Journal of Medical Sciences

ISSN 1682-4474

Research Paper

J. Med. Sci., 8 (3): 298-301
1st April, 2008

JMS (ISSN 1682-4474) is an International, peer-reviewed scientific journal that publishes original article in experimental & clinical medicine and related disciplines such as molecular biology, biochemistry, genetics, biophysics, bio-and medical technology. JMS is issued eight times per year on paper and in electronic format.

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The Value of Chest Radiogram and Electrocardiogram in the Assessment of Left Ventricular Hypertrophy among Adult Hypertensives

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The objective of the study was to assess the relative contributions and benefits of chest radiogram and electrocardiogram in detecting left ventricular hypertrophy among adult hypertensives. Seventy consecutive, newly diagnosed hypertensive patients with forty age and sex comparable healthy controls were recruited for the study at the University of Maiduguri Teaching Hospital, Northeast, Nigeria. The echocardiographic mean Left Ventricular Mass (LVM) was 260.8±72.9 g (range 109.8 to 429.8 g) and 136.9±18.1 g (range 104 to 188.9 g) in patients and controls respectively ($p<0.001$). Echocardiographic LVM correlated fairly with Cardiothoracic Ratio (CTR) on chest X-ray ($r = 0.43$, $p<0.01$) followed by SV_2+RV_6 with a correlation of 0.39 ($p<0.01$). However, in terms of sensitivity, specificity and accuracy in comparison with ECHO LVM, SV_2+RV_6 had better indices than CTR. The sensitivity, specificity and accuracy indices were 0.60, 0.93 and 0.67 for SV_2+RV_6 as compared to 0.53, 0.87 and 0.60 for CTR, respectively. Though previous studies had noted echocardiography as the gold standard in this form of assessment, however most centres in the developing world lacked facility for this purpose. In contrast radiography and electrocardiography are uniformly available. In view of the results, we recommend that chest X-ray and electrocardiograms might be simple screening procedures in the management of hypertensive heart disease where echocardiography is inaccessible.

Key words: Hypertensive left ventricular hypertrophy, echocardiographic LVM, electrocardiographic criteria, cardiothoracic ratio

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INTRODUCTION

Hypertension is a worldwide clinical problem. It is estimated to cause 4.5% of current global disease burden and prevalent in both developed and developing countries (Whitworth *et al*., 2003). The age-adjusted prevalence in a national survey in Nigeria for both sexes was 9.3% (Akinkugbe, 2000). It is associated with multiple target organ damage (Mensah *et al*., 2002). Left Ventricular Hypertrophy (LVH) is the leading consequent of target organ damage in Nigeria (Onwubere and Ike, 2000). Previous studies have recognized systolic blood pressure and LVH as independent risk factors for sudden death (Tin *et al*., 2002; Vakili *et al*., 2001; Krauser and Devereux, 2006), ventricular arrhythmias (Araoye *et al*., 2000, Messerli, 1999) and coronary heart disease (Prisant, 2005; Jafar *et al*., 2005).

Therefore early recognition and intervention in LVH is essential in the management of hypertension. Left Ventricular Mass (LVM) detected by Echocardiography (ECHO) had been established to have excellent correlation with values obtained by cardiac imaging (Alfakih *et al*., 2004a; Maruyama *et al*., 2003).

Limited resources and high cost of maintenance make availability of ECHO facilities infeasible for all centres in developing countries. Further, even in developed countries a survey of a random sample of primary care physicians across six European countries reported only 5% (Netherlands) to 37% (United Kingdom) of general practitioners had direct access to echocardiography in patients undergoing assessment for suspected left ventricular dysfunction (Hobbs *et al*., 2000). In comparison electrocardiography and X-ray machines are readily available in centers across developing countries. In addition, these modalities are potentially useful as Miller *et al*. (2000) found no significant difference in CTR derived by the traditional standard of cardiac enlargement from either helical computed tomography or routine chest x-ray. While Devereux *et al*. (2001) in the study involving hypertensives with echocardiographically confirmed LVH found simultaneous ECG LVH in 62% of the patients using previously established criteria.

The aim of the study was therefore to assess the relative contributions and benefits of chest X-ray and ECG in the assessment of hypertensive LVH.

MATERIALS AND METHODS

Seventy consecutive, newly diagnosed hypertensive adult patients seen at University of Maiduguri Teaching Hospital, Northeastern, Nigeria between December, 2000 and May, 2001 and forty age and sex-comparable healthy controls were studied. Exclusion criteria were diabetes mellitus, chronic kidney disease, concomitant cardiovascular diseases, cor pulmonale, kyphosis, scoliosis or both. Arterial blood pressures were recorded in supine positions and in accordance with guidelines of WHO expert committee on hypertension (Chalmers *et al*., 1999). Standard 12-lead resting electrocardiogram was recorded at 25 mm sec^{-1} and 1 mV mm^{-1} standardization after overnight fast using Schiller AG Cardiovit AT-2 plus microcomputer augmented cardiograph. However, calibrations were halved where necessary. ECG LVH was determined using Araoye (1996) proposed criteria for LVH in black hypertensives. Left ventricular hypertrophy was determined as follows: the sum of SV_2+RV_6 in males of ≥40 mm and females of ≥35 mm and RI ≥12 mm.

All subjects had a standard, penetrated, erect, posterior-anterior x-ray of the chest (CXR) exposed at full inspiration for determination of the Cardiothoracic Ratio (CTR) by the method of Danzer as shown by Miller *et al*. (2000). A CTR of 0.55 and above was considered significant as an earlier study in normal black subjects had shown that up to 0.55 may still be normal (Raphael and Donaldson, 1993).

Echocardiographic examination was performed with Kontron Sigma Instrument with the following ultrasonic emission characteristics: frequency of 1,000 sec^{-1} and a wave length of 3.5 MHz. Using the parasternal long axis view at the level of the mitral valve tips, measurements were taken for interventricular septal wall thickness (IVSD), posterior wall thickness (PWT) and left ventricular internal diameter at diastole (LVIDd) according to the Penn convention. Left ventricular mass (LVM) was then calculated according to the formula of Devereux and Reichek (1977). LVH was defined as LVM of more than 215 g, which exceeds the largest reported normal value in previous studies (Geiser and Bove, 1974). The LVM was then indexed to body surface area to provide left ventricular mass index (LVMI).

Data was analysed using the EPI Info version 6.04c statistical package. Sensitivity, specificity and accuracy of the tests were determined from previous established statistical methods as reviewed by Deeks (2001). Mean± SD were derived for LVM, ECG LVH, CTR and other constitutional variables. Correlation coefficients were also calculated between LVM and these variables. The student t-test for non-paired samples was used to determine the significance of difference between the variables. All levels of statistical significance were read at 2-tail level of < 0.05.

RESULTS AND DISCUSSION

Both patients and controls were comparable in terms of age and body surface area as their means were not significantly different (Table 1). However the mean arterial blood pressure of the hypertensives were

Table 1: Clinical characteristics of subjects of 70 patients and 40 healthy controls

Items	Controls	Patients	p-values
No.	40	70	
Sex ratio (M:F)	18:22	38:32	
Age	39.70±7.20	44.80±10.6	>0.05
Body surface area	1.76±0.10	1.80±0.19	0.30
Mean arterial pressure (mmHg)	81.90±6.30	128.90±13.2	<0.001

Table 2: Composite data of chest X-ray, ECG criteria and ECHO from 70 patients and 40 controls

Variables	Controls	Patients
CTR	0.44±0.04	0.53±0.05*
SV_2+RV_6	22.60±5.80	38.10±11.4*
RI	7.20±2.60	9.90±3.60*
LVM	136.90±18.1	260.80±72.9*
LVMI	76.30±13.5	148.90±49.9*

*There is significant difference from controls (p<0.001)

Table 3: LVM versus CTR and ECG criteria among 70 patients of the study

Variables	Mean±SD	r^2	p-values
LVM	260.80±72.9	1.00	
CTR	0.53±0.05	0.43	<0.001
SV_2+RV_6	38.10±11.4	0.39	<0.01
RI	9.90±3.6	0.04	>0.80

Table 4: Sensitivity, specificity and accuracy of CTR and ECG criteria among 70 patients of the study

Variables	Sensitivity	Specificity	Accuracy
CTR	0.53	0.87	0.60
SV_2+RV_6	0.60	0.93	0.67
RI	0.29	0.86	0.41

significantly different from the controls (p<0.001). The echocardiographic mean LVM in Table 2 was 260.8±72.9 g (range of 109.8 to 429.8 g) as compared with 136.9±18.1 g (range 104.0 to 188.9 g) in controls (p<0.001). Similar trends were shown in Table 2 with the other variables of CTR, SV_2+RV_6, RI and LVMI as all showed statistical difference between patients and controls (p<0.001). Analysis of correlation between LVM and the tested variables (Table 3) revealed that chest X-ray had better correlation (r = 0.43) as compared to SV_2+RV_6 (r = 0.39) and RI (r = 0.04). The latter had also a weak statistical association (p>0.80). However, in terms of sensitivity, specificity and accuracy in comparison with ECHO LVM (Table 4), SV_2+RV_6 had better indices than CTR. The sensitivity, specificity and accuracy indices were 0.60, 0.93 and 0.67 for SV_2+RV_6 as compared to 0.53, 0.87 and 0.60 for CTR, respectively.

It is generally known that systemic hypertension leads to LVH generally due to adjustment of the heart to various factors including elevated blood pressure (Lip *et al*., 2000; Agabiti-Rosei *et al*., 2006). The detection of LVH is very important in the management of hypertension because of its documented consequences. Therefore imaging studies are useful in evaluating all patients with hypertension. ECHO is the gold standard in the assessment however access to the modality is beyond the reach of majority of hypertensive patients in developing countries.

Radiography and electrocardiography on the other hand are widely available across developing countries. Hence these modalities will remain useful in primary care of hypertensives. Pisarczyk and Allan (1976) in a study of a Caucasians group found that CTR on chest X-ray appeared to be more sensitive than ECG LVH when correlated with ECHO LVH. In the study of 47 hypertensives, 10 out 14 with an increased CTR >0.50 had left Ventricular Posterior Wall (LVPW) while ECG failed to show LVH in 14 out of 16 patients (88%) with combined increased LVPW and CTR >0.50. The outcome of the study agrees with this study which demonstrated that increased CTR on X-ray had better correlation than ECG in detecting hypertensive heart disease when compared with ECHO LVH. Additionally, in concordance to present study, Rayner *et al*. (2004) found that cardiothoracic ratio on chest X-ray (r = 0.34, p<0.02) and ECG voltage (r = 0.58, p<0.00005) were independently correlated with left ventricular mass.

The SV_2+RV_6 criterion of ECG LVH studied produced better sensitivity, specificity and accuracy indices than CTR. This is probably a landmark as it is sex-specific with different cut-off values for males and females. This is consistent with the study showing differential voltages between women and men in previously studied criteria (Alfakih *et al*., 2004b). Therefore with this advantage the criterion may be employed as a screening tool in the evaluation of hypertensives.

In 12-lead electrocardiograms among healthy population, Araoye (1982) found that RI possess a unique attribute as it had been shown to maintain a relatively constant voltage independent of age and gender unlike the wide variations in the R amplitude in inferior and mid-preacordial leads. Despite this, we found a poor correlation of 0.04 with low sensitivity and moderate specificity of 0.86.

Though ECHO is the gold standard in assessing LVH in hypertensives, we recommend the combination of chest X-ray and documented sensitive and reliable ECG criteria for LVH where ECHO is not available for the initial screening tests and evaluation for hypertensives. This is clearly relevant in developing countries in view of the obvious financial implications. In addition, these modalities have added advantages as ECG may detect arrhythmias and chest X-ray will be simple tool for aortic aneurysm. Both conditions are associated with hypertensive LVH.

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