

ELECTROCARDIOGRAPHIC LEFT VENTRICULAR HYPERTROPHY AMONG GAMBIAN DIABETES MELLITUS PATIENTS

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SUMMARY

Background: The global prevalence of diabetes and its complications is increasing worldwide. Its role in coronary heart disease has been linked with the presence of left ventricular hypertrophy (LVH). The present study aims to determine the prevalence of electrocardiographic left ventricular hypertrophy (ECG-LVH) in adult diabetic subjects, its epidemiological and clinical correlates.

Methods: A descriptive cross-sectional study involving 534 patients was conducted at the Edward Francis Small Teaching Hospital (formerly Royal Victoria Teaching Hospital), The Gambia. Four hundred and forty patients were included using a standard questionnaire. Anthropometry, laboratory investigations and electrocardiogram were carried out. We used the Lewis, Cornell, and Sokolow-Lyon Voltage criteria to define ECG-LVH. Minitab™ statistical software version 13.20 was used for analysis.

Results: 146 (35.2%) patients had ECG-LVH using all 3 criteria and this prevalence was higher among women being 116 (79.5%). A generally high prevalence of overweight (155/37.4%) and obesity (119/28.6%) was observed among study participants, and both clinic-day systolic and diastolic blood pressure (BP) were significantly higher in those with ECG-LVH. Poor diabetes control was observed in both groups.

Conclusion: There was a high prevalence of ECG-LVH and it is especially so with combining multiple criteria, hence the need for screening. Clinic-day hypertension was associated with ECG-LVH hence the need for diagnosing and aggressive treatment of hypertension in patients with diabetes mellitus.

Keywords: Diabetes mellitus, ECG-LVH, The Gambia, voltage criteria

INTRODUCTION

The global prevalence of diabetes mellitus (DM) continues to rise at an alarming rate.¹ It is acknowledged as a principal risk factor for cardiovascular morbidity and mortality and has a heavy impact on the global health expenditure due to both its short and long term complications.² DM is closely linked to coronary events³ and left ventricular hypertrophy (LVH) in DM patients has been widely implicated^{4,5} and therefore considered as a treatment target⁵, as associated cardiovascular risks become normal with full regression of LVH.⁶ Insulin resistance and associated abnormal glucose metabolism have been implicated in many reports as a possible pathophysiological mechanism of LVH. This therefore highlights the need for the early detection of LVH in DM in order to institute a timely effective intervention.⁷

Electrocardiogram remains a cheap, useful and a widely available tool to determine LVH.⁸ This paper aims to determine the prevalence of electrocardiographic left ventricular hypertrophy (ECG-LVH) among adult Gambian DM patients and also to determine its associated clinical factors.

METHODS

This study was conducted at the Edward Francis Small Teaching Hospital (EFSTH) in Banjul, The Gambia during routine clinic visits (on every Monday and Wednesday) from the 6th November, 2008 to the 4th January 2009 between the hours of 8am and 2pm.

Study Population: All patients with a confirmed diagnosis of DM and who attend the medical out-patient department, EFSTH for routine care were eligible for inclusion into the study. Pregnant women and those who did not consent for inclusion were excluded.

Subjects less than 25 years of age and those with bundle branch block were excluded from the present analysis.

Study design: cross-sectional study.

Questionnaire: a trained research field assistant in a language understood by the study participant administered a standard questionnaire designed for the purpose of the study. The questionnaire was divided into 3 sections. Section A included items on demographic details like age, sex, address, ethnicity, religion, educational level, smoking status as well as background details about the participant's DM. Occupations were coded as manual if involving mainly unskilled labour; as trades for occupations mainly involving skilled manual labour; or as non-manual. The rest were coded as others. Section B covered information about the usual medical care the patient receives (including activities at clinic visits, medications prescribed) and also evidence of diabetic foot (or feet) complication(s). Section C involved carrying out basic anthropometric measurements, blood pressure (BP) measurements, urine dipstick, and venous blood sampling for serum biochemistry and also obtaining a standard 12-lead surface ECG.

Blood pressure: Blood pressure and pulse rate were recorded with an Omron 705IT machine (Omron, Kyoto, Japan) with the participant in a seated position using the subject's left arm positioned at heart level. The BP was taken first when the patient enters the consulting room and after five minutes. Two measurements were done at each time and the mean of the two readings was recorded.

Anthropometry: Height was measured without footwear or headwear with the subject standing fully erect on a flat surface, with heels, buttock and shoulders flat to the height meter, and the subject looking straight ahead using a daily calibrated stadiometer (Leicester height measure, Seca 214, Birmingham, UK). Measurement was done to the nearest 0.5cm. Weight was measured with the subject wearing light clothing with no footwear using a digital scale (Tanita Corporation, Tokyo, Japan). The value was recorded to the nearest 0.1kg. Waist circumference measured at the level of the upper margin of the iliac crest, was measured to the nearest centimeter with a flexible tape. Body mass index (BMI) was defined as weight (kg)/height (m).² We used a new generation foot-to-foot bioimpedance device (Tanita TBF300GS, Tanita Corporation) to measure fat percent, fat mass, total body water (TBW) with the subject standing erect in bare feet on the bioimpedance analyzer.

Blood and urine samples: Venous blood samples were collected and analysed using a COBAS INTEGRA 400 plus analyser (Roche Diagnostics GmbH) at the EFSTH laboratories for total cholesterol, high density lipoprotein cholesterol (HDL-cholesterol), low density lipoprotein cholesterol (LDL-cholesterol), triglycerides, creatinine, fructosamine, albumin and uric acid levels. Blood glucose was determined using a portable glucometer (Accu-Chek). Urine sample was also collected and urine dipstick was done for glucose and protein.

Electrocardiography: The study participants had a standard surface 12-lead ECG recorded with the patient lying supine and relaxed on a flat surface (using a Cardioline Delta 1 EKG Machine). The machine was regularly checked to ensure that it was in a proper working condition. After explaining the procedure to the patient, the ECG leads were placed according to standard practice. The paper speed was set at 25mm/s whilst the voltage set at 10mm/mV. The ECG recordings were sent to Aristide Le Dantec Teaching Hospital, in Dakar, Senegal and analysed by a group of cardiology residents, supervised by an electrophysiologist with many years of experience using a specially designed protocol. The various parameters studied included the rhythm, heart rate, PR interval, presence of significant Q wave, LVH (using Lewis, Cornell, and Sokolow-Lyon voltage criteria) and ST-T changes.

ECG-LVH was defined according to standard criteria using the mean of 3 consecutive QRS values as follows: Lewis voltage as (R wave in lead 1-R wave in lead 3)+(S wave in lead 3-S wave in lead 1) \geq 1.7mV⁹ Cornell voltage as S wave in V3+ R wave in aVL \geq 2.0mV in women and 2.8mV in men¹⁰ Sokolow-Lyon Voltage as S wave in V1+R wave in V5 or V6 \geq 3.5mV¹¹

Data Management

The data of each participant was collected on a questionnaire which was then entered into Microsoft Excel 2007 by double entry. The data was cross-checked and all inconsistencies were corrected. The data was then transferred to and analyzed using MinitabTM statistical software version 13.20. The characteristics of patients with ECG-LVH and those without it were compared using two-sample t-test for continuous variables and Chi-square test for categorical variables. P-values of less than 0.05 were considered to be of statistical significance.

Ethical Consideration

The School of Medicine and Allied Health Sciences, University of the Gambia Research and Publication Committee approved the study protocol.

An informed consent was obtained from each of the study participants after explanation and careful consideration by the participant signing or thumbs printing a written consent form.

RESULTS

A total of 534 patients (171 males and 363 females) took part in the study, of whom 440 (131 males and 309 females) had a standard surface ECG. Of those who had an ECG, 415 (121 males and 294 females) met criteria for inclusion in this analysis. The majority of participants, 80.3% were between the ages of 40 and 69; The actual age distribution according to age groups (25-39, 40-54, 55-69 and ≥ 70 years) was 49 (11.8%), 175 (42.2%), 158 (38.1%) and 33 (7.9%) respectively.

The prevalence of ECG-LVH according to the different criteria used is shown in Table 1. The highest prevalence was recorded with the Cornell voltage criteria. With the Lewis but especially the Cornell voltage criteria, where the number of females diagnosed was significantly higher than that of males. However, this large difference was not observed with the Sokolow-Lyon criteria.

Table 1 Prevalence of LVH in diabetic patients according to different ECG criteria

ECG Criteria	Male N= 121	Female N= 294	Total N=415	P- value
Lewis	9 (7.4%)	35 (11.9%)	44 (10.6%)	0.179
Cornell	13 (10.7%)	89 (30.3%)	102 (24.6%)	<0.001
Sokolow-Lyon	15 (12.4%)	38 (12.9%)	53 (12.8%)	0.883
Combined criteria	30 (24.8%)	116 (39.5%)	146 (35.2%)	0.004

One hundred and forty-six (35.2%) patients met one or more of the three standard criteria that we have used to define ECG-LVH, of whom 116 (79.5%) were females. Among the female population studied, 116 (39.5%) had ECG-LVH compared to 30 (24.8%) of males.

Table 2 Clinical characteristics of diabetic patients by ECG-LV

Variable	ECG-LVH N=146	No ECG- LVH N=269	P value
Age (years)	52.9 \pm 11.1	53.1 \pm 11.5	0.910
Age at diagnosis (years)	48.1 \pm 10.9	47.2 \pm 12.0	0.488
Sex			
Female	116 (79.5%)	178 (66.2%)	0.004
Height (cm)	161.9 \pm 6.9	162.7 \pm 8.8	0.352
Weight (Kg)	73.3 \pm 13.9	72.4 \pm 15.2	0.564
BMI (kg/m ²)	28.0 \pm 5.2	27.4 \pm 6.1	0.352
History of hypertension	97 (66.4%)	152 (56.5%)	0.056
Systolic BP(mmHg)	137.5 \pm 22.5	129.8 \pm 21.3	0.001
Diastolic BP(mmHg)	80.3 \pm 12	76.5 \pm 9.5	< 0.001

BMI- body mass index, BP- blood pressure

As shown in Table 2, there was no significant difference in the age of patients with or without ECG-LVH both at the time of diagnosis of diabetes and also at the time of the study.

Hypertension was more prevalent among subjects with ECG-LVH but this was not statistically significant. However, clinic-day systolic and diastolic BPs were significantly more elevated among patients with ECG-LVH.

Two hundred and seventy-four (66%) of patients were either overweight (155/37.4%) or obese (119/28.6%). We found a significant difference between the sexes as 48 (39.7%) and 9 (7.4%) of males were respectively overweight and obese compared to 107 (36.4%) and 110 (37.4%) of females ($P<0.001$); indeed the distribution of subjects by BMI (<18.5, 18.5-24.9, 25-29.9 and ≥ 30) was 9 (2.2%), 132 (31.8%), 155 (37.3%) and 119 (28.7%) respectively.

However, as shown in Table 3 there was no significant statistical difference between BMIs of subjects with or without ECG-LVH. Serum creatinine and lipid profile were similar in both groups. However, serum albumin level was significantly lower among patients with ECG-LVH. In this cohort, fructosamine levels were high in both groups.

Table 3 Metabolic features of diabetic patients by ECG-LVH

Variable	ECG-LVH N=146	No ECG-LVH N=269	P value
Fructosamine (μ mol/L)	375 (363-389)	377 (368.7-385.3)	0.877
Serum creatinine (μ mol/L)	69.1 (66.6-71.6)	71.4 (69.7-73.1)	0.433
Serum albumin (g/L)	38.9 (38.4-39.4)	40.1 (39.8-40.4)	0.033
Total cholesterol (mmol/L)	5.3 (5.2-5.4)	5.2 (5.1-5.3)	0.560
Serum triglycerides (mmol/L)	1.3 (1.25-1.35)	1.3 (1.23-1.32)	0.644
HDL-cholesterol (mmol/L)	0.87 (0.85-0.89)	0.86 (0.85-0.88)	0.720

Results are shown as mean and 95% CI

DISCUSSION

The prevalence of ECG-LVH using all three standard criteria (Lewis, Cornell and Sokolow-Lyon Voltage) in this study was high (35.2%). The prevalence was higher in females compared to males using either all or any of the aforementioned criteria. Using the individual criteria, the prevalence of ECG-LVH was highest with the Cornell voltage criteria (26.8%) and lowest with the Lewis voltage criteria (10.6%).

It has been demonstrated from previous studies that ECG has a lower sensitivity compared to echocardiography in determining LVH.¹² Generally, black individuals have greater precordial QRS voltages than whites and many of the LVH criteria have higher sensitivity in detecting LVH in blacks and lower specificity compared with whites.^{13,14} However, many of the criteria proposed like the Araoye for African blacks are yet to be validated and so far have offered no comparative advantage over the standard criteria.¹⁵

Additionally many factors might limit the accuracy of ECG in determining LVH including age, body habitus, obesity and chronic lung diseases. Hence many authors advocate the use of echocardiography to determine LVH. However, the availability of echocardiography is still limited and not feasible in many places especially in our sub-region. Besides the unavailability of technical expertise to operate echocardiography in many places, high costs further limits its usage. The present study compared different voltage criteria and showed the superiority of using more than one criterion to determine ECG-LVH. This is advocated by many authors and has been demonstrated in various studies.^{16,17,18}

We found in the present study that both systolic and diastolic BP were significantly higher in those with ECG-LVH which is consistent with the findings by Desai *et al*¹⁹, There is therefore the need for a more aggressive BP control. Niiranen *et al* found home measured blood pressure values to be more strongly associated with ECG-LVH.²⁰ In the Cascale Monferrato study however, the prevalence of hypertension was high and systolic BP were raised in both groups (i.e. those with ECG-LVH and those without) but with no statistical difference.⁶

There is paucity of data regarding the relationship between low serum albumin level and LVH in DM patients which we found in our study. This needs evaluation with further studies as low serum albumin has been strongly linked to cardiovascular events in a previous study.²¹

We used fructosamine to assess glycaemic control which we found to be poor in both groups but with no significant difference. This finding is similar to that in the Cascale Monferrato study where glycated hemoglobin was used as a marker for glycaemic control.⁶ There was a high prevalence among study participants of overweight and obesity. This is consistent with the findings in a previous study in urban Gambia.²² This, and the poor metabolic control are risks for cardiovascular complications and hence require effective intervention.

Women with DM have been shown to have a higher cardiovascular morbidity and mortality than their male counterparts.^{23, 24, 25} Therefore the higher prevalence of females with LVH and obesity in this cohort is worrying and needs attention.

We advocate for the early detection and aggressive treatment of LVH to prevent potentially life-threatening consequences. Many antihypertensive agents have been recommended for the treatment of LVH. However, agents with intrinsic sympathomimetic properties or with direct vasodilatory effects (e.g. hydralazine and minoxidil) must be avoided.²⁶ The most effective agents in reducing left ventricular mass are angiotensin II receptor blockers, angiotensin-converting enzyme inhibitor, calcium channel blockers and diuretics.²⁷ Bauml and Underwood recommend that treatment should consist of an angiotensin II receptor blocker or an angiotensin-converting enzyme inhibitor²⁸ which have additional renoprotective effect as well as reversing LVH. However, these agents are less efficacious in blacks according to the investigators of Studies of Left Ventricular Dysfunction (SOLVD)²⁹ but who have been shown to benefit from treatment with diuretic agents.²⁶

CONCLUSION

We found a higher prevalence using multiple criteria to determine ECG-LVH and this prevalence was higher among females and associated with high clinic-BP. Therefore, screening, aggressive treatment for ECG-LVH and associated high BP should be instituted in the standard care of DM patients.

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