

The Diagnostic Yield of Routine Electrocardiography in Hypertension and Implications for Care in a Southwestern Nigerian Practice

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Background: Nigeria, like other developing nations, has an increasing burden of hypertension. Electrocardiography is an integral part of the diagnostic work-up for the newly diagnosed hypertensive subjects. The aim of this study was to determine the diagnostic yield of electrocardiography in hypertensive patients of a southwestern Nigerian hospital.

Patients and Methods: This was a retrospective descriptive study of electrocardiographs of hypertensive patients over a six-year period. Electrographic variables of interest were cardiac rhythm and rate, left ventricular hypertrophy (LVH), left atrial enlargement (LAE), T wave abnormalities, cardiac axis, blocks, complexes, QT segment abnormalities, atrial fibrillation (AF)/flutter, supraventricular tachycardia and pre-excitation syndrome. The Pearson's chi square was used to test for differences across age groups (15–44yrs, 45–64yrs and >65yrs) and between male and female subjects with the significance level set at 5% ($p < 0.05$).

Results: Hypertension was the indication for 40% of electrocardiographs completed and comprised of 3713 electrocardiograms (ECG) over a six-year period. The commonest abnormalities were left axis deviation (LAD) (32.2%), LVH (20.7%), rhythm abnormalities (16.7%) and LAE (14.5%). The diagnostic yield (presence of at least one electrographic abnormality) was 51% in 15–44 yrs age group, 64% in middle aged and 76.5% in the >65 yrs age group. While the male subjects in this study had a slightly increased likelihood of having an abnormal finding (odds ratio 1.18: 95% CI 1.02–1.35), the odds ratio for an abnormal ECG in subjects younger than 45 years was 0.48 (95% CI 0.41–0.57).

Conclusion: The diagnostic yield of electrocardiography in this study was considerable, although lowest in subjects younger than 45 years and increased with age. This may reflect an increased burden and earlier onset of hypertension and its complications. This should also engender prompt and aggressive management of hypertension, especially in the elderly in whom the cardiovascular complications from hypertension is most severe.

Keywords: electrocardiography, hypertension, Nigeria

Introduction

Hypertension presents a growing and significant public health challenge, being a primary contributor to heart and kidney diseases, stroke and premature death.^{1–3} It is estimated that over a billion people in the world have hypertension with two-thirds living in low and middle income countries (LMIC). This figure has been projected to expand further by 29% by the year 2025 with the majority of this increase expected to be driven by the developing nations.³

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Yet these LMICs like Nigeria, have limited availability and affordability of diagnostic and therapeutic services.^{4,5} Hence there is often a pragmatic need for the critical evaluation of routine medical interventions and investigations for their roles in clinical decision making. One of the routine tests recommended in the evaluation of the hypertensive patient is the electrocardiogram (ECG), a simple, noninvasive, largely accessible and relatively inexpensive electrophysiological test that evaluates cardiac function.⁶ Its low sensitivity for the detection of left ventricular hypertrophy (LVH) has been described,⁷ yet it remains an important guide for risk stratification in hypertension.

The aim of this study was to determine the diagnostic yield of a routine ECG in subjects with hypertension seen at the cardiac electrophysiology unit at the University of Medical Sciences Teaching Hospital Complex, Akure, over a six-year period.

Patients and Methods

A six-year study of the ECGs performed in the cardiac electrophysiology unit of University of Medical Sciences Teaching Hospital Complex, Akure, Ondo state (formerly State specialist hospital, Akure) was conducted. This unit is the major electrocardiography services provider to a population of about 642,000 people residing in Akure, the capital city of oil and cocoa-rich Ondo state, southwest Nigeria. The unit made use of a General Electric MAC 5500 HD electrocardiography machine.

Anonymized data were extracted from the cardiac electrophysiology records and were collated into a spreadsheet. Demographic variables such as age and gender, referral, indication for ECG and medical diagnoses were retrieved. Electrocardiographic variables included the cardiac rhythm and rate, LVH, left atrial enlargement (LAE), T wave abnormalities, cardiac axis, blocks, complexes, QT segment abnormalities, atrial fibrillation (AF)/flutter, supraventricular tachycardia and pre-excitation syndrome.

LVH was evaluated using the Cornell's criteria (R wave in aVL + S wave in V3 > 28mm in males and >20mm in females), the Sokolow Lyon criteria (SV1 + R in V5 or V6 >35mm) or Framingham criteria (R aVL > 11mm, R V4–V6 > 25mm).⁸

ECG LAE was defined by any one of the following: P wave in any lead > 0.11s, notched P wave with inter-peak duration > 0.04s (P mitrale) and area of negative P terminal force in lead V1 (NPTF–V1) > 0.04s·mm.⁹

A composite score was also derived to primarily assess the presence and severity of ECG abnormalities in this cohort of hypertensive patients and secondarily, to determine the diagnostic yield. Twelve ECG parameters were assigned a score of 0 and 1 for normal and abnormal finding respectively, thus each ECG entry had a minimum score of 0 and a maximum score of 12.

Statistical Analysis

Data was analyzed with SPSS version 20. Sociodemographic and electrocardiographic variables of interest were presented as frequencies and percentages. The Pearson's chi square was used to test for differences across age groups (15–45 yrs, 45–64 yrs and >65 yrs) and between male and female subjects with the significance level set at 5% ($p < 0.05$).

Results

A total of 8029 ECGs were carried out over the six-year period, of which 3713 ECGs (40.7%) were completed in individuals with a medical diagnosis of hypertension. The majority of the ECGs in hypertensive subjects were conducted in females (62.4%) and in individuals within 45–64 years (52.4%) (Table 1).

The commonest abnormality in this study was axis deviation, being present in about a third of all ECGs and comprised predominantly by left axis deviation (LAD) (Table 2). Male sex and age ≥ 45 years were associated with LAD.

Voltage criteria for LVH was met in only a fifth of ECGs, least prevalent in the young, intermediate in the middle aged and most prevalent in the elderly.

There was also a similar and significant increment in prevalence of electrocardiographic LAE with age. There was a 16.7% prevalence of sinus arrhythmia, significantly higher in females (18.8 females: 13.2% males) but with no significant differences across age groups.

Abnormal heart rate was present in 13.7% of the study population. Female subjects had the highest proportion of

Table 1 Study Population

Age Groups	Male n(%)	Female n(%)	Total n(%)
≤45yrs	302(38.4)	481(61.6)	783(21.0)
45–64	703(36.0)	1244(64.0)	1947(52.4)
≥65yrs	392(40.2)	591(59.8)	983(26.4)
All	1397(37.6)	2316(62.4)	3713(100)

Table 2 ECG Abnormalities by Sex and Age

ECG Parameters		Males n(%)	Females n(%)	p value	≤45yrs n(%)	45–64yrs n(%)	≥65yrs n(%)	p value	Total n(%)
Atrial fibrillation/ flutter	Fibrillation	9(0.6)	16(0.7)	0.96	1(0.1)	5(0.2)	19(1.6)	0.001	25(0.7)
	Flutter	2(0.1)	4(0.1)		0(0)	4(0.2)	2(0.2)		6(0.2)
Abnormal axis	LAD	512(36.8)	685(29.6)	0.001	115(14.7)	648(33.3)	433(44.5)	0.001	1197(32.2)
	RAD	7(0.5)	10(0.4)		3(0.3)	7(0.3)	7(0.7)		17(0.5)
Blocks	1st AVB	46(3.3)	29(1.3)		9(1.1)	35(1.8)	30(3.0)		75(2.0)
	2nd AVB	1(0.1)	2(0.1)		0(0)	1(0.5)	2(0.2)		3(0.1)
	3rd AVB	1(0.1)	0(0)		0	0	1(0.1)		1(0.0)
	RBBB	32(2.3)	42(1.8)		6(0.7)	38(1.9)	30(3.0)		74(2.0)
	LBBB	10(0.7)	18(0.8)		1(0.1)	7(0.36)	19(1.9)		28(0.8)
	LAFB	103(7.4)	73(3.2)		8(1.0)	86(4.4)	82(8.4)		176(4.8)
Complexes	Atrial	43(3.1)	46(2.0)	0.045	7(0.8)	25(1.2)	57(5.8)	0.001	89(2.4)
	Ventricular	50(3.6)	66(2.9)		7(0.8)	46(2.3)	63(6.4)		116(3.1)
LAE		231(16.6)	305(13.2)	0.004	77(9.8)	291(14.9)	168(17.2)	0.001	536(14.5)
LVH		293(21.0)	473(20.4)	0.671	114(14.5)	401(20.6)	251(25.8)	0.001	766(20.7)
WPW		5(0.4)	2(0.1)	0.064	1(0.1)	2(0.1)	4(0.4)	0.324	7(0.2)
SVT		13(0.9)	21(0.9)	0.937	5(0.6)	16(0.8)	13(1.3)	0.431	34(0.9)
QT segment anomalies	Long	41(2.9)	98(4.2)	0.006	23(2.9)	81(4.1)	35(3.6)	0.768	139(3.8)
	Short	7(0.5)	2(0.1)		1(0.1)	6(0.3)	2(0.2)		9(0.2)
Rate disorders	Tachycardia	122(8.8)	343(14.8)	0.001	125(15.9)	246(12.6)	93(9.5)	0.004	465(12.6)
	Bradycardia	20(1.4)	19(0.8)		10(1.2)	18(0.9)	11(1.1)		39(1.1)
Rhythm disorders		184(13.2)	436(18.8)	0.001	148(18.9)	309(15.8)	162(16.6)	0.169	620(16.7)
T wave anomalies	Inferior	29(2.1)	33(1.4)	0.182	14(1.7)	32(1.6)	16(1.6)	0.015	62(1.7)
	Lateral	59(4.2)	75(3.2)		15(1.9)	63(3.2)	55(5.6)		134(3.6)
	Anterior	53(3.8)	91(3.9)		26(3.3)	82(4.2)	36(3.7)		144(3.9)

Abbreviations: AVB, atrioventricular blocks; LAE, left atrial enlargement; LAFB, left anterior fascicular block; BBB, left bundle branch block; LVH, left ventricular hypertrophy; PES, pre-excitation syndrome; PSVT, paroxysmal supraventricular tachycardia; RAD, right axis deviation; RBBB, right bundle branch block; SVT, supraventricular tachycardia; WPW, Wolff-Parkinson-White pre-excitation.

tachycardia (14.8%) and the least prevalence for bradycardia (0.8%). Tachycardia was also commonest in <45 years and rarest in >65 years.

T wave abnormalities were described in 9.2% of tests with inferior T-wave anomalies least prevalent. Atrial and ventricular complexes were observed in 5.5% of the study population and were rare under the age of 45years (1.6%), intermediate in ages 45–65years (3.5%), and commonest in subjects older than 65years (12.2%).

Long and short QT abnormalities accounted for 3.8% and 0.2% respectively in this cohort.

Left anterior fascicular block was present in only 4.8% of all ECGs and was twice as prevalent in males (2.3:1 M/F ratio) and in the elderly (8.4%). First degree AVB and RBBB were reported in 2% of all ECGs while complete heart block was documented in only 1 subject.

Rare electrocardiographic abnormalities included paroxysmal SVT (0.9%), AF (0.7%), atrial flutter (0.2%) and

Table 3 Composite Score of ECG Abnormalities

Comp. Score	Sex n(%)		Age Groups n (%)		
	Male	Female	< 45yrs	45–64yrs	≥ 65yrs
0	462(33.2)	853(36.9)	383(49.0)	700(36.0)	228(23.5)
1	390(28.0)	604(26.1)	179(22.9)	540(27.8)	273(28.1)
2	279(20.0)	459(19.9)	141(18.0)	366(18.8)	229(23.6)
3	160(11.5)	267(11.5)	64(8.2)	211(10.9)	152(15.7)
4	72(5.2)	93(4.0)	13(1.7)	93(4.8)	59(6.1)
5	20(1.4)	27(1.2)	1(0.1)	28(1.4)	18(1.9)
6	8(0.6)	6(0.3)	1(0.1)	5(0.3)	8(0.8)
7	1(0.1)	3(0.1)	0	0	4(0.4)

WPW pattern pre-excitation (0.2%). WPW had a male predilection (sex ratio of 4:1) while paroxysmal supraventricular tachycardia, AF and flutter had similar occurrence in both sexes. AF and WPW pattern pre-excitation in individuals older than 65 years were at least eight and four times commoner respectively than in the middle aged and the young.

About a third of all ECGs done in subjects with hypertension had no abnormality reported and four-fifths of completed tests had two or less electrocardiographic anomalies detected. Thus, less than a fifth of these tests had three or more abnormalities (Table 3).

Males had a slightly increased likelihood of having an abnormal ECG (odds ratio 1.18; 95% CI 1.02–1.35). The odds ratio for having an abnormal ECG in subjects younger than 45 years was least but greatest for individuals 65 years or older (Table 4).

Discussion

The majority of the subjects were older than 45 years; a finding that reflects the fact that hypertension increases with advancing age.¹⁰ The female predominance in this

population may be due to the general better health seeking behavior, better hypertension awareness and early identification of hypertensive disorders in pregnancy during antenatal care, as well as longer life expectancy.^{11–13}

AF was an uncommon finding in this study population unlike what obtains in previous studies in which AF was observed to be the most common arrhythmia found in hypertension.¹⁴ AF has been reported to be lower in Africans than people of other regions.¹⁵ A study in the USA showed that the prevalence of AF in Africans was notably lower among the African American population compared to Caucasians.¹⁶ AF prevalence of 0.7% was found in Kenyans and Tanzanians.^{17,18} A possibility of genetic factors being responsible for the low prevalence of AF in the African population has been suggested. The population distribution of the elderly accounting for the minority of the cohort studied may also explain the lower incidence of AF in this study, which contrasts with the preponderance of AF among the elderly population in other studies.¹⁹

Axis deviation, in particular LAD, was the most frequent electrocardiographic finding in this study and a wide array of reasons have been posited for its occurrence in many hypertensive subjects. At one end is that LAD may be inconsequential, probably as a result of the left anatomic position of the heart while at the other is that it may be due significant LVH and left bundle branch block.^{20–22} In this study, male sex and advancing age were determinants of the LAD, an observation that has been similarly established.²³

Isolated LAFB was the commonest block observed in this cohort but it has been traditionally considered a benign electrocardiographic finding in individuals without structural heart disease, commoner in males and with advancing age.^{24,25} However, its existence in the presence of other cardiac pathologies portends a poor prognosis.²⁶

First degree atrioventricular block (AVB) and right bundle branch block (RBBB) were reported in 2% of all ECGs of the study population, while complete heart block was present in only one of the subjects. Researchers have documented an association between various degrees of heart block and hypertension, which was attributed to possible infiltration of the atrioventricular conduction system by fibrosis as a result of high blood pressure.^{27,28}

Atrial and ventricular complexes were quite rare in the young (1.6%) but relatively common in the elderly (12.2%). Supra ventricular and ventricular ectopics are frequent findings in hypertensive subjects.¹⁴

Table 4 Probability of an Abnormal ECG by Age Groups and Sex

Variables		Odds Ratio	95% CI	P
Sex	Male	1.17	1.02–1.35	0.022
	Female	0.84	0.73–0.97	0.022
Age	<45yrs	0.48	0.41–0.56	0.0001
	45–64yrs	0.94	0.82–1.07	0.38
	≥ 65yrs	2.17	1.84–2.57	0.0001

=LAE was also shown to be of high prevalence in this cohort of subjects, being highest in subjects older than 65 years. LAE is a notable morphological adaptation found in hypertensive patients that occurs early in hypertension, influenced by age and an independent predictor of cardiovascular events.^{29–32}

LVH was found in 20% of the study population. The sensitivity of ECG LVH is low and echocardiography together with cardiac magnetic resonance imaging (CMRI) have been shown to give better LVH yield. A study found electrocardiographic LVH of 9% in contrast to echocardiographic LVH prevalence of 32% in the same group of patients.³³ Yet, electrocardiographic LVH correlates fairly well with increased cardiovascular morbidity and mortality in the hypertensive population and deserves due attention in clinical decision making. In this study the higher proportion of younger population may also contribute to the relatively low prevalence of LVH. QT abnormalities, noted in this study has been demonstrated repeatedly in hypertensive patients and its significant contribution to arrhythmias and premature cardiac death has been established.^{34,35} QT interval is a measure of myocardial depolarization. Cardiomyocyte hypertrophy and consequent increased left ventricular mass with accompanying changes in left ventricular transmural dispersion of depolarization, changes in the tone of the autonomic nervous system of some hypertensive patients, antihypertensive medications and rarely mechano-electrical feedback are some of the possible mechanisms that has been advanced as being responsible for the QT interval alteration observed in hypertensive subjects.³⁶

The only significant ECG abnormality that was not prevalent in the elderly was heart-rate disorder, which was most frequent in subjects younger than 45 years.

T wave abnormalities were described in the ECGs of the study group. T wave abnormalities in hypertensive individuals have reportedly varied widely, from non-specific T wave abnormality to strain T wave abnormality is a marker of LVH and it portends poor prognosis in hypertensive patients.^{37,38}

The diagnostic yield of ECG in the youngest age group was below 10% for most ECG abnormalities with the notable exceptions of LVH (14.5%), abnormal rhythm (18.9%), rate (17.3%) and axis deviation (15%). This may be attributable to shorter duration of hypertension and lower prevalence of hypertensive heart disease in this group.

The increased prevalence of ECG abnormalities in the elderly population may be explained by the higher

prevalence and severity of hypertension in the elderly population as established by previous studies.^{11,39,40}

The composite scores show that half of all ECGs performed on a young hypertension subject will show no abnormality in contrast to middle age and the elderly in which two-thirds and three quarters respectively of completed ECGs will have at least one electrocardiographic anomaly.

ECG is an essential investigation in hypertensive patients as ECG markers may predict sudden cardiac death, especially P wave duration, interatrial block, and deep terminal negativity of the P wave in V1, prolonged QT and T peak–T end intervals, QRS duration and between QRS and T vectors, premature ventricular contractions, and ECG hypertrophy criteria.⁴¹

Strengths

This study comprised of a large amount of ECGs and is likely to enhance its robustness and generalizability of its findings.

Limitations

This was a retrospective descriptive study that explored associations rather than causality. Also the roles of blood pressure control, medications, comorbidities such as renal disease, lifestyle factors such as smoking and lipid panels were not explored due to the retrospective nature of the study and non-inclusion of these important data in electrophysiology records of the institution.

Conclusion

The diagnostic yield of ECG in hypertension is highest in the elderly, intermediate in the middle aged and lowest in the young. These findings are likely to be linked to the duration of hypertension as well as age-related electrocardiographic changes. This increasing burden of ECG abnormalities across the age groups for hypertensive individuals calls for improved awareness of hypertension and vigorous interventions to limit the devastating cardiovascular consequences that may ensue.

Statement of Ethics

Ethical review and approval was obtained from Health Research Ethics Committee of the University of Medical Sciences, Ondo, Ondo state, Nigeria. Informed consent was not required due to the anonymized data, and this study was conducted in accordance with the Helsinki Declaration.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

Disclosure

The authors have no conflicts of interest to declare.

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