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Original Research Article

DIAGNOSTIC ACCURACY OF ECG TO DETECT LEFT VENTRICULAR HYPERTROPHY IN HYPERTENSIVE PATIENTS

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Abstract: *Hypertension is a significant public health problem with an increasing prevalence worldwide. Hypertension is a robust risk factor for Left Ventricular Hypertrophy (LVH). LVH is a compensatory adaptive response of myocardium against increased afterload to reduce wail stress and maintain pump function and is commonly seen in hypertensive patients. LVH is independently associated with an enhanced risk for myocardial infarction. The study's objective was to determine the diagnostic accuracy of electrocardiography to determine LVH in patients with hypertension by taking Echo as the gold standard. This cross-sectional study was conducted at the Cardiology Department, Rehmatul-Lil-Alameen Institute of Cardiology, Lahore, from July 25, 2019, to December 26, 2019. 236 hypertensive patients fulfilling the inclusion criteria were enrolled in the cardiology department. All patients were then undergoing ECG and Echo. Echo was performed by cardiologists who were also blind to the study group to which these ECHO belong. Outcome variables include the number of hypertensive patients having LVH on Echo and ECG. The mean age of patients was 58.24±14.29 years. There were 159(67.4%) males and 77(32.6%) females. The mean BMI of the patients was 25.12±1.94. The mean duration of hypertension was 15.14±6.76years. Sensitivity and specificity of ECG were 79.19% and 80.95%, respectively, and PPV & NPV was 91.95% and 58.62%, respectively; overall diagnostic accuracy was 79.66%. Based on the results, it can be concluded that the ECG has a high specificity, PPV, and diagnostic accuracy for the diagnosis of left ventricular hypertrophy in patients with hypertension by taking Echo as the gold standard.*

Keywords: Diagnostic accuracy, Electrocardiography, ECG, Left Ventricular Hypertrophy, Hypertension, Echocardiography

Introduction

Hypertension is a significant public health problem with an increasing prevalence worldwide. Currently, the global prevalence is around 40.8%, and the control rate of hypertension is around 32.3% (Oliveira et al., 2015). Long-standing hypertension can lead to pressure-related, end-organ damage with the potential for devastating consequences such as myocardial infarction, stroke, heart failure, and renal dysfunction. It is a major risk factor for a number of serious health conditions, including cardiovascular disease, cerebrovascular disease, and chronic kidney disease. 2 Because of its asymptomatic initial course during pathogenesis, it is considered a silent killer (Mancia et al., 2013; Montezano et al., 2015).
Around 9.4 million deaths are attributed to complications from hypertension worldwide. About 45% of all deaths secondary to complications of hypertension are due to coronary artery disease, and 51% are due to stroke, more commonly infarction stroke (Lim et al., 2012). Hypertension is more prevalent in countries with low economic status (Chow et al., 2013; Shafi and Shafi, 2017). The mortality in low-income countries is as high as 80% due to cardiovascular disease (Alwan, 2011). Hypertension is a robust risk factor for Left Ventricular Hypertrophy (LVH) (Riaz et al., 2016). LVH is a compensatory adaptive response of the myocardium against increased afterload to reduce wail stress and maintain pump function and is commonly seen in hypertensive patients (Singh et al., 2018). LVH is independently associated with an enhanced risk for myocardial infarction, sudden cardiac death, congestive heart failure, and stroke in the general population, as well as in patients with hypertension, coronary artery disease, chronic kidney disease, ventricular arrhythmias, and atrial fibrillation

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(Hayashi and Miyata, 2015; Mule et al., 2016; Riaz et al., 2015; Sultana et al., 2010).
Hypertensive LVH is also a risk factor for high insulin levels and resistance. A significant correlation between left ventricular mass, insulin-like growth factor-I, and insulin was observed in a cohort study (Khaznadar et al., 2018). In the general population around the globe, the prevalence of LVH is significant, with some estimates approaching 16%-20% in population-based samples, and in patients with hypertension, it is up to 50% (Sklyar et al., 2017). Similarly, LVH is an established cardiovascular risk factor in our country, increasing the risk of coronary atherosclerosis, arrhythmias, and cardiac failure (Bhatti et al., 2018). As LVH is associated with an increased risk of cardiovascular morbidity and mortality, so its early detection is of major importance for the initiation of treatment and its reversal by certain antihypertensive drugs like angiotensin-converting enzyme inhibitors and angiotensin receptor blockers (Singh et al., 2018). So the proper assessment of LVH in patients with hypertension has important therapeutic and prognostic relevance (Ogunlade and Akintomide, 2013). Advanced imaging techniques like echocardiography (Echo) or cardiac magnetic resonance imaging are required to diagnose LVH definitively. But such tests are not routinely advised for patients with HTV without signs or symptoms of cardiac dysfunction (Mahn et al., 2014).
Among the different methods for diagnosing LVH, ECG is the least expensive, portable, most broadly disseminated, reproducible, and easier to interpret. As a result, all over the world, the ECG remains the most commonly used screening tool (Rider et al., 2016). ECG presents high specificity for LVH, but it has low sensitivity. LVH, detected either by ECG or Echo, has long been recognized as a powerful predictor of serious cardiovascular sequelae, as shown by the Framingham investigators (KANNEL et al., 1969; Levy et al., 1990). American Heart Association has endorsed about 37 different ECG criteria to diagnose LVH. This figure suggests a lack of consensus, often confusing clinicians (Peguero et al., 2017). The most popular ECG criteria are the Sokolow-Lyon index/voltage, Carnell voltage, Cornell product, the Romhilt-Estes point score system, and Gubner-Ungerleider voltage. Different ECG criteria showed a sensitivity of 21% to 54.5% and a specificity of 77% to 97.5% by taking Echo as the gold standard (GHOUS and SYED TAHSEEN SHAHZAD, 2014; Saba et al.).
We live in a developing country with limited health facilities and resources. And one of the definitive modalities to diagnose LVH, i.e., echocardiography, is not readily available even in our district-level hospitals. Limited local data is available regarding the best ECG criterion, and international literature shows variability about the different ECG criteria and their sensitivity/specificity in detecting LVH. | want to collect the local data and reassess the diagnostic accuracy of ECG to detect LVH in hypertensive patients. So, just by applying a single criterion, one can have a diagnosis of LVH, and unnecessary referral to a tertiary care setup to get an Echocardiography is minimized.

Methodology

The current cross-sectional study was conducted at the Cardiology Department of Rehmatul-Lil-Alameen Institute of Cardiology, Lahore, from July 25, 2019, to December 26, 2019. A sample size of 236 patients was calculated with a confidence level of 95%, a margin of error of 10%, and a 54.5% (22) sensitivity of ECG Criteria to detect LVH in patients with hypertension and 97.5% Specificity (assumed 90%) and taking 40.8% expected prevalence of hypertension.
Diagnosed cases of hypertension, according to the operational definition with a minimum duration of disease of 03 years, were included in the study, both males and females with age limits of 18 to 85 years. Patients with secondary hypertension, ischemic heart disease/myocardial infarction, cardiomyopathy, congenital heart disease, cor pulmonale, valvular heart disease, bundle branch block, and a pre-excitation syndrome (on history/medical record) were excluded from the analysis.
After taking informed consent, 236 hypertensive patients fulfilling the inclusion criteria were enrolled from the cardiology department of Rehmatul-Lil-Alameen Institute of Cardiology, Lahore. Demographic data like Name, Age, and Gender were noted. The data was obtained from the patients through direct questioning.
All patients were then undergoing ECG and Echo. Standard 12 lead rest ECG was done using (CARDIMAX Model FX-7102, FUKUDA DENSHI CO. LTD) ECG machine at 25 mm/s speed, 10 mm/mV sensitivity, and 0.05 Hz to 150 Hz frequency. To avoid bias, every ECG was evaluated by two residents who were blind to the study group. Romhilt-Estes point score system was used to calculate the score. The residents used manual calipers to measure the amplitude of QRS complexes. ECHO was performed by cardiologists who were also blind to the study group to which these ECHOS belong.
Echocardiography was done using (Aplio ARTIDA Model SSH-880CV, TOSHIBA) machine. I collected the data. Outcome variables include the number of hypertensive patients with LVH on Echo and ECG (per operational definition). All this information was taken on proforma.

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Data was entered and analyzed in SPSS version 22.0. Mean + Standard deviation was calculated for quantitative variables like age. Frequency and percentages were calculated for qualitative variables like gender and the presence of LVH on ECG and Echo in patients with hypertension. Data was stratified for age, gender, BMI, and duration of hypertension. A 2x2 contingency table was used to find diagnostic accuracy. The Chi-square test was used to analyze the categorical data. The level of significance was set at p-value <0.05.

Results

The mean age of the patients was 58.24±14.29 years; the minimum age was 34 years, and the maximum was 84 years. There were 159 (67.4%) males and 77 (32.6%) females in this study (figure 1). The mean BMI of the patients was 25.12±1.94, the minimum BMI was 21.60, and the maximum was 30.10. The mean duration of hypertension was 15.14±6.76; the minimum duration was 4; the maximum was 30 (Table 1). The mean BMI of the patients was 25.12±1.94, the minimum BMI was 21.60, and the maximum was 30.10. The mean duration of hypertension was 15.14±6.76; the minimum duration was 4; the maximum was 30 (Table 1).

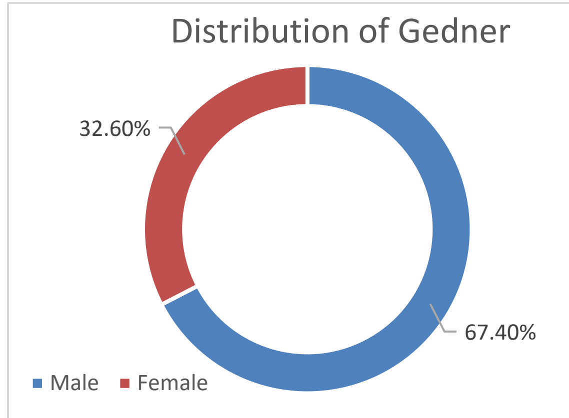

Figure 1 Gender distribution study population

Table 1 Demographics of the study group:

	Mean	**Standard Deviation**	**Minimum**	**Maximum**
Age	58.24	14.29	30	85
BMI	25.12	1.94	21.60	30.10
Duration of Hypertension	15.14	6.76	4	30

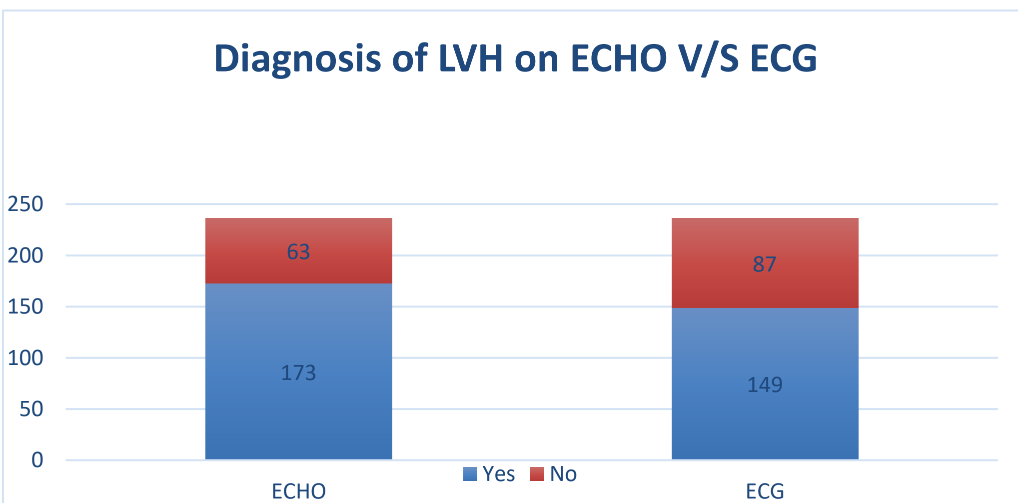

Figure 2 Frequency distribution of Diagnosis of LVH on ECHO V/S ECG

There were 173(73.3%) patients having LVH on Echocardiography, and 63(26.7%) patients did not have LVH on Echocardiography. There were 149 (63.1%) patients having LVH on ECG, while 87(36.9%) patients did not have LVH on ECG (Figure 2). The sensitivity and specificity of ECG were 79.19% and 80.95%, respectively; PPV and NPV were 91.95% and 58.62%, respectively, and overall diagnostic accuracy was 79.66% (table 2).

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Table 2: Diagnostic Accuracy of ECG for Diagnosis of LVH

ECG	LVH on Echo		Total
	Yes	No	
Yes	137	12	**149**
No	36	51	**87**
Total	**173**	**63**	**236**
Sensitivity 79.19%, Specificity 80.95%, Positive Predictive Value 91.95%, Negative Predictive Value 58.62%, Diagnostic Accuracy 79.66%			

Similarly, we also assessed the diagnostic accuracy of ECG after stratification of different parameters like age, gender, BMI, and hypertension duration. The diagnostic accuracy was 84.21%, 75%, and 82.69% in all three age groups, i.e., 30-50 years, 51-70 years, and 71-85 years, respectively. The diagnostic accuracy of males and females was 76.73% and 85.71%. The diagnostic accuracy was 80%, 81.11%, and 69.23% in the normal, overweight, and obese groups. The diagnostic accuracy was 80.42%, 79.27%, and 72.73% in the hypertension duration groups of 4-15, 16-25, and more than 25, respectively.

Discussion

Previous investigations have demonstrated that three-dimensional echocardiography improves the accuracy and reproducibility of left ventricular volume and mass estimates.(Gopal et al., 1997; Kupferwasser et al., 1997; Leotta et al., 1997) However, three-dimensional cardiac reconstructions have been limited by video-quality images, lengthy image acquisition times, limited acoustic windows, respiratory gating, and assumptions of left ventricular shape. In addition, its cost and the need for an expert to perform it make it difficult as a routine investigation. Although left ventricular mass determined on echocardiography is the most sensitive tool to diagnose LVH, ECG remains a useful initial investigation (Devereux et al., 1987).

Some studies have shown that electrocardiographic LVH and echocardiographic LVH are separate entities, and the former predicts cardiac morbidity and mortality independent of the latter (Kohsaka et al., 2005; Ogah et al., 2006). Therefore ECG should be performed in addition to echocardiography in patients with LVH to check the validity of the Romhilt Estee point score system of LVH (GHOUS and SYED TAHSEEN SHAHZAD, 2014). ECG criteria for LVH, particularly those that are heavily reliant on voltage criteria, may result from abnormal thickening of the left ventricular free wall or ventricular septum, left ventricular chamber dilatation, or increased left ventricular wall tension (Devereux et al., 1984; Nath et al., 1988).

Echocardiography provides direct information concerning left ventricular wall thickness and chamber size. Increased left ventricular mass is also a diagnostic standard because the formula considers left ventricular wall thickness and diastolic dimension, presumably defining left ventricular hypertrophy more accurately than increased left ventricular wall thickness or left ventricular enlargement alone (Devereux et al., 1984). Ghous et al. 2014 (GHOUS and SYED TAHSEEN SHAHZAD, 2014) reported 48% positive for LVH on ECG, though this result is not very high. Poor patients may be screened out first on ECG, and if no result is found, then echocardiography may be done, and it can be more effective by combining Sokolow Lyons voltage criteria and Cornell voltage criteria with Romhilt Estes point score (Bauml and Underwood, 2010). While in our study, the positive predictive value for ECG was 91.95%, and the over-diagnostic accuracy was 79.66% which is better than the abovementioned study.

Another study by Abid Amin Khan, Zaheer Alam, and Sara Inayat (Khan et al., 2012) shows that patients with left ventricular hypertrophy found 44% and without left ventricular hypertrophy 56% on ECG, which is in agreement with the results of the study by Ghous el al 2014 (GHOUS and SYED TAHSEEN SHAHZAD, 2014) while in our study Left ventricular hypertrophy was found in 63.1% patients and without left ventricular hypertrophy it was 36.9% with a little increase our findings were almost similar with the findings of the abovementioned study.

A study conducted by Abbas (Devereux et al., 1987) concluded that echocardiography should be used in preference to ECG to determine left ventricular mass in hypertensive patients. The point scoring of Romhilt-Estes has been reported as 60% sensitivity and 98% specificity when the ECG was compared with findings at necropsy by the scientists Romhilt and Estes (Romhilt and Estes Jr, 1968), whereas in our study, the sensitivity and specificity of ECG for LVH was 79.19% and 80.95%. In the study by Crow et al. (Crow et al., 1995), correlations between ECG and echocardiographic left ventricular mass index were modest (<0.40). ECG- left ventricular hypertrophy sensitivity at 95% specificity was < 34%, whereas our study reported a sensitivity of 79.19% and a

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specificity of 80.95% for ECG compared to Eco. The study by Saba et al. (Saba et al., 2014) also showed that ECG in diagnosing LVH is less sensitive than an echocardiogram.

In the study, Hameed et al. (Hameed et al., 2005) comparison between ECG and echocardiogram using Romhilt Estes score point for diagnosis of LVH revealed that this criterion has 35% sensitivity and 90% specificity and suggested that the sensitivity of ECG is low in detecting LVH. However, sensitivity can be improved by combining Sokolow Lyons voltage and Cornell voltage criteria with the Romhilt-Estes point score. These findings are different from the findings of our study, as our study suggested high sensitivity (79.19%) and specificity (80.95%) for ECG. Whereas in Waqas et al., the study combination of Sokolow Lyon and Cornell products does not improve the diagnostic efficacy of ECG for LVH. The sensitivity and specificity of these criteria vary widely depending upon the populations studied, the "gold standard" employed, and the severity of LVH. Overall, conservative estimates of the sensitivity of the various criteria for moderate to severe LVH are in the 30 to 60 percent range, with specificities in the 80 to 90 percent range (Murphy et al., 1985). Molloy et al. Suggested that the simple product of voltage and QRS duration is useful for identifying LVH more accurately than voltage criteria alone (Molloy et al., 1992).

Conclusion

ECG has a high specificity, PPV, and diagnostic accuracy for diagnosing left ventricular hypertrophy in patients with hypertension by taking Echo as the gold standard.

Conflict of interest

The authors declared an absence of conflict of interest.

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