

Association between Electrocardiographic Criteria of Left Atrial Enlargement and Left Atrial Volume Index by 2d Echocardiogram: Single Tertiary Care Centre Observational Study

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Abstract: ***Background:** Left atrial enlargement detection is very important in clinical medicine and cardiology. In patients with cardiovascular diseases, it is associated with increased morbidity and mortality. Left atrial enlargement is associated with arrhythmias, thromboembolism, stroke, diastolic dysfunction. ECG assessment is noninvasive and universally available and ECHO is quantitatively assessing LA size. **Aims and objectives:** To find the association between electrocardiographic evidence of left atrial enlargement and Left atrial volume index by 2D echocardiogram. **Methods:** A descriptive observational study was conducted in 80 participants who attended as outpatient clinic or admitted in cardiology department, Madras medical college with electrocardiogram evidence of left atrial enlargement were subjected to 2D-ECHO and LA volume index (LAVI) were measured. **Results:** There was a significant association between electrocardiographic left atrial enlargement and echocardiographic assessment of left atrial size (LA volume index) in the study. **Conclusion:** A good association exists between ECG evidence of LA enlargement and ECHO evidence of LA enlargement*

Keywords: Left atrial enlargement, Left atrial volume index, Electrocardiographic data 2DE chocardiogram, Cardiology

1. Introduction

Left atrial enlargement detection is very important in clinical medicine. In patients with cardiovascular diseases, left atrial enlargement is associated with increased morbidity and mortality. Left atrial enlargement is associated with stroke, arrhythmias, thromboembolism, diastolic dysfunction. ECG assessment is noninvasive and universally available and ECHO is quantitatively assessing LA size.

It has three functions (Reservoir, Conduit and Emptying). Common causes of Left atrial enlargement are Mitral stenosis, Mitral regurgitation, LV systolic and diastolic dysfunction from CAD, Systemic hypertension, Cardiomyopathy, Aortic valve disease. LAE is common finding in LVH.

ECG is more readily available for quick assessment of electrical and structural conditions of the heart compared to ECHO. In this study, we also intend to determine the sensitivity and specificity of the ECG in relation to Echocardiographic measurement of LA volume

Intraatrial and interatrial blocks produce conduction disturbance and changes the P wave morphology. Left atrial activation is delayed and produces wide P wave. P wave duration is prolonged beyond 120 milliseconds. In case of isolated interatrial block, P wave morphology in lead V1 is

positive or only presents a small negative part as the second part of the loop is not directed backward because there is no LAE. Occurs as an isolated abnormality or associated with structural abnormalities. Independent predictor of atrial fibrillation, left atrial thrombi and systemic embolization.

Aim and Objectives

To find the association between electrocardiographic evidence of left atrial enlargement and Left atrial volume index by 2D echocardiogram

2. Methodology

Patients with ECG evidence of Left atrial enlargement, who attended cardiology OP clinics and admitted as Inpatient (April 2022-April 2023), history, clinical examination and transthoracic echocardiographic were done, LA volume index was obtained.

Participants

A descriptive observational study was conducted in 80 participants who attended as outpatient clinic or admitted in cardiology department, Madras medical college with electrocardiogram evidence of left atrial enlargement were subjected to ECHO and 2D LA volume index were measured.

Inclusion Criteria:

- Patients with ECG evidence of left atrial enlargement
- Age > 18 years
- Patient is in sinus rhythm

Exclusion Criteria:

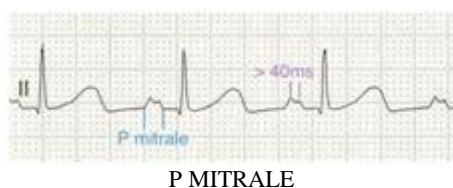
- Age < 18 years
- Patients with atrial fibrillation
- Poor Echocardiographic window
- In overt heart failure

Period of study: 1 year (April 2022-2023)

Protocol:

80 patients in the study groups were then subjected to history, examination, ECG and ECHO

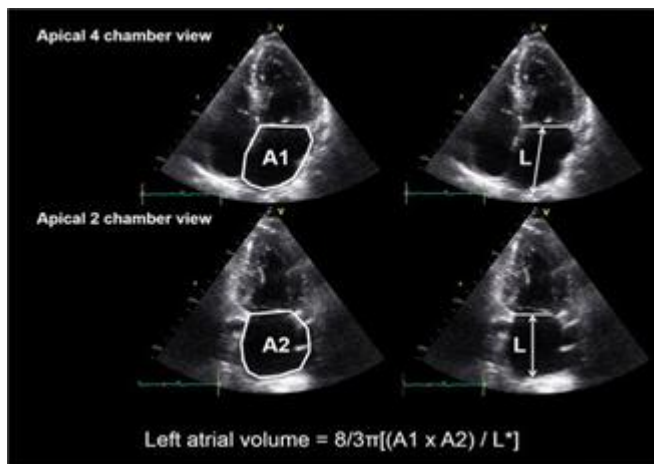
Measurement of electrocardiogram: Standard 12 lead ECGs were done for the study participants with normal standardization (10mm/mV) and paper speed of 25 mm/sec were obtained. ECG criteria were then evaluated and recorded: 1) a P wave ≥ 120 msec in lead II, 2) P wave with two peaks separated by a duration of ≥ 40 msec in lead II (P mitrale), and 3) a terminal negative portion of P wave in lead V1 (the P terminal force) > 40 mmsec (Morris index) 4) a P/PR segment > 1.6 in lead II (Macruz)



P terminal force in V1 (Morris Index)

Transthoracic Echocardiogram

2D area length technique (BIPLANE METHOD) was done: LAVI = 0.85 x A1 X A2/L



According to the ASE guidelines. The LA enlargement is defined as a maximum LA indexed volume ≥ 29 mL/m² (normal = 16 mL/m² to 28 mL/m², mild enlargement = 29 to 33; moderate enlargement = 34 mL/m² to 39 mL/m², severe enlargement ≥ 40 mL/m²).

3. Statistical Analysis

The data collected were entered into Microsoft excel 2019 and the master chart was created. The master chart was then loaded onto SPSS version 26 for statistical analysis. Both descriptive and inferential statistics were used. The quantitative variables were expressed using mean and standard deviation and the qualitative variables using frequency and percentage. To find out the degree of agreement between ECG LAE criteria and LAVI, Kappa statistics were used. To find out the sensitivity, specificity, positive predictive value, negative predictive value and diagnostic accuracy, Medcalc's diagnostic test evaluation calculator was used. 95% confidence interval was estimated for the evaluation indicators.

4. Results

The mean age among the participants was 40.17 ± 13.13 years. 66.3% were males. The mean height among the participants was 159.23 ± 7.15 cms. The mean weight was 59.50 ± 9.26 Kgs. The mean BSA was 1.61 ± 0.16. The mean heart rate was 80.89 ± 9.30 bpm. The mean systolic blood pressure was 113.34 ± 15.32 mmHg. The mean diastolic blood pressure was 74.56 ± 8.51 mmHg. 58.8% had rheumatic mitral stenosis, 28.7% had hypertension, 13.8% had mitral regurgitation, 3.8% had aortic stenosis and 2.5% had dilated cardiomyopathy (table 1).

With regard to P wave duration, 71 (88.8%) had left atrial enlargement. With regard to P mitrale, the proportion was 65%. The proportion was 95% in case of Morris index criteria and 32.5% with regard to left axis deviation. When Macruz index was used, the proportion was 26.3% (Table 2). 8.8% had LAVI of less than or equal to 29, 7.5% had LAVI between 30 and 33, 70% had LAVI of 34 to 39 and in 13.8% LAVI was more than or equal to 40 (Fig 1).

Table 1: Baseline characteristics among the participants

Variable		Mean ± SD
Age (in years)		40.17 ± 13.12
Sex	Male	53 (66.3)
	Female	27 (33.8)
Height (in cms)		159.23 ± 7.15
Weight (in Kgs)		59.50 ± 9.26
BSA		1.61 ± 0.16
Heart rate (beats per min)		80.89 ± 9.30
Systolic blood pressure (mmHg)		113.34 ± 15.32
Diastolic blood pressure (mmHg)		74.56 ± 8.51
Underlying pathology	Rheumatic mitral stenosis	47 (58.8)
	Mitral regurgitation	11 (13.8)
	Aortic stenosis	3 (3.8)
	Hypertension	23 (28.7)
	Dilated cardiomyopathy	2 (2.5)

Table 2: Distribution according to left atrial enlargement criteria

Variable	Criteria for LAE	N (%)
P wave duration	>110 ms	71 (88.8)
P mitrale	≥40 msec	52 (65)
Morris index	>40 mm ms	76 (95)
Left axis deviation	-30 to -45 degrees	26 (32.5)
Macruz index	>1.6 mm	21 (26.3)

Among the participants with LAVI > 29, 89% was also diagnosed by P wave duration to have LAE. There was slight agreement (0.029) between P wave duration criteria and LAVI diagnosis. With the P mitrale criteria, the true positives were 65.8% and there was slight agreement between P mitrale and LAVI. With Morris index, the true positives were 100% and there was substantial agreement between Morris index and LAVI. With the criteria of left atrial deviation and Macruz index, the true positives were 32.9% and 27.4%, respectively. Both the also found to have slight agreement in Kappa statistics (Table 2).

With regard to P wave duration criteria, the sensitivity was 89.1%, specificity was 14.2%, PPV was 91.5%, NPV was

11.1% and diagnostic accuracy was 82.5%. With P mitrale criteria, the sensitivity was 65.7%, specificity was 42.8%, PPV was 92.3%, NPV was 10.7% and accuracy was 63.7%. With Morris index criteria, the sensitivity was 100%, specificity was 57.1%, PPV was 96.1%, NPV was 100% and accuracy was 96.3%. With left axial deviation, the sensitivity was 32.8%, specificity was 71.4%, PPV was 92.3%, NPV was 9.26% and accuracy was 36.2%. The Macruz index criteria had sensitivity of 27.4%, specificity was 85.7%, PPV was 95.2%, NPV was 10.1% and accuracy was 32.5% (Table 3).

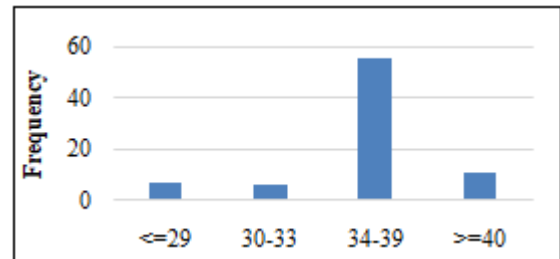


Figure 1: Bar chart showing distribution according to LAVI

Table 2: Kappa agreement between each LAE criteria and LAVI measured

LAE criteria		LAVI				Kappa value	Interpretation
		>29		≤ 29			
		N=73	%	N=7	%		
P wave duration	LAE present	65	89	6	85.7	0.029	Slight agreement
	Absent	8	11	1	14.3		
P mitrale	LAE present	48	65.8	4	57.1	0.037	Slight agreement
	Absent	25	34.2	3	42.9		
Morris index	LAE present	73	100	3	42.9	0.709	Substantial agreement
	Absent	0	0	4	57.1		
Left Axis deviation	LAE present	24	32.9	2	28.6	0.01	Slight agreement
	Absent	49	67.1	5	71.4		
Macruz index	LAE present	20	27.4	1	14.3	0.030	Slight agreement
	Absent	53	72.6	6	85.7		

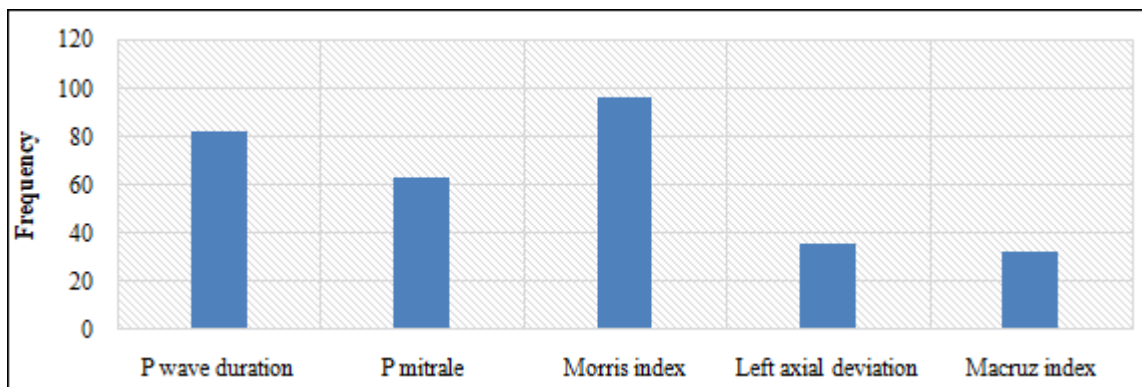


Figure 2: Bar chart showing distribution according to diagnostic accuracy for different categories of LAE criteria

Table 3: Diagnostic evaluation of LAE criteria and LAVI measured

LAE criteria	Sensitivity	Specificity	PPV	NPV	Accuracy
P wave duration	89.1 (79.5 - 95.1)	14.2 (0.36 - 57.8)	91.5 (82.8 - 96.4)	11.1 (0.328 - 48.3)	82.5 (73.3 - 90.1)
P mitrale	65.7 (53.7 - 76.4)	42.8 (9.9 - 81.5)	92.3 (81.4 - 97.8)	10.7 (2.2 - 28.2)	63.7 (52.2 - 74.2)
Morris index	100 (95.1 - 100)	57.1 (18.4 - 90.1)	96.1 (88.8 - 99.1)	100 (39.7 - 100)	96.3 (89.4 - 99.2)
Left axis deviation	32.8 (25.3 - 44.8)	71.4 (29.1 - 96.3)	92.3 (74.8 - 99.1)	9.26 (3.1 - 20.3)	36.2 (25.7 - 47.7)
Macruz index	27.4 (17.6 - 39.1)	85.7 (42.1 - 99.6)	95.2 (76.1 - 99.8)	10.1 (3.8 - 20.8)	32.5 (22.4 - 43.8)

5. Discussion

The left atrium is affected by increased resistance across the mitral valve, or volume overload caused by mitral valve regurgitation, increased ventricular filling pressure. Left atrial enlargement is common in rheumatic mitral valve disease, where LA pressure is also increased. So the mere presence of an enlarged left atrium or elevated left atrial pressure does not establish the cause of ECG changes. The role of atrial inflammation or scarring can also produce electrocardiographic abnormalities of LA enlargement by causing conduction defects. In our set up, majority of patients suspected of having LA enlargement, had rheumatic mitral valve disease

The ECG remains widely used for LA enlargement detection due to its simplicity and accessibility. However, ECHO has become the gold standard in clinical practice.

According to van Dam et al, out of 100 patients, LA enlarged in 13 patients. No relationship between the ECG diagnosis of LA enlargement and the LA size as measured by the ECHO [2].

According to Waggoner et al. showed that the sensitivity and specificity of ECG-LA enlargement were 67% and 94.4%, respectively [7]. They concluded that ECHO is better at diagnosing LA enlargement than the ECG criteria [7].

Another study by Waqas et al. on the sensitivity and specificity of 'P' mitrale on ECG in diagnosing LA enlargement on ECHO, they discovered that 'P' mitrale has a sensitivity of 22.5% and a specificity of 100% [8].

Lee et al. showed an association between ECG and ECHO-LA volume enlargement. They used the modified Simpson's method of disks in estimating the LA volume on ECHO and found the biphasic "P" wave in lead V1 to be specific and the "P" wave duration in lead 2 to be sensitive in detecting ECHO-LA enlargement.

6. Conclusion

This study demonstrated a strong association exists between ECG evidence of LA enlargement and ECHO evidence of LA enlargement. Left atrial enlargement on ECG can better be assessed using P terminal force on lead V1 and P mitrale on lead II.

References

- [1] Blume, G. G. et al. Left atrial function: physiology, assessment, and clinical implications. *European Journal of Echocardiography* 12, 421-430 (2011)
- [2] van Dam I, Roelandt J, Robles de Medina EO: Left atrial enlargement: an electrocardiographic misnomer? An electrocardiographic-echocardiographic study. *Eur Heart J.* 1986, 7: 115-117
- [3] Wong RC, Yeo TC: Left atrial volume is an independent predictor of exercise capacity in patients with isolated left ventricular diastolic dysfunction. *Int J Cardiol.* 2010, 144: 425-427. 10.1016/j.ijcard.2009.03.060
- [4] Lester SJ, Ryan EW, Schiller NB, Foster E: Best method in clinical practice and in research studies to determine left atrial size. *The Am J Cardiol.* 1999, 84: 829-832. 10.1016/S0002-9149(99)00446-4
- [5] Leung DY, Boyd A, Ng AA, Chi C, Thomas L: Echocardiographic evaluation of left atrial size and function: current understanding, pathophysiologic correlates, and prognostic implications. *Am Heart J.* 2008, 156: 1056-1064. 10.1016/j.ahj.2008.07.021
- [6] Barnes ME, Gersh BJ, Bailey KR, Seward J: Left atrial volume as a morphophysiological expression of left ventricular diastolic dysfunction and relation to cardiovascular risk burden. *Am J Cardiol.* 2002, 90: 1284-1289. 10.1016/S0002-9149(02)02864-3
- [7] Waggoner AD, Adyanthaya AV, Quinones MA, Alexander JK: Left atrial enlargement. Echocardiographic assessment of electrocardiographic criteria. *Circulation.* 1976, 54: 553-557. 10.1161/01.cir.54.4.553
- [8] Waqas H, Muhammad SR, Shafqat A, Muhammad MH, Muhammad A, Sohail A: P' mitrale and left atrial enlargement: comparison with echocardiography. *Pak J Physiol.* 2009, 5: 24-26.
- [9] Erol MK, Yilmaz M, Acikel M, Karakelleoglu S: Left atrial mechanical function in patients with essential hypertension. *Acta Cardiol.* 2002, 57: 323-327. 1
- [10] Chandraratn PA, Aronow MS, Aronow WS. Significance of Echocardiographic left atrial enlargement in aortic stenosis. *Clinical cardiology:* 1982 Oct; 5 (10): 520-522.