assessment. It is easy to perform, results are reproducible and compares favourably with all other techniques of cardiac function assessment [1,2]. It also gives simultaneous information about cardiac anatomy, left ventricular regional and global systolic function.

In spite of these attractive advantages in this technique, it also has its disadvantages. First, because of its non-invasive nature it is subject to abuse. Some of the requests for echocardiographic assessment may be inappropriate. Secondly the results of echocardiographic assessment are also subject to misinterpretation. Many factors such as age, sex, and race, loading conditions for example are known to influence diastolic function indices [3,4,5]. Thus, in apparently healthy individuals from the age of 60 years, for example, E/A ratio reversal (< 1.0) which defines diastolic dysfunction may be seen, yet, the individual is cardiac asymptomatic. For this aged population, this may be regarded as "normal" diastolic function [6]. It is therefore appropriate to make a distinction between normal and abnormal echocardiographic evaluation results taking above factors into consideration.

There are no published reports on normal values for echocardiographic parameters in Nigeria including our area of clinical practice. The aim of this study is to evaluate apparently healthy adult Nigerians by echocardiography in order to establish the normal reference values for the commonly measured echocardiographic parameters in our area of clinical practice.

Materials and methods

Following approval by the ethical committee of A. B. U. Teaching Hospital, Zaria, one hundred and fifty (150) consecutive volunteers aged 30 years and above from within and outside the hospital community were examined clinically after a careful history to rule out any form of illness or factors that could influence echocardiographic results. Basic laboratory investigations such as full blood count, urea and electrolytes, serum proteins, cholesterol, fasting blood sugar, ECG and chest X-ray were done. Elec-

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trocardiographic left ventricular hypertrophy (ECG – LVH) was determined using the Sokolow and Lyon criteria for left ventricular hypertrophy of $SV_1 + RV_5$ or $RV_6 > 35mm$ [7]. Ninety two (92) subjects out of the one hundred and fifty (150) met the inclusion criteria.

Excluded from the study were subjects who had one or more of the following:- anaemia (PCV < 30%); significant alcohol consumption (60 – 80g/day > 5 years), smoked ⊕ 10 sticks of cigarettes per day or low serum albumin (< 3 g /100ml)[8]. Also excluded were subjects who had impaired glucose tolerance, impaired renal function, evidence of valvular or ischaemic heart diseases.

Those subjects who were normotensive adult Nigerians and free from above exclusion criteria were evaluated echocardiographically using ALOKA SSD 1700 2 – Dimensional Echocardiograph/Doppler and colour flow ultrasound machine. M – mode measurements were taken in accordance with the Penn convention [9] and the left ventricular mass (LVM) was then calculated according to the formula of Devereux and Reichek and indexed to body surface area (LVMI) [10] Left ventricular hypertrophy (LVH) was defined as LVMI of >134glm [2] for males and > 110glm [2] for females [10].

Measurements taken were interventricular septal thickness (IVS), left ventricular posterior wall thickness (LVPW), left ventricular internal dimension (LVID) in both diastole and systole.

The end diastolic volume (EDV), end systolic volume (ESV), stroke volume (SV), ejection fraction (EF) and fractional shortening (FS) were calculated, automatically by the machine using the POMBO calculation formula. The left atrial diameter (LA) and aortic root (AR) were also measured.

Indices of diastolic function were measured by Doppler echocardiography in accordance with the recommendations by the Canadian consensus Recommendations for the measurement and reporting of Diastolic Dysfunction by Echocardiography [11], All measurements were taken three times and the average also taken.

Data analysis

All values were reported as means ± standard deviation where applicable. Student 't' test was used to determine the statistical significance of the difference between the means of the males and females. A 'p' value of 0.05 or less was considered significant. Linear correlation coefficient between variables was also used where necessary. The reference intervals were calculated using the standard statistical formula as follows:-

1. Lower limit =Mean – 1.96 (Standard deviation)
2. Upper limit =Mean + 1.96 (Standard deviation)

Results

The 92 subjects studied met the inclusion criteria. They were made up of 54 males and 38 females. Table 1 shows the demographic and clinical characteristics of the study subjects. The majority of the subjects, 37, were in the 6th decade, followed by 28 subjects in the 5th decade; 12 subjects in the 4rth decade, 9 subjects in the 7th decade and 6 subjects in the 8th decade and above. There was no statistically significant difference between the males and females in terms of age, body mass index (BMI) cardiothoracic ratio (CTR), systolic, (SBP) diastolic (DBP) and mean arterial (MAP) blood pressures except electrocardiographic left ventricular hypertrophy (ECG – LVH). This difference is however not seen with echocardiographically determined LVH. All the subjects had normal laboratory values for urea and electrolytes, creatinine, packed cell volume, fasting blood sugar, cholesterol, etc.

Table 1: Demographic and clinical characteristics of the study subjects

Parameters	Means ± SD			p. value
	Study group mean ± SD (n=92)	Study group mean ± SD according to sex		
		M	F	
Age (year)	51.4± 11.15	50.84±11.36	52.67±11.98	0.2517
Sex	54 (m) 38(f)	54	38	
BMI(kg/m2)	23.85± 4. 91	23.56±4.91	23.24±5.13	0.1085
CTR	0.49±0.05	0.49±0.04	0.48±0.05	0.069
ECG–LVH (mm)	27.3±7.46	25.76±6.62	29.45±8.11	0.018*
SBP (mmHg)	125.0±9.94	125.1±10.7	124.7±8.8	0.85
DBP (mmHg)	79.7±6.23	79.7±6.64	79.3±5.68	0.775
MAP	94.7±6.54	94.8±6.81	94.5±6.15	0.797

**P < 0.05 (significant)*

Table 2: Mean values of echocardiographic parameters of the study subjects.

Parameters	Study group mean ± SD (n-92)	Study group mean ± SD according to sex		p. value
		M	F	
IVSd(cm)	1.04 ± 0.21	1.02 ±0.23	1.04 ± 0.24	0.50
LVPWd(cm)	0.88 ± 0.22	0.86 ± 0.20	0.92 ± 0.25	0.15
LVIDd(cm)	4.29 ± 0.64	4.33 ± 0.67	4.24 ± 0.66	0.50
IVSs(cm)	1.22 ± 0.25	1.24 ± 0.24	1.21 ± 0.25	0.78
LVPWs(cm)	1.12 ± 0.19	1.10 ± 0.19	1.15 ± 0.19	0.21
LVIDs (cm)	3.0 ± 0.4	3.04 ± 0.49	2.96 ± 0.51	0.45
EDV (mls)	85.42 ± 32.64	88.13 ± 32.35	80.6 ± 32.7	0.27
ESV (mls)	29.83 ± 15.82	30.56 ± 14.64	28.80 ± 19.47	0.50
SV (mls)	54.80 ± 21.91	53.8 ± 29.11	57.36 ± 21.18	0.44
EF (%)	66.35 ± 8.37	66.42 ± 0.64	66.24 ± 8.09	0.50
FS (%)	30.60 ± 5.87	30.43 ± 5.89	30.85 ± 5.91	0.73
LA (cm)	2.97 ± 0.56	3.10 ± 0.57	2.80 ± 0.52	0.05*
AR(cm)	2.66 ± 0.40	2.64 ± 0.43	2.67 ± 0.38	0.79
E(m/s)	0.59 ± 0.16	0.59 ± 0.18	0.60 ± 0.13	0.50
A(m/s)	0.53 ± 0.11	0.54 ± 0.11	0.51 ± 0.12	0.10
E/A ratio	1.16 ± 0.36	1.12 ± 0.38	1.22 ± 0.32	0.10
DT (msec)	182.86±36.40	184.2 ± 40.83	180.21±29.37	0.50
DR(m/sec²)	3.69 ± 1.40	3.71 ± 1.64	3.66 ± 1.01	0.86
LVM(g)	157.46± 49.99	157.9 ± 51.3	156..8 ± 48.8	0.91
LVMI(g/m²)	86.84 ± 25.2	87.5 ± 26.1	85.9 ± 24.3	0.76

** P Value < 0.05 (Significant)*

Table 2 shows the mean values for the echocardiographic data of the 92 subjects studied and the

mean values for the subjects according to sex. Again there was no statistically significant difference between the males and the females in all the echocardiographic data except left atrial diameter (LA), $P < 0.05$.

Table 3: Correlation between echocardiographic parameters and some demographic and clinical parameters of t he study subjects

Parameters	Age	BMI	SBP	DBP	MAP
IVSd(cm)	0.069	0.165	0.182	0.146	0.185
LVPWd (cm)	-0.126	0.070	0.188	0.043	0.128
LVIDd(cm)	0.015	0.273**	0.064	0.049	0.053
IVSs	0.031	0.114	0.082	0.126	0.114
LVPWs	0.092	0.127	0.088	0.204	0.178
LVIDs	0.027	0.177	0.083	-0.012	0.027
EDV (mls)	0.006	0.280**	0.044	0.092	0.072
ESV (mls)	-0.001	0.114	0.108	0.065	0.085
EF (%)	-0.106	0.031	-0.033	0.158	0.084
FS (%)	-0.068	-0.020	-0.052	0.125	0.054
LA (cm)	0.258*	0.421**	0.198	0.220*	.237*
E (m/s)	-0.299**	-0.037	0.089	-0.080	.004
A (m/s)	0.354**	-0.051	0.163	0.003	0.080
E/A ratio	-0.435**	-0.014	-0.008	-0.055	-0.027
DT (msec)	0.346**	-0.158	-0.069	0.075	-0.002
DR (m/sec^2)	-0.340**	0.075	0.075	-0.059	0.011
LVM (g)	-0.055	0.308**	0.222*	0.157	0.209*
LVMI (g/m2)	0.023	0.188	0.206*	0.081	0.155

***Correlation is significant at the 0.01 level (2-tailed)*
** Correlation is significant at the level 0.05 level (2-tailed)*

Table 4: Recommended Normal values of Echocardiographic parameters of adult Nigerians aged 30 years and above in Zaria

Parameters	Recommended Normal reference intervals
IVSd	(0.63-1.45) cm
LVIDd	(3.04 – 5.54) cm *
LVPWd	(0.45 – 1.31) cm
IVSs	(0.73– 1.71) cm #
LVIDs	(2.04 – 3.96) cm
LVPWs	(0.75– 1.49) cm#
EDV	(21.05 – 148.99) ml
ESV	(-1.17 – 60.83) ml
SV	(11.86 – 97.74) ml
EF	(49.95 – 82.75)%
FS	(14.20-47.00)%
LA	(1.88-4.06) cm
AR	(1.88-3.44) cm
E	(0.28-0.90) m/s*
A	(0.32-0.74) m/s
E/A ratio	(0.46- 1.86) *
DT	(111.48-254.24) msec
DR	(0.93-6.45) m/sec^2
LVM	(59.48-255.44) g
LVMI	(37.44-136.26) g/m^2

** Values are lower than Caucasian average*
 # Values are higher than Caucasian average [11-14]

Table 3 shows correlation between echocardiographic data and some demographic and clinical parameters of the study subjects. Age showed a significant correlation with all the indices of diastolic function and left atrial diameter. The correlation with these parameters were r= - 0.299, P= 0.004 for E wave; r= 0.354, P=0.0001 for A wave; r = 0.435, P=001 for E/A ratio; r = 0.346, P=0.0001 for DT; r = - 0.340, P = 0.001 for DR and r = 0.258 P = 0.013 for LA. While the BMI showed no significant correlation with any of the diastolic function indices, it showed significant correlation with M-mode derived data such as LVIDd (r = 0.273, p = 0.008), EDV (r = 0.280, P=0.007), LA (r =0.421, P=0.0001) and LVM (r = 0.308, P=0.003).

The systolic blood pressure (SBP) only correlated significantly with LVM and LVMI; r = 0.222, P = 0.033 and r = 0.206, p= 0.048 respectively. While diastolic blood pressure (DBP) correlated significantly, r = 0.220, P = 0.035, with only the left atrial diameter (LA), the mean arterial pressure (MAP) correlated significantly with LA and LVM. (r = 0.237, P = 0.023) and r = 0.204 P= 0.045 respectively. Table 4 represents the recommended normal reference intervals of the Echocardiongraphic data based on the results of this study.

Table 5 represents the mean ± standard deviation of diastolic function indices stratified by age in decades and the corresponding reference intervals.

Discussion

In this study of 92 normal subjects attempts were made to highlight those factors which could influence directly or indirectly the numerical values of the commonly measured echocardiographic parameters. A number of studies have reported on normal values for mitral and pulmonary venous inflow and on the effect of age and sex on filling dynamics in normal individuals [3,4] results of this study showed that the gender status of the subjects had no influence on the echocardiographic data obtained. There was no statistically significant difference between the females and the males with respect to age, body mass index (BMI), cardiothoracic ratio (CTR), ECG – LVH, blood pressures and all the echocardiographic data obtained except left atrial diameter (LA). Age in this study appears to be the most important factor that influenced the values of echocardiographic data obtained especially the left ventricular diastolic function indexes. In the work of Klein *et al* [4], it was demonstrated that linear changes occur in most measures of diastolic filling with increasing age.

Appleton and Hatle [12] also summarized the progressive changes that take place as we age. These linear changes in diastolic filling dynamics with increasing age were also demonstrated in this study. However, left ventricular inflow velocities in normal subjects stratified by age in decades showed that E/A ratio reversal started in the 7th decade of life in our subjects compared to 8th decade of life in other published reports [11]. This difference may be related to accelerated aging caused by poor economic

Table 5: Mean values and reference intervals of diastolic function indices of subjects stratified by age in decades

Decades of life	4th (30-39)	5th (40-49)	6th (50-59)	7th (60-69)	8th (70-79) & above
Number of subjects	12	28	37	9	6
Peak E wave (m/sec)	0.64± 0.02 (0.61-0.67)	0.64±0.14 (0.37-0.91)	0.59±0.17 (0.26-0.92)	0.46±0.13 (0.21-0.71)	0.54±0.21 (0.13-0.95)
Peak A wave (m/sec)	0.48±0.02 (0.45-0.51)	0.50±0.02 (0.47-0.53)	0.53±0.12 (0.30-0.76)	0.56±0.02 (0.53-0.59)	0.66±0.15 (0.37-1.95)
E/A ratio	1.35±0.26 (0.85-1.85)	1.29±0.26 (0.79-1.79)	1.13±0.36 (0.43-1.83)	0.85±0.25 (0.36-1.34)	0.89±0.57 (-0.22-2.00)
DT (msec)	165.08±32.43 (101.52-288.64)	169.86±30.10 (110.87-228.85)	192.89±40.17 (114.16-271.62)	195.00±12.00 (171.48-218.52)	199.00±45.38 (110.06-287.94)
DR (m/sec²)	4.19±1.25 (1.74-6.64)	4.13±1.45 (1.29-6.97)	3.52±1.48 (0.62-6.42)	2.73±0.73 (1.30-4.16)	3.09±0.83 (1.47-4.71)

Reference Intervals shown in brackets
E = Peak early rapid ventricular filling in diastole
A = Peak late ventricular filling due to atrial contraction
DT - Deceleration time
DR - Deceleration rate

conditions and lack of health promoting social infrastructures. Despite the obvious influence of age on measures of diastolic filling, age had no significant influence on M-mode measurements of the internal dimensions, thickness and mass of the chambers of the heart and the derived measures of left ventricular function.

Henry *et al* [13] in their echocardiographic study of normal subjects to detect growth-related changes that occur between infancy and early adulthood found that thickness of the ventricular septum and left ventricular free wall varied in a linear relation to the square root of the body surface area. Estimated left ventricular mass varied linearly with the direct measurement of body surface area, while the ejection fraction, (EF) fractional shortening, (FS) and percent systolic thickening of the ventricular septum and left ventricular free wall were independent of body surface area despite a marked increase in the size of the left ventricle during normal growth and development. The body mass index (BMI) in this study which was weakly related to the body surface area (BSA) only correlated significantly with left ventricular internal dimension (LVIDd), end diastolic volume (EDV), left atrial diameter (LA) and left ventricular mass (LVM). These correlations however did not extend to the measures of LV systolic or diastolic function.

The echocardiographic data presented in this study represent the mean ± standard deviation,(Table 2) and the normal reference intervals for each parameter,(Table 4) taking into consideration the various factors that could have influenced these values. Since age correlated with indices of diastolic function, an attempt was made to present values for different age subgroups as shown in Table 5. In this study, the numbers of subjects examined in each age range were relatively small especially in people sixty years (60) and older. This resulted in a wide range of normal values for each decade.

While the values for LVIDd, E, and E/A ratio in this study are lower than the Caucasian average the values for the IVSs and LVPWs are higher [11,14]. The general pattern is however similar. The numerical differences observed may be due to shortened life span or life expectancy occasioned by poor standard of living when compared to Caucasians. For example, poor nutrition due to economic hardship makes our people look older than their age. It may also be due to the fact that measurements are technically challenging and may require a quality assurance program to ensure consistency and precision in a given laboratory. Adoption of a standardized approach will facilitate comparison of results from different laboratories, as well as decrease measurement variability.

Data from much larger numbers of subjects are required and preferably from a multi-center study to enable us establish normal reference values of echocardiographic parameters in Nigeria. It is hoped that this study will stimulate more interest in this subject.

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