



## DIAGNOSTIC ACCURACY OF ELECTROCARDIOGRAPHY IN DIAGNOSIS OF LEFT ATRIAL ENLARGEMENT TAKING ECHOCARDIOGRAPHY AS THE GOLD STANDARD

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### ABSTRACT

**Introduction:** Atrial enlargement is a marker of increased cardiovascular events. Anatomic left atrial (LA) enlargement (LAE) is a marker of left ventricular (LV) diastolic dysfunction and is associated with an abnormal stress test in subjects with known or suspected coronary artery disease. In addition, it is a predictor for the development of atrial fibrillation, congestive heart failure, stroke, increased cardiac mortality, incidence and survival after myocardial infarction and combined cardiovascular events.

**Materials and Methods:** The study was designed as a descriptive cross-sectional study with a duration of six months, conducted from October 2, 2021, to April 1, 2022, after the approval of the ethical committee. All patients who fulfilled the inclusion criteria and visited to NICVD, Karachi were included in the study. Informed consent was taken after explaining the procedure, risks and benefits of the study. All patients underwent electrocardiography and then echocardiography was done. The findings of electrocardiography and echocardiography were compared in order to evaluate diagnostic accuracy of electrocardiography. All the collected data were entered into the proforma attached at the end and used electronically for research purpose.

**Results:** Mean  $\pm$  SD of age was 62.4 $\pm$ 12.2 years. In distribution of gender, 95 (45.5%) patients were male while 114 (54.5%) were female. Diagnostic accuracy of electrocardiography was noted as 56.46% in diagnosis of left atrial enlargement with sensitivity 55.41%, specificity 57.04% PPV 41.41% and NPV 70.00% by using echocardiography as gold standard.

**Conclusion:** It is to be concluded that evaluating left atrial enlargement with electrocardiography did not prove helpful and comparable to echocardiography. Echocardiography should be done in each and every case to ensure adequate treatment.

**Keywords:** Electrocardiography, Diagnostic Accuracy, Left Atrial Enlargement

## INTRODUCTION

Left atrial enlargement (LAE) is a crucial component of the cardiac physiology, reflecting structural remodeling process, which occurs in response to chronic pressure and volume overload [1]. LAE occurs most commonly in association with diastolic dysfunction, left ventricular hypertrophy, mitral valvular disease, and systemic hypertension [2, 3]. LAE is associated with a number of serious complications such as atrial fibrillation (AF), other atrial tachyarrhythmias, and systemic embolic phenomena. The diagnostic accuracy of electrocardiography (ECG) criteria of left atrial enlargement taking echocardiography as the gold standard [4]. However, echocardiography is the gold standard for measurement of left atrial size, but electrocardiography can be simple, cost-effective, and noninvasive in clinical practice [5]. Research reveals that LAE has differing incidence and diagnostic accuracy [6, 7, 8]. Echocardiography is an accurate method for assessing LA size; ECG is a practical and affordable alternative. LAE is essential in the diagnosis of left ventricular diastolic dysfunction and predicts the development of cardiovascular illnesses and heart failure. In order to improve clinical procedures and promote early diagnosis, this study attempts to ascertain the ECG's diagnostic accuracy for LAE diagnosis using echocardiography as the gold standard. As medicine advances, ongoing research will improve diagnostic standards [9].

## MATERIALS AND METHODS

A descriptive cross-sectional study was conducted at the Department of Adult Cardiology, National Institute of Cardiovascular Disease (NICVD), Karachi, conducted from October 2, 2021, to April 1, 2022, after the approval of the ethical committee. Data was analyzed on SPSS Version 25. The sample size was calculated by taking sensitivity and specificity of electrocardiography as (54.4%) and (57.1%) respectively, and prevalence of left atrial enlargement 32%, the margin of error  $d=10\%$  for sensitivity and  $d=10\%$  for specificity and confidence interval 95%. Therefore, the sample size was taken as 209 patients, following non-probability, consecutive sampling technique. Patients between age 40 to 80 years, either gender or presented with shortness of breath were considered. Patients with history of unstable angina, STEMI and NSTEMI, hypothyroidism or hyperthyroidism, pulmonary hypertension, pulmonary embolism, valvular disease, patients assessed by history and confirmed by dating scan, with history of stroke, renal impairment and chronic obstructive pulmonary disease, asthma and CCF were excluded.

**Table 1: Descriptive statistics of Shapiro-Wilk test (n=209)**

Variable	Mean±SD	p-Value
Age (years)	62.4±12.2	0.063
Duration of Shortness of Breath (weeks)	3.5±1.2	0.136

- Mean ± SD of age was 62.4±12.2 with C.I (60.73.....64.06) years as shown in **Table 2**.

**Table 2: Descriptive statistics of age (n=209)**

Mean	62.4 (years)
Standard Deviation	12.2
95% Confidence Interval	60.73.....64.06
Minimum	40
Maximum	80
Range	40

- Mean ± SD of duration of shortness of breath was 3.5±1.2 with C.I(3.33.....3.66) weeks as

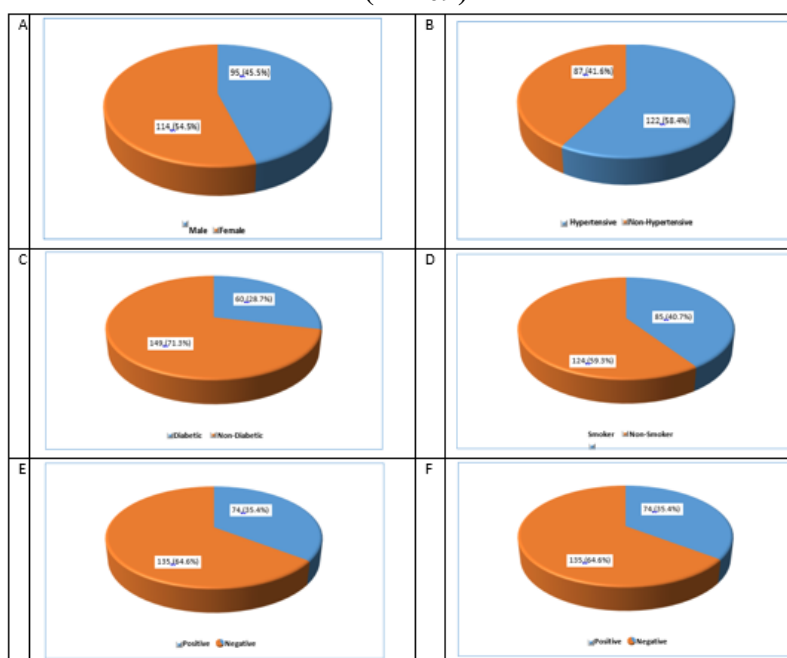
shown in **Table 3**.

**Table 3: Descriptive statistics for duration of shortness of breath (n=209)**

Mean	3.5 (weeks)
Standard Deviation	1.2
95% Confidence Interval	3.33.....3.66
Minimum	1
Maximum	12
Range	11

- In distribution of gender, 95 (45.5%) patients were male while 114(54.5%) were female patients as shown in **Figure 1A**
- Hypertension was found to be in 122 (58.4%) patients as shown in **Figure 1B**.
- Type II diabetes mellitus was documented in 60 (28.7%) patients as shown in **Figure 1C**.
- Out 209 patients, 85 (40.7%) patients were smoker while 124(59.3%) patients were non-smoker as shown in **Figure 1D**.
- Left atrial enlargement was found in 120 (57.4%) patients on electrocardiography as shown in **Figure 1E**.
- Left atrial enlargement was diagnosed in 74 (35.4%) patients on echocardiography (gold standard) as shown in **Figure 1F**

**Figure 1: Frequency of gender, hypertension, diabetes mellitus, smoking status, left atrial enlargement on electrocardiography, and left atrial enlargement on Echocardiography (n=209)**



- Diagnostic accuracy of electrocardiography was noted as 56.46% in diagnosis of left atrial enlargement with sensitivity 55.41%, specificity 57.04% PPV 41.41% and NPV 70.00% by using echocardiography as gold standard as shown in **Table 1**.

**Table 1: Diagnostic accuracy of electrocardiography for left atrial enlargement by using echocardiography as gold standard (n=209)**

Electrocardiography	Echocardiography (Gold Standard)	
	Positive	Negative
Positive	True positive (A) 41	False positive (B) 58
Negative	False negative (C) 33	True negative (D) 77

Total	A + C74	B + D135
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				95% Confidence Interval	
				Lower	Upper
Sensitivity	A/ (A + C)	0.5541	<b>55.41</b>	0.4408	0.6673
Specificity	D/ (B + D)	0.5704	<b>57.04</b>	0.4869	0.6539
Prevalence of Disease	(A+ C)/ (A+ B+ C+ D)	0.3541	<b>35.41</b>	0.2892	0.4189
Positive Predictive Value	A/ (A +B)	0.4141	<b>41.41</b>	0.3171	0.5112
Negative Predictive Value	D/ (C+ D)	0.7000	<b>70.00</b>	0.6144	0.7856
Overall Accuracy**	(A+ D)/ (A+ B+ C+ D)	0.5646	<b>56.46</b>	0.4974	0.6318

- Stratification of age group, gender, diabetes mellitus type II, hypertension and diabetes mellitus were done with respect to electrocardiography to find statistical difference from **Table [2—6]**.

**Table 2: Stratification of age group for left atrial enlargement with respect to electrocardiography (n=209)**

Age Group [In Years]		Echocardiography (Gold Standard)		
		Positive	Negative	
40 --- 60(n=82)	Electrocardiography	Positive	True Positive (A)12	False Positive (B) 8
		Negative	False Negative (C)17	True Negative (D)35
>60 (n=127)	Electrocardiography	Positive	True Positive (A)29	False Positive (B)40
		Negative	False Negative (C)16	True Negative (D) 42

For Age Group 40---60 (n=82)				95% Confidence Interval	
				Lower	Upper
Sensitivity	A/ (A + C)	0.4138	<b>41.38</b>	0.2345	0.5930
Specificity	D/ (B + D)	0.6604	<b>66.04</b>	0.5329	0.7879
Prevalence of Disease	(A+ C)/ (A+ B+ C+ D)	0.3537	<b>35.37</b>	0.2502	0.4571
Positive Predictive Value	A/ (A +B)	0.4000	<b>40.00</b>	0.2247	0.5753
Negative Predictive Value	D/ (C+ D)	0.6731	<b>67.31</b>	0.5456	0.8006
Overall Accuracy**	(A+ D)/ (A+ B+ C+ D)	0.5732	<b>57.32</b>	0.4661	0.6802

For Age Group > 60 (n=127)				95% Confidence Interval	
				Lower	Upper
Sensitivity	A/ (A + C)	0.6444	<b>64.44</b>	0.5046	0.7843
Specificity	D/ (B + D)	0.5122	<b>51.22</b>	0.4040	0.6204
Prevalence of Disease	(A+ C)/ (A+ B+ C+ D)	0.3543	<b>35.43</b>	0.2711	0.4375
Positive Predictive Value	A/ (A +B)	0.4203	<b>42.03</b>	0.3038	0.5368
Negative Predictive Value	D/ (C+ D)	0.7241	<b>72.41</b>	0.6091	0.8392
Overall Accuracy**	(A+ D)/ (A+ B+ C+ D)	0.5591	<b>55.91</b>	0.4727	0.6454

**Table 3: Stratification of gender for left atrial enlargement with respect to electrocardiography (n=209)**

Gender		Echocardiography (Gold Standard)		
		Positive	Negative	
Male (n=95)	Electrocardiography	Positive	True Positive(A) 44	False Positive (B) 28
		Negative	False Negative(C)19	True Negative (D)34
Female(n=114)	Electrocardiography	Positive	True Positive(A) 27	False Positive (B)30
		Negative	False Negative(C)14	True Negative (D) 43

For Gender Male (n=95)				95% Confidence Interval	
				Lower	Upper
Sensitivity	A/ (A + C)	0.4242	<b>42.42</b>	0.2556	0.5929
Specificity	D/ (B + D)	0.5484	<b>54.84</b>	0.4245	0.6723

<b>Prevalence of Disease</b>	(A + C)/ (A+ B+ C+ D)	0.3474	<b>34.74</b>	0.2516	0.4431
<b>Positive Predictive Value</b>	A/ (A +B)	0.3333	<b>33.33</b>	0.1908	0.4759
<b>Negative Predictive Value</b>	D/ (C+ D)	0.6415	<b>64.15</b>	0.5124	0.7706
<b>Overall Accuracy**</b>	(A+ D)/ (A+ B+ C+ D)	0.5053	<b>50.53</b>	0.4047	0.6058

For Gender Female (n=114)				95% Confidence Interval	
				Lower	Upper
<b>Sensitivity</b>	A/ (A + C)	0.6585	<b>65.85</b>	0.5134	0.8037
<b>Specificity</b>	D/ (B + D)	0.5890	<b>58.90</b>	0.4762	0.7019
<b>Prevalence of Disease</b>	(A+ C)/ (A+ B+ C+ D)	0.3596	<b>35.96</b>	0.2716	0.4477
<b>Positive Predictive Value</b>	A/ (A +B)	0.4737	<b>47.37</b>	0.3441	0.6033
<b>Negative Predictive Value</b>	D/ (C+ D)	0.7544	<b>75.44</b>	0.6426	0.8661
<b>Overall Accuracy**</b>	(A+ D)/ (A+ B+ C+ D)	0.6140	<b>61.40</b>	0.5247	0.7034

**Table 4: Stratification of diabetes mellitus type ii for left atrial enlargement with respect to electrocardiography (n=209)**

Diabetes Mellitus Type II			Echocardiography (Gold Standard)	
			Positive	Negative
<b>Diabetic(n=6)</b>	<b>Electrocardiography</b>	<b>Positive</b>	True Positive (A)16	False Positive (B)20
		<b>Negative</b>	False Negative (C)12	True Negative (D)12
<b>Non-Diabetic(n=149)</b>	<b>Electrocardiography</b>	<b>Positive</b>	True Positive (A)25	False Positive (B)38
		<b>Negative</b>	False Negative (C)21	True Negative (D)65

For Diabetes Mellitus Type II (Diabetic) (n=60)				95% Confidence Interval	
				Lower	Upper
<b>Sensitivity</b>	A/ (A + C)	0.5714	<b>57.14</b>	0.3881	0.7547
<b>Specificity</b>	D/ (B + D)	0.3750	<b>37.50</b>	0.2073	0.5427
<b>Prevalence of Disease</b>	(A+ C)/ (A+ B+ C+ D)	0.4667	<b>46.67</b>	0.3404	0.5929
<b>Positive Predictive Value</b>	A/ (A +B)	0.4444	<b>44.44</b>	0.2821	0.6068
<b>Negative Predictive Value</b>	D/ (C+ D)	0.5000	<b>50.00</b>	0.3000	0.7000
<b>Overall accuracy**</b>	(A+ D)/ (A+ B+ C+ D)	0.4667	<b>46.67</b>	0.3404	0.5929

For Diabetes Mellitus Type II (Non-Diabetic) (n=149)				95% Confidence Interval	
				Lower	Upper
<b>Sensitivity</b>	A/ (A + C)	0.5435	<b>54.35</b>	0.3995	0.6874
<b>Specificity</b>	D/ (B + D)	0.6311	<b>63.11</b>	0.5379	0.7243
<b>Prevalence of Disease</b>	(A+ C)/ (A+ B+ C+ D)	0.3087	<b>30.87</b>	0.2345	0.3829
<b>Positive Predictive Value</b>	A/ (A +B)	0.3968	<b>39.68</b>	0.2760	0.5176
<b>Negative Predictive Value</b>	D/ (C+ D)	0.7558	<b>75.58</b>	0.660	0.8466
<b>Overall accuracy**</b>	(A+ D)/ (A+ B+ C+ D)	0.6040	<b>60.40</b>	0.5255	0.6826

**Table 5: Stratification of hypertension for left atrial enlargement with respect to electrocardiography (n=209)**

Hypertension			Echocardiography (Gold Standard)	
			Positive	Negative
<b>Hypertensive(n=122)</b>	<b>Electrocardiography</b>	<b>Positive</b>	True Positive(A)29	False Positive (B)41
		<b>Negative</b>	False Negative(C)23	True Negative (D)29
<b>Non-Hypertensive (n=87)</b>	<b>Electrocardiography</b>	<b>Positive</b>	True Positive(A)12	False Positive (B)17
		<b>Negative</b>	False Negative(C)10	True Negative (D)48

For Hypertension (Hypertensive) (n=122)				95% Confidence Interval	
				Lower	Upper
<b>Sensitivity</b>	A/ (A + C)	0.5577	<b>55.77</b>	0.4227	0.6927
<b>Specificity</b>	D/ (B + D)	0.4143	<b>41.43</b>	0.2989	0.5297

<b>Prevalence of Disease</b>	(A+ C)/ (A+ B+ C+ D)	0.4262	<b>42.62</b>	0.3385	0.5140
<b>Positive Predictive Value</b>	A/ (A +B)	0.4143	<b>41.43</b>	0.2989	0.5297
<b>Negative Predictive Value</b>	D/ (C+ D)	0.5577	<b>55.77</b>	0.4227	0.6927
<b>Overall Accuracy**</b>	(A+ D)/ (A+ B+ C+ D)	0.4754	<b>47.54</b>	0.3868	0.5640

<b>For Hypertension (Non-Hypertensive) (n=87)</b>				<b>95% Confidence Interval</b>	
				<b>Lower</b>	<b>Upper</b>
<b>Sensitivity</b>	A/ (A + C)	0.5455	<b>54.55</b>	0.3374	0.7535
<b>Specificity</b>	D/ (B + D)	0.7385	<b>73.85</b>	0.6316	0.8453
<b>Prevalence of Disease</b>	(A+ C)/ (A+ B+ C+ D)	0.2529	<b>25.29</b>	0.1615	0.3442
<b>Positive Predictive Value</b>	A/ (A +B)	0.4138	<b>41.38</b>	0.2345	0.5930
<b>Negative Predictive Value</b>	D/ (C+ D)	0.8276	<b>82.76</b>	0.7304	0.9248
<b>Overall Accuracy**</b>	(A+ D)/ (A+ B+ C+ D)	0.6897	<b>68.97</b>	0.5924	0.7869

**Table 6: Stratification of smoking status for left atrial enlargement with respect to electrocardiography (n=209)**

<b>Smoking Status</b>		<b>Echocardiography (Gold Standard)</b>		
		<b>Positive</b>	<b>Negative</b>	
<b>Smoker(n=85)</b>	<b>Electrocardiography</b>	<b>Positive</b>	True Positive(A)26	False Positive (B)33
		<b>Negative</b>	False Negative(C)17	True Negative (D)9
<b>Non-Smoker(n=124)</b>	<b>Electrocardiography</b>	<b>Positive</b>	True Positive(A)15	False Positive (B)25
		<b>Negative</b>	False Negative(C)16	True Negative (D)68

<b>For Smoking Status (Smoker) (n=85)</b>				<b>95% Confidence Interval</b>	
				<b>Lower</b>	<b>Upper</b>
<b>Sensitivity</b>	A/ (A + C)	0.6047	<b>60.47</b>	0.4585	0.7508
<b>Specificity</b>	D/ (B + D)	0.2143	<b>21.43</b>	0.0902	0.3384
<b>Prevalence of Disease</b>	(A+ C)/ (A+ B+ C+ D)	0.5059	<b>50.59</b>	0.3996	0.6122
<b>Positive Predictive Value</b>	A/ (A +B)	0.4407	<b>44.07</b>	0.3140	0.5674
<b>Negative Predictive Value</b>	D/ (C+ D)	0.3462	<b>34.62</b>	0.1633	0.5290
<b>Overall Accuracy**</b>	(A+ D)/ (A+ B+ C+ D)	0.4118	<b>41.18</b>	0.3071	0.5164

<b>For smoking status (non-smoker) (n=124)</b>				<b>95% Confidence Interval</b>	
				<b>Lower</b>	<b>Upper</b>
<b>Sensitivity</b>	A/ (A + C)	0.4839	<b>48.39</b>	0.3079	0.6598
<b>Specificity</b>	D/ (B + D)	0.7312	<b>73.12</b>	0.6411	0.8213
<b>Prevalence of disease</b>	(A+ C)/ (A+ B+ C+ D)	0.2500	<b>25.00</b>	0.1738	0.3262
<b>Positive Predictive Value</b>	A/ (A +B)	0.3750	<b>37.50</b>	0.2250	0.5250
<b>Negative Predictive Value</b>	D/ (C+ D)	0.8095	<b>80.95</b>	0.7255	0.8935
<b>Overall accuracy**</b>	(A+ D)/ (A+ B+ C+ D)	0.6694	<b>66.94</b>	0.5866	0.7522

## DISCUSSION

Left atrial (LA) enlargement is associated with a number of serious complications such as atrial fibrillation, other atrial tachyarrhythmia and systemic embolic phenomena [10]. The assessment of LA size may be helpful in guiding patient management strategies e.g. institution of anti-coagulants or cardiac glycoside therapy. Electrocardiography(ECG) is a simple, non-invasive, cost-effective, accessible and reproducible means to diagnose increased LA size [11]. Angiography is a better method of demonstration of left atrial contour and permits more accurate measurements [12, 13]. But it has limited utility in evaluating large populations due to its invasive nature and complex procedure. Left ventricular hypertrophy (LVH) profoundly affects morbidity and mortality like

coronary artery disease, congestive cardiac failure, stroke, ventricular arrhythmias and sudden cardiac death [14]. The 12 lead ECG is the most common investigation available for the diagnosis of LVH as it is cost effective and convenient with reliable probability [15, 16]. Nowadays, echocardiography is the gold standard for the diagnosis of LVH. At least 30 ECG criteria have been used in past 10 years to diagnose LVH, still, it was not clear which ECG criterion is better over other in diagnosing LVH [16]. In current study, mean age was  $62.4 \pm 12.2$  years. The findings of our study are comparable with different studies conducted by various researchers worldwide [6, 7]. In our study, 95 (45.5%) patients were male while 114 (54.5%) were female patients. There were 54% men and 46% women in the study of Cuspidi et al. [7]. The study of Lee et al. reported to have 47% men and 53% women. In this study, LAE was found in 120 (57.4%) patients on electrocardiography. Left atrial enlargement was diagnosed in 74 (35.4%) patients on echocardiography (gold standard) [6]. As per the study of Batra et al. LAE was found in 52.7% of patients on ECG and in 85.6% on echocardiography [8]. Cuspidi et al. found the prevalence of left atrial enlargement to be 32% [7]. LA enlargement was present in 43% of patients [6]. In present study, diagnostic accuracy of electrocardiography was noted as 56.46% in diagnosis of left atrial enlargement with sensitivity 55.41%, specificity 57.04% PPV 41.41% and NPV 70.00% by using echocardiography as gold standard. The diagnostic accuracy of electrocardiographic criteria of left atrial enlargement taking echocardiography as the gold standard had sensitivity 87.5%, specificity 85%, positive predictive value 92.1%, and negative predictive value 77.2% [4]. Batra et al. evaluated diagnostic accuracy of electrocardiographic criteria of left atrial enlargement taking echocardiography as the gold standard and found sensitivity, specificity, positive predictive value, negative predictive value, and accuracy of electrocardiography for left atrial enlargement were 54.4%, 57.1%, 88.3%, 17.4%, and 54.8% [8]. Left atrial (LA) size is one important part of cardiac remodeling in a variety of cardiovascular diseases [17, 18]. Strong evidence suggests that, increased left atrial size has been associated with severity and duration of diastolic dysfunction, atrial fibrillation (AF), predictor of stroke once atrial fibrillation is manifest, congestive heart failure (CHF), incidence and survival after myocardial infarction and a strong predictor of cardiovascular morbidity and mortality [19].

## 2. CONCLUSION

In conclusion, echocardiography is more accurate than electrocardiography in assessing left atrial enlargement. To guarantee appropriate care, echocardiography should be performed in each and every instance.

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