"Echocardiography in Nigeria: use, problems, reproducibility and potentials"

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Abstract

**Background:** Although echocardiography is a useful and cost-effective technique for the detection of morphological and functional cardiac abnormalities, it has a main limitation in its subjectivity. Therefore the aim of the present study was to assess the intra-observer reproducibility and validity of 2-dimensional guided M-mode echo measurements at a Nigerian metropolitan Hospital

**Methods:** Standard echocardiographic examination was performed on twenty randomly selected patients (11 men and 9 women) aged 59.8 ± 12.6 years in two different sessions seven days apart.

**Results:** A good degree of intraobserver agreement was observed between test 1 and test 2. The correlation coefficient between the first and second studies ranged between 0.60 and 0.96; measurement errors between 0.050 and 0.205.

**Conclusion:** We would conclude that 2-dimensional guided M-mode measurements at echocardiography performed at our centre are reproducible with low intra-observer variability.

Background

Echocardiography came into use in Nigeria in the mid 70’s, however, in very few centres mostly concentrated in urban areas. Accessibility to echocardiography in Nigeria is still very low due to the high costs of the technique and to the lack of highly specialized personnel performing it. In fact, the country has less than fifty cardiologists serving a population of over 120 million inhabitants. Training in echocardiography is part of the postgraduate residency training requirements in cardiology in Nigeria.

The country, like most developing nations does not have an accreditation process as those designed in Europe and the United States. Separate proficiency examinations in echocardiography such as the British Society of echocardiography examination or similar examination recently introduced by the European Society of Echocardiography are not available. Nevertheless, some of the cardiologists had part or all of their clinical training in advanced countries.

Echocardiography is a highly subjective technique that requires a standardized approach due to its proven clinical usefulness.
Therefore, the aim of our study was to assess the intraobserver variability in M-mode echocardiographic measurements in an urban hospital and to provide a picture of the main indications to an echo exam in Nigeria. This type of survey was never addressed before. We therefore, assessed the intraobserver variability in echocardiographic measurement in our centre.

**Methods**

The study was carried out at the Department of Medicine, Federal Medical Centre, Abeokuta, Nigeria between September and November 2005. The centre is a relatively young tertiary institution, established in 1993 by the Federal Government of Nigeria to cater for the health need of the people of Ogun State in South-western Nigeria. The state has a population of about 3.2 million and a land area of about 16,409.26 square kilometres.

Echocardiography is performed at our centre on a weekly basis except in emergency situations. An average of ten echocardiograms is performed per week.

During the period of the study, a total of one hundred and four subjects had echocardiogram. The main indications for echocardiography were hypertensive heart disease, congestive cardiac failure, heart murmur and pre-operative evaluation of cardiac function. Twenty-three of the subjects were randomly selected for the study. (with the use of computer generated random numbers) Two of the subjects had poor ‘echo’ window and one had regional wall motion abnormality due to left bundle branch block and were therefore excluded. All the other twenty subjects had symmetrically contracting left ventricles.

Informed consent was obtained from the subjects and ethical approval was obtained from our institution’s ethical review committee.

**Clinical evaluation**

Baseline clinical and demographic characteristics were obtained from the subjects. These included date of birth, age, gender and indication for echocardiogram.

Blood pressure measurements were obtained according to standard guidelines [1] with a mercury sphygmomanometer (Accoson London). Systolic and diastolic blood pressures were measured at Korotkoff sounds phase I and V respectively. Blood pressure was measured at the right arm three times after a 5 minutes rest. Blood pressure 140/90 and above was taken as hypertension. Subjects were weighed without shoes and in light clothing on a standard beam balance. Height was measured to the nearest centimetre using anthropometrical plane with subjects not putting on shoes or headgear.

Body mass index (BMI) was calculated using the formula: 

\[
BMI = \frac{Weight\ (kg)}{Height^2\ (m^2)}
\]

Body surface area (BSA) was calculated using the formula of Dubois [2].

**Echocardiography**

Two-dimensional guided M-mode echocardiography with the use of commercially available echo-machine (ALOKA SSD-1, 100) and a 3.5 MHz linear array transducer was performed on each subject in the partial decubitus position. All measurements were made according to the American Society of Echocardiography (ASE) leading edge to leading edge convention [3]. LV measurement was obtained at end diastole and end systole in the parasternal long axis view. The LV measurements take include right ventricular outflow tract diameter (RVOT), aortic root diameter (AO), and aortic valve opening (AVO) and left atrial diameter (LA). Others include interventricular septal thickness at end-diastole (IVSTd) and end-systole (IVSTs), the posterior wall thickness at end diastole (PWTd) and end-systole (PWTs), and the LV internal dimensions at end systole (LVIDs) and end diastole (LVIDd). The end of diastole was taken as the peak of the R-wave of the ECG tracing on the echocardiograph while the end-systolic measurements were taken at the nadir of the LV septal wall [3].

LV mass was calculated from the ASE measurements using the cubed formula [4]:

\[
LV\ mass\ (g) = 0.8 \times \{1.04 \times [(IVSTd + LVIDd + PWTd)^3 - (LVIDd)^3] + 0.6
\]

All the measurements were taken at baseline and one week after. Measurements were taken online and in three cardiac cycles and average of the three values calculated. Off-line measurements were not possible because of the lack of the software in our centre. Image storage was with the use of videotapes. One experienced cardiologist performed all the echocardiography.

| Table 1: Baseline characteristics of the subjects |
|-----------------------------------------------|
| Age                                           | 59.8 (12.6) |
| Gender (Male/Female)                          | 11/9 (55%/45%) |
| Weight (Kg)                                   | 73 (19.3)   |
| Height (cm)                                   | 161.5 (9.4) |
| Body Mass Index (Kg/m²)                       | 28.2 (6.9)  |
| Body Surface Area (m²)                        | 1.77 (0.25) |
| Systolic Blood Pressure (mmHg)                | 139.4 (26.6) |
| Diastolic Blood Pressure (mmHg)               | 84.7 (16.5) |
| Heart Rate (beats/min)                        | 85.6 (12.9) |
| Indication for Echocardiography               |             |
| * Hypertensive Heart Disease                   | 16 (80%)    |
| * Rheumatic Heart Disease                      | 2 (10%)     |
| * Dilated Cardiomyopathy                       | 2 (10%)     |
Data analysis

Data management and analysis were performed with SPSS software version 11.0. (SPSS, Inc. Chicago, Illinois). Continuous variables were expressed as mean ± SD (standard deviation) and categorical variables expressed as percentages. The paired student t-tests was used to compare the means of baseline and repeated measures. Differences between the repeated measures (measurement 1 minus measurement 2) were plotted against the mean of repeated measures (measurement 1 plus measurement 2 divided by 2) according to the method of Bland and Altman[5].

A 2-tailed p value <0.05 was considered to be significant.

Results

Table 1 shows the baseline clinical and demographic characteristics of the subjects. The study subjects were made up of eleven men and nine women constituting 55% and 45% respectively. The mean age was 59.8 ± 12.6 years (range 39–76 years).

The mean body mass index was 28.2 ± 6.9 kg/m² while mean body surface area was 1.77 ± 0.25 m². Mean systolic blood pressure, diastolic blood pressure and pulse rate were 139.4 ± 26.6 mmHg, 84.7 ± 16.5 mmHg and 85.6 ± 12.9 beats/min respectively.

The indications for echocardiography were hypertensive heart disease (sixteen subjects), rheumatic heart disease (two subjects) and dilated cardiomyopathy (two subjects).

Echocardiographic diagnosis made were hypertensive heart disease (left ventricular hypertrophy and/or diastolic dysfunction) in ten of the sixteen hypertensives, and normal study in the remaining six subjects. Mixed mitral valve disease (but predominantly mitral stenosis) was diagnosed in the two female subjects with rheumatic heart disease.

The dilated cardiomyopathy cases were pregnancy related (peripartal cardiomyopathy) which is a common disorder in Nigeria especially in northern Nigeria, which is reported to have the highest incidence in the world.

Scatter plots of LV measurements were performed for measurements 1 and 2 (plots not shown) Bland–Altman plots were also performed to determine the 95% confidence limits of agreement between the two measurements. Two of such plots are shown in figures 1 and 2.

The plots provided visual information on the degree of disagreement, as well as the relationship of the differences and size of the measurements. Most of the plots were near the zero-difference line and showed uniform distribution pattern.

Table 2 displays the degree of correlation between the first and second measurements as well as the 95% confidence intervals. There was good correlation between the two measurements in all the parameters. The intraobserver concordance correlation coefficient for RVOT, aortic root...
diameter, aortic valve separation, left atrial diameter, IVSd, IVSs, LVID, LVIS, PWTd, PWTs and LVM were 0.76, 0.91, 0.60, 0.91, 0.93, 0.81, 0.92, 0.96, 0.75, 0.79 and 0.89 respectively.

Table 3 depicts the intraobserver comparisons. Difference between first and second measurement of interventricular septal wall thickness in diastole was statistically significant.

Large standard deviations of the difference were found for end diastolic LV diameter, right ventricular outflow tract diameter, aortic root diameter, aortic valve opening and LVM.

**Discussion**

Echocardiography is becoming a common practice in Nigeria especially in the major cities. Conventional echocardiographs are commoner. Portable echo-machine is probably available in only one centre. Transoesophageal echocardiography is yet to be introduced into the country. Measurements are obtained on-line in all the centres due to the high cost of off-line software and machines. Recording is mainly by videotapes.

The common indications for echocardiography in Nigeria are hypertensive heart disease, cardiomyopathies, and valvular heart disease.

In a report by Balogun et al[6], hypertensive heart disease, cardiomyopathies, normal echocardiogram, valvular heart disease and pericardial diseases constituted 53%, 21%, 13%, 7%, and 4% respectively of echocardiographic diagnoses in their series. An audit of 1544 echocardiograms performed over a 19-month period (article in press) showed that hypertensive heart disease (51.8%),

| PARAMETER    | r     | P       | 95% CI       |
|--------------|-------|---------|--------------|
| RVOT         | 0.76  | <0.0001 | 0.470–0.898  |
| AO           | 0.91  | <0.0001 | 0.787–0.965  |
| AVO          | 0.60  | 0.0041  | 0.217–0.825  |
| LA           | 0.91  | <0.0001 | 0.789–0.970  |
| IVSD         | 0.93  | <0.0001 | 0.835–0.933  |
| IVSS         | 0.81  | <0.0001 | 0.566–0.920  |
| LVID         | 0.92  | <0.0001 | 0.795–0.967  |
| LVIS         | 0.96  | <0.0001 | 0.90–0.98    |
| PWTd         | 0.75  | <0.0001 | 0.453–0.894  |
| PWTs         | 0.79  | <0.0001 | 0.526–0.911  |
| LVM          | 0.89  | <0.0001 | 0.748–0.958  |

RVOT = Right Ventricular Outflow Diameter, AO = Aortic Root Diameter, AVO = Aortic Valve Opening, LA = Left Atrial Diameter, IVSd = Interventricular Septal wall thickness in diastole, IVSs = Interventricular septal wall thickness in systole, LVIDd = Left ventricular Internal Diameter in Diastole, LVIS = Left Ventricular internal diameter in Systole, PWTd = Posterior Wall Thickness in Diastole, PWTs = Posterior Wall Thickness in Systole, LVM = Left Ventricular Mass

| PARAMETER    | n  | TEST 1(SD)     | TEST 2 (2D) | MEAN DIFFERENCE (2D) | P VALUE |
|--------------|----|----------------|-------------|-----------------------|---------|
| RVOT         | 20 | 2.95(0.58)     | 2.99(0.53)  | -0.06(0.39)           | 0.534   |
| AO           | 20 | 2.74(0.36)     | 2.77(0.36)  | -0.025(0.152)         | 0.470   |
| AVO          | 20 | 1.86(0.46)     | 1.94(0.35)  | -0.08(0.37)           | 0.365   |
| LA           | 20 | 3.89(0.69)     | 3.76(0.71)  | 0.12(0.29)            | 0.078   |
| IVSd         | 20 | 1.02(0.27)     | 0.93(0.25)  | 0.09(0.10)            | 0.001   |
| IVSS         | 20 | 1.26(0.36)     | 1.22(0.34)  | 0.04(0.22)            | 0.450   |
| LVIDd        | 20 | 5.33(0.88)     | 5.35(1.08)  | 0.02(0.41)            | 0.850   |
| LVIDs        | 20 | 3.80(1.08)     | 3.83(1.24)  | 0.03(0.37)            | 0.744   |
| PWTd         | 20 | 1.08(0.20)     | 1.10(0.23)  | 0.03(0.16)            | 0.744   |
| PWTs         | 20 | 1.46(0.25)     | 1.56(0.29)  | 0.10(0.18)            | 0.575   |
| LVM          | 20 | 217.5(70.2)    | 211.8(81.0) | 5.68(36.3)            | 0.492   |

RVOT = Right Ventricular Outflow Diameter, AO = Aortic Root Diameter, AVO = Aortic Valve Opening, LA = Left Atrial Diameter, IVSd = Interventricular Septal wall thickness in diastole, IVSs = Interventricular septal wall thickness in systole, LVIDd = Left ventricular Internal Diameter in Diastole, LVIS = Left Ventricular internal diameter in Systole, PWTd = Posterior Wall Thickness in Diastole, PWTs = Posterior Wall Thickness in Systole, LVM = Left Ventricular Mass
normal study (36.5%), valvular heart disease (3.5%),
dilated cardiomyopathy (1.9%) were the most frequent
diagnoses.

The potential of echocardiography as a research tool in
Nigeria cannot be overemphasized. Studies emanating
from the country have focused on the common cardiovas-
cular diseases in the country such as hypertensive heart
disease [7-15], heart failure [16,17], dilated cardiomyopa-
thy including peripartal heart disease, and valvular heart
disease [18,19]. Others have also studied cardiac function
in diabetes mellitus [20-22], congenital heart diseases [23]
and sickle cell disease [24]. The usefulness of ECG criteria
for the diagnosis of left ventricular hypertrophy in Nigeri-
ans using echocardiography as standard has also been
reported [25].

This quality assessment study addressed the intraobserver
variation of 2-dimensional guided M-mode echocardio-
graphic measurements in our centre. The study demon-
strated that echocardiographic measurements by a single
cardiologist is consistent and has acceptable intraobserver
variation. Interobserver variation was not evaluated in
this study because only one cardiologist performs the pro-
cedure in our hospital.

Results from other studies on intraobserver variations
of echocardiographic measurements vary in study design
and method of analyses.

Schieken et al [26] studied the intraobserver variability of
aortic root diameter, left atrial diameter, LV septal and pos-
terior wall thickness, LV interval dimensions and ejection
time in 20 healthy children aged 6–16 years. The measure-
ment errors (standard deviation divided by 2) were
reported as 0.5, 0.6, 0.6, 1.3, 0.6, 1.0 mm and 0.01 second
respectively. These are comparable to the findings in this
study (Table 3). Our measurement errors were 0.195, 0.076, 0.145, 0.050, 0.110, 0.202, 0.185, 0.080, and 0.090 for RVOT, aortic root diameter, aortic root sepa-
ration, left atrial diameter, IVSd, IVSs, LVID, LVIS, LVM,
and PWT respectively. Our finding is similar to the obser-
vation of Dai et al [27]. Valdez et al [28] reported
significant intraobserver difference in only one person in
the measurement of LV end diastolic posterior wall diam-
eter in his study of 20 subjects. In the present study signif-
ificant intraobserver difference was observed only in LV
septal wall thickness in diastole (LVIDd).

In the study by Ladipo et al [29], intraobserver variations
were assessed in 10 subjects. The mean difference of 0.7–1.2, 0.2–0.8, 0.3–0.4 and 0.4–0.8 mm were reported for LV internal dimensions in diastole and systole, LV poste-
rior wall thickness in diastole, LV septal wall thickness in
diastole respectively. Table 4 shows a summary of previ-
ous studies and present study.

The main limitation of echocardiography is its subjectivity
in the face of a proven clinical usefulness. Training and
accreditation procedures are key factors to obtain a reli-
able and standard examination. The results of our study
demonstrate that when the same person with an appro-
appropriate training performs echocardiography, the intra-
observer variability is low. This assessment is important in
order to have an internal control for our laboratory since
this technology might represent the only possible proce-
dure for any given clinical condition. Our data are consist-
ent with previous reports.

Workers have highlighted the sources of variation in
echocardiographic measurements [30-32]. These include
factors that affect image quality such as subject’s body

| Parameter | Dai et al (ref 27) | Present Study | Ladipo et al (ref 29) | Schieken et al (ref 26) |
|-----------|-------------------|---------------|----------------------|------------------------|
| RVOT      | NA                | NA            | NA                   | NA                     |
| AO        | 0.05              | 1.20          | 0.60                 | 0.025                  |
| AVO       | NA                | NA            | NA                   | NA                     |
| LA        | 0.15              | 1.35          | 0.675                | 0.12                   |
| IVSd      | 0.05              | 0.82          | 0.41                 | 0.09                   |
| IVSs      | 0.05              | 1.13          | 0.565                | 0.04                   |
| LVIDd     | -0.60             | 0.97          | 0.485                | 0.02                   |
| LVIDs     | -0.15             | 1.18          | 0.595                | 0.03                   |
| PWTd      | 0.13              | 0.84          | 0.42                 | 0.03                   |
| PWTs      | 0.33              | 1.14          | 0.57                 | 0.10                   |
| LVM       | -1.82             | 18.79         | 9.40                 | 5.68                   |

RVOT = Right Ventricular Outflow Diameter, AO = Aortic Root Diameter, AVO = Aortic Valve Opening, LA = Left Atrial Diameter, IVSd = Interventricular Septal wall thickness in diastole, IVSs = Interventricular septal wall thickness in systole, LVIDs = Left ventricular Internal Diameter in Diastole, LVIS = Left Ventricular internal diameter in Systole, PWTd = Posterior Wall Thickness in Diastole, PWTs = Posterior Wall Thickness in Systole, LVM = Left Ventricular Mass, Mdiff = Mean difference, SD = Standard Deviation, Error = SD/2 NA = Not Available.
build, respiratory status and co-operation. Others include ability of the sonographer to correctly recognize image signals, transducer orientation and placement as well as his/her familiarity with the machine.

**Limitations of the study**

Interobserver variability was not analyzed in the present study since echocardiography is performed at our center by only one cardiologist. In Nigeria as previously stated, the number of cardiologists is very small. Nonetheless this analysis and results were aimed at providing an objective assessment of the quality of our laboratory. Furthermore, Doppler measurements were not evaluated. We also did not obtain measurement using the 2D technique, which has been shown to have better reliability than the M-mode technique.

**Conclusion**

We would conclude that quantitative 2-dimensional guided M-mode echocardiography performed in our centre is reproducible and has good validity. It therefore provides a valuable tool for cardiac structure and function studies.

**Competing interests**

The authors declare that they have no competing interests.

**Authors’ contributions**

OSO conceived of the study, carried out the echocardiograms, analysed the data and drafted the manuscript.

AAT, OAS and JJT participated in the recruitment of subjects and in data management. All authors read and approved the final manuscript.

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