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2011 appropriate use criteria audit of an echocardiography lab in South Western Nigeria

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Abstract

Cardiovascular diseases are the major cause of death worldwide. Since its discovery in the 20th century, Echocardiography (ECHO) has become one of the pivotal tools in assessing cardiac structure and function. With the increase in requests for ECHO, there has risen an unwanted problem - inappropriate requests for ECHO. There has therefore arisen the need to audit ECHO labs for the appropriateness of ECHO requests. The patients referred from the outpatient clinics and in-patient wards for ECHO from June 1st, 2015 till September 30th, 2016 were recruited. Their request form data, clinical information, and ECHO results were analyzed as appropriate. The 2011 appropriate use criteria for Transthoracic ECHO was utilized. The most common indication out of the 2174 ECHOs reviewed was hypertension (16%), closely followed by hypertensive heart disease (12.4%). The percentage of appropriate, inappropriate, and uncertain indications according to the 2011 appropriate use criteria (AUC) for transthoracic echocardiography were 41.4%, 31.1%, and 0.1% respectively. Less than ten percent (9.3%) of the indications could not be classified by the 2011 AUC while 18.1% of the ECHOs had no indication. When indications of Hypertension, Hypertensive Heart Disease (HHD) and heart failure were compared, heart failure was significantly associated with eccentric Left Ventricular Hypertrophy (LVH), larger LV mass, lower BMI, larger cardiac dimensions, reduced ejection fraction, lower trans mitral A velocities than the other two indications. Concentric LVH was showed a trend towards being most in those with HHD (p= 0.072). The percentage of appropriate indications was low in this study as compared to others, largely because of large inappropriate indications. There is a need to ensure appropriate indications are filled for ECHO request forms. The 2011 AUC may need to be reviewed to expand the appropriate group of indications.

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Introduction

Transthoracic Echocardiography (ECHO) has evolved since its discovery in the 1950s as a simple, non-invasive, relatively cheap and objective tool for assessing cardiac function.[1] Transoesophageal echocardiography also evolved a few decades ago, which has increased spatial resolution with an improved evaluation of the atrial appendages and the mitral valvular apparatus.

The relatively low cost, non-invasiveness, minimal patient discomfort involved and the real-time imaging of cardiac structures and function of echocardiography makes it an invaluable tool in cardiovascular imaging as compared to other modalities like ventriculography, cardiac computed tomography imaging and magnetic resonance imaging. Apart from cardiac specific conditions,

diverse systemic problems could also benefit from Echo, including stroke, Ehler-Danlos syndrome, Marfan's syndrome, adult polycystic kidney disease among others.[2–5]

The presence of various risk factors among people groups and the recognition of various indices of cardiac dysfunction prompts referrals for echocardiography. Also, the anticipation of a possible change in cardiovascular status following an intervention like the administration of cytotoxic drugs may prompt referrals for ECHO. The preoperative cardiovascular assessment of patients may also warrant the referral for echo as required.

Nigeria is blessed with a population of about one hundred and seventy-five million people and has an array of cardiovascular risk factors for which people seek proper cardiovascular evaluation.[6] History taking and physical examination have been used as invaluable screening tools over the years for various risk factors. However, history taking and physical examination are limited and there is a need for improvement in cardiovascular assessment and diagnosis of on-going or established target organ damage so as to institute appropriate levels of prevention and intervention.

It is also noteworthy, however, that a tool with such wide applicability like ECHO is prone to abuse and misuse. It has been speculated that where ready aids like ECHO and electrocardiography exist, the mind goes to sleep. Thus, what should have been a complement to sound reasoning following proper history and physical exam now becomes the primary screening tool. This breeds what has been appropriately termed hyposkillia-deficiency of clinical skills which is covered up by use of investigations.[7] This contributes on the long run to overburdening of the health sector, incurring of undue cost for both patients and cardiologists, and brain drain.

The American college of cardiology foundation developed an appropriate use criteria for evaluating requests for Transthoracic (TTE) and Transoesophageal Echocardiography (TEE), first in 2007 and now 2011.[8] This has been used in North America and Europe but not yet in West Africa to the best of our knowledge. We therefore set out to use the same tool to evaluate our practice in Nigeria, Africa's most populous nation.

Materials and Methods

The study was carried out at the Cardiology Unit of the University College Hospital (UCH). University College Hospital is located in Ibadan, the capital city of Oyo state. It is the Premier Teaching Hospital in Nigeria and the major tertiary centre in the state, sub-serving the whole state and neighbouring states within the South West geopolitical zone. Most clinical specialties refer patients for echocardiography for various reasons.

Echocardiography commenced in UCH about 2 decades ago and has become a cornerstone tool in evaluating cardiac structure and function. The ECHO suite is presently well-staffed with physiologists, cardiac nurses and cardiologists. Echocardiography is done routinely every Wednesday, though it is also done on any day of the week for emergencies, as occasion demands.

Eligible participants in the study were people referred for echocardiography to the ECHO suite of UCH, Ibadan. The study was a descriptive, cross-sectional study involving a review of the records of all requests and services provided by the unit over a period of sixteen months. Those included were individuals aged 12 years and above who were referred for echocardiography to the ECHO suite of UCH, Ibadan. Those aged less than 12 years at the time of echocardiographic evaluation and patients with incomplete data were excluded from the study.

A total sampling method was used, which essentially consisted of all the patients that were referred for ECHO from June 2015 till September 2016. All those who satisfied the inclusion criteria were incorporated into the study. The ethical approval was obtained from the joint University of Ibadan and University College Hospital ethical review board. This research conformed to widely accepted ethical principles as stated at the declaration of Helsinki.

The cardiac structure and function of the subjects and controls were evaluated at the ECHO Suite of the hospital. Data were collected using a proforma consisting of the following sections: Demographics, anthropometric information, indications for referral, cadre of doctor referring patient and Echocardiographic variables, including the diagnosis. Measurements were made according to the recommendations of the American Society of Echocardiography.[9]

Data management

Data were collected using a standard proforma. Analysis was done using the Statistical Package for Social Sciences (SPSS) version 20. Continuous variables were expressed as means and categorical variables expressed as percentages. Differences in categorical variables were assessed using the chi-square test while that of continuous variables was evaluated using T-test and Analysis of Variance (ANOVA) test. A two-tailed P value <0.05 was considered significant.

Results

A total of 2174 echocardiography studies were done. Out of these, 394 people were referred for Echocardiography with no indications for the test on their request cards. The appropriate use criteria - 2011 edition- has a total of 98 indications for transthoracic echocardiography. These are categorized into appropriate, inappropriate and uncertain. A total of 34 indications were applicable to this ECHO lab. These are listed below in Table 1.

Seven hundred and thirty-three (33.7%) of echocardiography tests done were not classified as 339 (15.6%) of these had indications that were not addressed by the 2011 AUC document. The other 394 (18.1%) requests had no indication for echocardiography on the request forms. Of the 1578 ECHOs that could be evaluated by the 2011 appropriate use criteria, 56.9% of them were appropriate, 43% were inappropriate and 0.001 were uncertain. Table 2 shows the ECHOs addressed by the 2011 AUC, including those with no indications and those that could not be classified by the AUC.

Table 3 shows the characteristics of the ECHO results according to the indications for ECHO. Those with appropriate, inappropriate and unclassified indications had 23.6%, 24% and 27.9% normal results respectively. Those with appropriate indications clearly showed a significant difference between those with normal and those with abnormal ECHOs in terms of their systolic blood pressures, left ventricular ejection fractions and their left atrial sizes. Other details can be seen in Table 3.

Cardiologists were the chief source of echocardiogram referrals, followed by surgeons. About a third of the referrals could not be traced to any particular source due to incompleteness of records.

Those in the inappropriate category were generally older, had higher Body Mass Index (BMI), higher blood pressure and pulse pressure values than the other categories. Subjects in the appropriate category had larger left atrial diameters, lower ejection fractions, larger left ventricular volumes and heavier left ventricles than others. Details can be seen in Table 4.

Hypertension, hypertensive heart disease and heart failure

Those with hypertension were younger than those with Hypertensive Heart Disease (HHD), with a mean age difference of 4 years. Twenty percent (20%) of those with hypertension had left atrial enlargement, as compared to HHD (37.1%) and heart failure (65%; p=0.000). Those with hypertension weighed more, had higher body surface area, lower left ventricular mass and higher left ventricular ejection fraction as compared to those with hypertensive heart disease. Details can be seen in Table 5.

Those with heart failure had lower systolic and diastolic blood pressures, larger cardiac dimensions, higher LV mass, lower ejection fraction, slower trans-mitral A velocities and shorter E deceleration time. Details can be seen in Table 6.

Geometric patterns among hypertension, hypertensive heart disease and heart failure

Those with heart failure had significantly less normal geometric patterns as compared to either hypertension or hypertensive heart disease, especially in women (p=0.000). Concentric remodelling was however relatively common, especially among men with hypertension (P=0.000). Eccentric LVH was significantly more in those with heart failure among either gender (p=0.000 for men and women). Concentric LVH was not different whithin the three classes, though showing a trend towards being highest in those with hypertensive heart disease (p=0.072).

Discussion

A total of 2174 ECHO studies were recruited in this study. Hypertension was the most common indication for ECHO (16%). This is comparable to the findings of Oyedeji *et al.*, where hypertension was the most common indication for ECHO.[10] The percentage of 16.1% is however much lower than that in Cuspidi *et al.* (30.4%).[11] This is likely due to the fact that Hypertension and

Table 1. Indications for echocardiography at the ECHO suite, University College Hospital.

Number of indication	Summary of indication	N (%)
1	Symptoms or conditions potentially related to suspected cardiac aetiology	240(11)
2	Prior testing that is concerning for heart disease or structural abnormality	120(5.5)
4	Frequent VPCs or exercise induced VPCs	1(0)
5	Sustained or non-sustained atrial fibrillation, SVT or VT	8(0.4)
6	Asymptomatic isolated sinus bradycardia	17(0.8)
7	Clinical symptoms or signs consistent with a cardiac diagnosis known to cause light headedness/pre-syncope/syncope	5(0.2)
9	Syncope with no symptoms/signs of CV disease	3(0.1)
13	Routine perioperative evaluation of ventricular function with no symptoms/signs of CV disease	227(10.4)
15	Evaluation of suspected pulmonary hypertension, RV function and Pulmonary artery pressure	12(0.6)
21	Acute chest pain with suspected MI and non-diagnostic ECG	2(0.1)
28	Suspected Pulmonary embolism in order to establish diagnosis	2(0.1)
29	Known acute pulmonary embolism to guide therapy	7(0.3)
31	Re-evaluation of known pulmonary embolism after thrombolysis or thrombectomy	1(0.0)
34	Initial evaluation when there is a reasonable suspicion of valvular or structural heart disease	5(0.2)
37	Re-evaluation of known valvular heart disease with a change in clinical status to guide therapy	1(0.0)
47	Initial post-op evaluation of prosthetic valve	1(0.0)
52	Initial evaluation of suspected infective endocarditis with positive blood cultures/a new murmur	3(0.1)
55	Re-evaluation of infective endocarditis at high risk of progression/ a change in clinical status	1(0.0)
57	Suspected Cardiac mass	2(0.1)
58	Suspected cardiovascular source of embolus	1(0.0)
59	Suspected pericardial conditions	2(0.1)
61	Re-evaluation of known pericardial effusion to guide management or therapy	6(0.3)
63	Evaluation of the ascending aorta in the setting of a known or suspected connective tissue disease	2(0.1)
67	Initial evaluation of suspected hypertensive heart disease	186(8.6)
68	Routine evaluation of systemic hypertension without symptoms or signs of hypertensive heart disease	351(16)
70	Initial evaluation of known or suspected HF (systolic and diastolic) based on symptoms or signs	124(5.7)
71	Re-evaluation of known HF with a change in clinical status	1(0.0)
72	Re-evaluation of the known HF with a clear precipitating change in medication or diet	2(0.1)
73	Re-evaluation of known HF to guide therapy	2(0.1)
79	Routine surveillance of implanted device without a change in clinical status or cardiac exam	1(0.0)
86	Initial evaluation of known or suspected cardiomyopathy	21(1)
87	Re-evaluation of known cardiomyopathy with change in clinical status or cardiac exam or to guide therapy	2(0.1)
91	Baseline and serial re-evaluations in a patient undergoing therapy with cardio toxic agents	70(3.2)
92	Initial evaluation of known or suspected adult congenital heart disease	3(0.1)

hypertensive heart disease are separate indications in this study (as compared to theirs), with both having a combined prevalence of 24.6%. Oyedeji *et al.* considered hypertension and hypertension-related indications together and reported a joint prevalence of 38.1% in their study. They worked in a similar geopolitical zone (just 133 km south of our centre). However, their higher prevalence may be due to the type of clinical practice - theirs is a private clinic with a total number of 168 cases over a 2-years period while ours is a public, tertiary hospital which grossed over 1200% of their number of patients, cutting across most disciplines of medicine. The sizable number of referrals for surgeons, family physicians and other disciplines may have accounted for a salutary effect on the prevalence of hypertension and hypertension-related indications in this study.

The next most common indication is that of symptoms suspect of a potential cardiac aetiology (11%). These consisted of stroke, palpitations, breathlessness, pedal swelling, among others. Other common indications include preoperative cardiac evaluation (10.4%), evaluation of cardiac function in those about to commence cardiotoxic agents (5.7%), prior testing that is concerning heart disease (5.5%) and heart failure (3.2%).

The appropriateness of the indications for echocardiography at the ECHO suite

Most studies have shown that most Transthoracic echocardiogram labs largely comply with 2011 AUC criteria, with greater than 80% of the indications being appropriate.[12–14] However, this study found that only 41.1% of the indications for ECHO were appropriate. This is in stark contrast to the findings from most studies. This could be possibly explained by the unduly high proportion of those ECHO requests that had no indication. If these were taken out, the adjusted prevalence of appropriate indications will be 50.4%. Another reason is that the most common indication for ECHO in our lab, hypertension, is classified as inappropriate

Table 2. Appropriateness of indications for Echocardiography.

Indication	N(%)
Appropriate	898(41.3)
Inappropriate	678(31.1)
Unclassified	203(9.3)
No indication	394(18.1)
Uncertain	2(0.1)

Table 3. Classification of ejection fraction, left atrial diameter and blood pressure according to the appropriateness of the indication for echocardiography.

Appropriate-Variables	Normal study (n=210)	Abnormal study (n=681)	P value
Ejection fraction (%)	68.7±8.6	58.9±18.2	0.000
Left atrial diameter (cm)	3.31±0.46	3.86±0.81	0.000
Systolic blood pressure (mmHg)	127.8±18.8	132.4±22.5	0.025
Inappropriate-Variables	**Normal study(n=115)**	**Abnormal study(n=364)**	**P value**
Ejection fraction (%)	68.9±9.54	68.4±12.8	0.61
Left atrial diameter (cm)	3.37±0.42	3.59±0.58	0.000
Systolic blood pressure (mmHg)	136.4±18.6	142.1±21.6	0.011
Unclassified-Variables	**Normal study (n=39)**	**Abnormal study (n=101)**	**P value**
Ejection fraction (%)	70.3±7.1	66.3±12.9	0.035
Left atrial diameter (cm)	2.77±0.39	2.87±0.4	0.107
Systolic blood pressure (mmHg)	127.3±16.6	130.2±20.4	0.421

Table 4. Anthropometric, clinical and echocardiographic variables among the major appropriate use criteria classes.

Variables	Appropriate n=898	Inappropriate n=678	Unclassified n=203	F static	P value
Age (years)	54.0±17.1	58.6±14.0	52.6±18.1	19.407	0.000
Systolic BP (mmHg)	131.2±21.8	140.8±20.9	129.2±19.6	32.639	0.000
Diastolic BP (mmHg)	83.0±13.3	86.9±13.5	81.6±12.8	15.089	0.000
Aortic root Diameter (cm)	2.85±0.43	2.87±0.42	2.84±0.40	0.741	0.477
Left atrial diameter (cm)	3.72±0.78	3.54±0.55	3.54±0.71	16.999	0.000
Stroke volume (cm^3)	70.8±25.5	73.1±24.6	67.3±24.7	4.479	0.011
Fractional shortening (%)	34.6±12.0	39.4±9.4	38.2±9.7	39.592	0.000
Ejection Fraction (%)	61.3±17.1	68.5±12.2	67±12.7	47.731	0.000
Body mass index (Kg/m^2)	27.0±6.2	27.8±5.9	26.5±5.4	4.796	0.008
Pulse Pressure (mmHg)	48.2±16.42	53.8±16.4	47.6±14.5	18.529	0.000
Height (m)	1.65±0.1	1.65±0.1	1.64±0.1	3.957	0.019
LV mass indexed to $Height^{2.7}$ ($g/m^{2.7}$)	45.1±19.7	42.8±15.2	41±17.4	5.341	0.005
LV mass indexed to BSA (g/m^2)	97.3±42.3	90.2±30.4	87.0±34.9	9.129	0.000
BSA (Dubois) (m^2)	1.81±0.2	1.82±0.2	1.76±0.2	5.198	0.006
LV Volume BSA (cm^3)	70.1±33.4	60.9±21.5	59.4±25.9	22.145	0.000

by the AUC 2011. This causes a sharp fall in the percentage of appropriate indications.

Two hundred and three ECHOs were done which could not be classified by the 2011 AUC. Some of these indications include cancer, chronic kidney disease, prostate enlargement, simple multi nodular goitre, sickle cell anaemia, suspected COPD, Ischaemic heart disease, routine ECHO, suspected stroke and diabetes mellitus, among others. While it is true that some of these conditions may get complicated and require ECHO, they do not qualify as standalone indications, nor were they addressed as being either inappropriate or uncertain in the 2011 AUC.

An unpleasant finding is that of 394 ECHOs being done at the lab with absolutely no indication. This is more in number than the highest-ranking indication for ECHO (16% vs18.1%) This has not been commonly reported.

The correlation between the indications and the results of the ECHO

All classifications of indications for ECHO revealed normal findings, with appropriate, inappropriate and unclassified yielding percentages of 23.6%, 24%, and 27.9% respectively. The results of the ECHOs done for those with appropriate indications showed a significant difference in the systolic blood pressure, left ventricular ejection fraction and left atrial diameter among those with normal as compared to those with abnormal findings. This suggests that those with abnormal findings on ECHO had significantly higher blood pressure readings than their counterparts, had reduced systolic function and had larger left atrial diameters - a measure of diastolic dysfunction.[15] It is interesting to note that this pattern is not found in the other classifications, as those with inappropriate indications had similar left ventricular ejection fractions regardless of whether the ECHO report ended up being normal or not. However, for those who had abnormal ECHO results, the systolic blood pressure was significantly higher as compared to those with normal results. This suggests that there may be a yet undefined blood pressure cut-off point at which ECHO may be indicated-regardless of the duration of hypertension or presence of other risk factors. This also may be a fall out of the fact that Hypertension, the most common indication for ECHO in this lab, was classified as inappropriate according to the 2011 AUC guideline.

Those with an unclassified indication for ECHOs had significantly lower left ventricular ejection fractions among those with abnormal ECHO findings as compared with those who had normal ECHOs. However, their left atrial diameters and systolic blood pressures were essentially the same in both groups.

The summary of this is that the appropriate indications have good discriminant ability, with those having abnormal ECHO findings having elevated blood pressure as compared to those with normal findings. The findings from inappropriate indications' analysis suggest that there may be a yet to be defined cut off point, at which

Table 5. Comparison between those with indications of hypertension and hypertensive heart disease.

Variables	Hypertensive heart disease n=170	Hypertension n=325	P value
Height (cm)	164.9±9.7	165.2±9.5	0.673
Weight (kg)	74.5±14.1	78.1±15.9	0.013
Age (years)	60.4±14.1	56.4±13.5	0.001
Systolic BP (mmHg)	140.3±22.7	143.3±20.4	0.183
Diastolic BP (mmHg)	86.1±14.3	89.1±13.3	0.036
Aortic root diameter (cm)	2.9±0.42	2.87±0.4	0.318
Aortic valve opening (cm)	1.97±0.36	1.97±0.34	0.890
Left atrial diameter (cm)	3.8±0.73	3.6±0.58	0.000
Left ventricular internal diameter (diastole) (cm)	4.95±0.9	4.78±0.7	0.019
Left ventricular internal diameter (systole) (cm)	3.3±1.1	2.9±0.8	0.000
End diastolic volume (cm^3)	121.3±55.5	109.9±38.4	0.006
End systolic volume (cm^3)	51.6±48.1	37.8±27.0	0.000
Stroke volume (cm^3)	71.4±25.0	73.0±23.7	0.469
Fractional shortening (%)	35.5±11.5	39.1±9.9	0.000
Ejection fraction (%)	63.1±16.5	67.9±12.9	0.000
E velocity (m/sec)	0.75±0.25	0.70±0.21	0.023
A velocity (m/sec)	0.70±0.23	0.72±0.20	0.137
E deceleration time (msec)	188.8±72.0	178.7±68.2	0.117
BMI (kg/m^2)	27.7±6.4	28.7±6.0	0.076
LV mass (kg)	183.2±88.6	166.9±57.8	0.011
Relative wall thickness	0.41±0.13	0.41±0.12	0.692
End-diastolic volume ^{BSA} (cm^3/m^2)	69.4±31.4	60.6±20.6	0.000
Pulse pressure (mmHg)	54.3±18.9	54.1±16.1	0.944
Left ventricular mass indexed to height $^{2.7}$ ($g/m^{2.7}$)	48.3±23	43.3±14.4	0.004
Body surface area Monstellar (m^2)	1.84±0.18	1.88±0.2	0.015
Body surface area Dubois (m^2)	1.81±0.17	1.85±0.20	0.022
Left ventricular mass ^{BSA} (g/m^2)	102.5±49.4	90.4±29.3	0.001

uncontrolled blood pressure may be a stand-alone indication for ECHO. The unclassified indications may be sorted out individually and standardized based on individual merit or demerit.

Over 2000 ECHOs were done during the period of review. Only 41.1% of the indications were appropriate according to the 2011 AUC, a percentage that is quite low as compared to figures from most parts of the world.[16,17] The main reason is that hypertension, the most common indication for ECHO in this study, is an inappropriate indication, a point which was further emphasized by recommendations of use of TTE in hypertension.[18] However, 74% of people referred with inappropriate indications had left atrial enlargement. Their blood pressures were also significantly higher than those with normal findings on ECHO. Over 18% of the ECHOs done had no indication whatsoever. Cardiologists are also the chief source of referral for ECHOs to the lab, though accounting for only 27.2% of all referrals. There is, therefore, a need to educate the healthcare community on what indications are appropriate, while also re-evaluating the 2011 appropriate use criteria itself for possible modifications to properly classify patients. This has been proposed by Fonseca *et al.*[19]

Hypertension, hypertensive heart disease and heart failure

Long standing, uncontrolled hypertension progresses inexorable to heart failure and as a result, about 75% of heart failure patients have a history of hypertension.[20,21] Hypertensive heart disease is common in Nigeria and hypertension is the most common cause of heart failure-consistently responsible more than 50% of cases nationwide.[22,23] Those with Hypertension in this study weighed more, were younger and generally had higher blood pressures than those with heart failure (possibly due to other aetiologies causing heart failure or due to decapitated hypertension). The mean age of patients with heart failure in this study (58.1±15.7 years) is essentially same with those of the Inter-CHF study (59±0.2 years).[24] Those with heart failure had lower BMI (possibly from imminent cardiac cachexia), larger cardiac dimensions, reduced left ventricular ejection fraction, higher trans-mitral E velocities, lower trans-mitral A velocities and shorter E deceleration rates than those with hypertension and hypertensive heart disease. The trans-mitral E/A ratio and E deceleration time suggests a pseudo normal filling pattern for those with heart failure. They also had higher left ventricular mass and narrower pulse pressures than the other two groups.

Left ventricular geometry

Eccentric LVH was the predominant geometry in heart failure cases for either gender (almost 50% of all heart failure cases) while concentric remodelling was infrequent in heart failure patients, especially in men. Interestingly, Concentric LVH was not significantly more common among the three classes though the absolute prevalence was highest in those with hypertensive heart disease.

The normal LV geometry was unsurprisingly most prevalent in those with hypertension and least prevalent in those with heart failure.

Table 6. Comparison between those with indications of hypertensive heart disease and heart failure.

Variables	Hypertensive heart disease n=170	Heart failure n=114	P value
Height (cm)	164.9±9.7	166.1±8.9	0.299
Weight (kg)	74.5±14.1	74.1±17.8	0.852
Age (years)	60.4±14.1	58.1±15.7	0.180
Systolic BP (mmHg)	140.3±22.7	121.2±21.3	0.000
Diastolic BP (mmHg)	86.1±14.3	79.5±13.6	0.001
Aortic Root Diameter (cm)	2.9±0.42	2.90±0.45	0.927
Aortic valve opening (cm)	1.97±0.36	1.91±0.31	0.110
Left atrial diameter (cm)	3.8±0.73	4.3±0.88	0.000
Left ventricular internal diameter in diastole (cm)	4.95±0.9	5.74±1.2	0.000
Left ventricular internal diameter in systole (cm)	3.3±1.1	4.4±1.5	0.000
End diastolic volume (cm^3)	121.3±55.5	173.2±78.1	0.000
End systolic volume (cm^3)	51.6±48.1	103.7±67.4	0.000
Stroke volume (cm^3)	71.4±25.0	69.7±27.3	0.572
Fractional shortening (%)	35.5±11.5	25.5±13.9	0.000
Ejection fraction (%)	63.1±16.5	45.6±19.5	0.000
E velocity (m/sec)	0.75±0.25	0.80±0.30	0.122
A velocity (m/sec)	0.70±0.23	0.59±0.35	0.002
E deceleration time (msec)	188.8±72.0	156.4±70.1	0.000
Body mass index (Kg/m^2)	27.7±6.4	26.9±6.2	0.305
LV mass (Kg)	183.2±88.6	217.8±86.0	0.001
Relative wall thickness	0.41±0.13	0.34±0.14	0.000
End-Diastolic volume BSA (cm^3/m^2)	69.4±31.4	99.9±45.3	0.000
Pulse pressure (mmHg)	54.3±18.9	41.6±15.0	0.000
LV mass height $^{2.7}$ ($g/m^{2.7}$)	48.3±23	55.4±18.8	0.009
Body surface area (Monstellar) (m^2)	1.84±0.18	1.84±0.24	0.986
Body surface area (Dubois) (m^2)	1.81±0.17	1.81±0.22	0.875
LV Mass ^{BSA} (kg/m^2)	102.5±49.4	122.5±44.7	0.001

Conclusions

The audit of the ECHO lab showed that the percentage of appropriate indications for ECHO is relatively low and the inappropriate indications unduly high. However, 20% of people who were referred for hypertension had left atrial enlargement, a feature of hypertensive heart disease. This suggests that hypertension may be re-classified as an appropriate indication for ECHO, at least in Africans. There is a need to corroborate this finding in other studies.

Limitations

The profile of patients referred for ECHO to the lab was not exhaustive. Important information such as occupational status, level of education, source of funding for ECHO, and even patient satisfaction with the services rendered at the ECHO lab are pivotal pieces of information that make for a holistic assessment of the functioning of the lab. These are not routinely nor periodically collected.

This study was also limited by the available data and the medical record system that is presently operating in the hospital, where individual case notes have to perused to see if each ECHO did have a positive, pivotal impact on patient management or not. This could be easy to do if an electronic medical record system were operational and checklists in this regard were incorporated into the day-to-day functioning of the hospital.

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