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Original Article

# Detection of Left Atrial Enlargement by Echocardiography and Electrocardiogram Correlation in Cardiac and Non-cardiac Diseases

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## Abstract

**Introduction:** Left atrial enlargement (LAE) is an important pathologic change in many forms of heart disease. There is growing recognition of an association between LAE and increased morbidity and mortality in patients with cardiovascular diseases.

**Materials and Methods:** This study was undertaken from July 2014 to August 2015 in all medical units of Mahatma Gandhi Memorial Hospital, Warangal, 120 randomly selected cases of suspected LAE were studied using two-dimensional echocardiography (ECHO), and it was compared with an electrocardiogram (ECG).

**Results:** In the present study, age of the patient ranges from 17 to 90 years with mean age of 49.21 years. Most of the cases have rheumatic mitral and aortic valve disease (45%) followed by hypertension (18.3%) and ischemic heart disease (13.3%). Criteria "Duration of negative phase of P-wave in lead $V_1$" have the highest sensitivity 87.5%. Criteria of LAE "P-wave notching" have the highest specificity 100% for detection of LAE in ECG.

**Conclusion:** Morris index P-terminal force in precordial lead $V_1$ is the best criterion having sensitivity 85% and specificity 95%. The sensitivity of various ECG criteria of LAE shows variable response, but specificity remains constant at progressively higher ranges of LA dimension.

**Key words:** Echocardiogram, Electrocardiogram, Left arterial enlargement

## INTRODUCTION

Left atrial enlargement (LAE) is associated with a number of serious complications such as atrial fibrillation (AF), other atrial tachyarrhythmias, and systemic embolic phenomena.[1] The assessment of LA size may be helpful in guiding patient management strategies, e.g. institution of anticoagulants or cardiac glycoside therapy.[2] The ability to maintain normal sinus rhythm after cardioversion from AF similarly correlates with LA size.[2]

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LA size is a marker for severity and chronicity of diastolic dysfunction:

During ventricular diastole, LA is directly exposed to left ventricular (LV) pressures through the open mitral valve. With worsening LV compliance, LA pressure increases to maintain adequate LV filling, which results in LAE.[3] LA volume overload resulting from mitral valve regurgitation, arteriovenous fistula, left to right shunt, or high cardiac output state can also contribute to LA chamber remodeling. Therefore, LA volume may reflect the severity of diastolic dysfunction. LA remodeling may also represent the chronicity of exposure to abnormal LV filling pressure. Thus, LA volume as a reflection of severity and chronicity of diastolic dysfunction provides prognostic information incremental to that of diastolic function class determined by multiple load dependent Doppler parameters reflective of instantaneous LV diastolic function and filling pressures.[4]

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Therefore, LA volume has been termed "glycosylated hemoglobin of diastolic dysfunction."

Several large population-based prospective studies have shown a strong association between M-mode anteroposterior LA diameter and the risk of new onset AF.[5,6]

In the Framingham Heart Study, every 5 mm increase in LA diameter increased the development of AF by 39%, while the cardiovascular (CV) health study showed a four-fold increase in the risk of new AF with LA diameter 0.5 mm.[5]

Evidence from these studies indicates that LA size encompasses information not captured by clinical data or one-dimensional M-mode assessment and thus represents a superior predictor of outcomes including AF.[7-9]

In recent trials such as the Losartan Intervention for Endpoint reduction in hypertension trial, LA diameter/height predicted the risk of CV events independent of other clinical risk factors in hypertensive patients with LV hypertrophy.[10]

Similarly, in a very large study of patients referred for echocardiography (ECHO), LA volume index predicted all-cause mortality independent of LV geometric patterns. The prognostic implication of LA size has also been shown in high-risk subgroups, such as patients with acute myocardial infarction, atrial arrhythmia, LV dysfunction, or dilated cardiomyopathy, and patients undergoing valve replacement for aortic stenosis and mitral regurgitations.[11]

So, the size of the LA is an important index of cardiac status.

Electrocardiography (ECG) is a simple, non-invasive, cost-effective, accessible, and reproducible means to diagnose increased LA size as well as serial follow-up evaluation.[2]

X-ray studies measure only gross changes in atria.[12]

Angiography is a better method of demonstration of LA contour and permits more accurate measurements. However, it has limited utility in evaluating large populations due to its invasive nature and complex procedure.[13,14]

ECHO is comparable to angiography in assessing LA size.[15] Being an accurate and non-invasive technique for obtaining anatomical measurements, it is the universally accepted.

### Diagnostic Standard

LA volume has been measured using three-dimensional ECHO and has shown good correlation with other methods including magnetic resonance imaging.

However, in the Indian setting, ECG is widely used and has added advantage over ECHO in being cost-effective, easily available, and accessible.

## MATERIALS AND METHODS

### Study Setting and Duration

This study was undertaken from July 2014 to August 2015 in all medical units of Mahatma Gandhi Memorial Hospital, Warangal. This was a prospective cross-sectional study. The study group comprised 120 randomly selected patients who are referred for two-dimensional (2D) echo.

Patients with age <14 years, pericardial effusion, chronic obstructive pulmonary diseases, usage of drugs such as beta blockers, digitalis, calcium channel blockers, AF, and conduction defects.

120 suspected cases of LAE were subjected to the following: Detailed history taking, general physical examination, systemic examination, ECG, and 2D ECHO.

The number of true positives, true negatives, false positives, and false negatives was calculated for the individual ECG criteria as parameters of diagnostic accuracy, sensitivity, specificity, positive predictive value, and negative predictive value were calculated. Studies of correlation were done for absolute value of LA (obtained by echo) with P-wave duration in lead II, duration of the negative phase of P-wave in lead $V_1$, and depth of negative phase of P-wave in lead $V_1$. In each case, the Pearson's correlation coefficient was calculated.

## RESULTS

Age of the patient ranges from 17 to 90 years with mean age of 49.21 years. There were 72 females and 48 males.

In this study, most of the cases have rheumatic mitral and aortic valve disease followed by hypertension, ischemic heart disease (IHD), isolated aortic valve disease, cardiomyopathies, mitral valve prolapse, and thyrotoxicosis (Tables 1-3).

- Sensitivity: 87.5%
- Specificity: 85%
- Positive predictive value: 92.1%
- Negative predictive value: 77.2%
- Pearson correlation coefficient: 0.51.

**Table 1: Age and sex wise distribution of the cases**

| Age group in years | Females | Males | Total |
|---|---|---|---|
| 14-20 | 4 | 4 | 8 |
| 21-30 | 8 | 4 | 12 |
| 31-40 | 8 | 6 | 14 |
| 41-50 | 18 | 20 | 38 |
| 51-60 | 18 | 4 | 22 |
| >60 | 16 | 10 | 26 |
| Total | 72 | 48 | 120 |

**Table 2: Etiological analysis of cases**

| Etiology | Males | Females | Total |
|---|---|---|---|
| Rheumatic mitral and aortic valve disease | 14 | 40 | 54 |
| Hypertension | 14 | 8 | 22 |
| IHD | 12 | 4 | 16 |
| Mitral valve prolapse | 2 | 2 | 4 |
| Cardiomyopathies | 6 | 2 | 8 |
| Thyrotoxicosis | 0 | 4 | 4 |
| Isolated aortic valve disease | 8 | 4 | 12 |
| Total | 56 | 64 | 120 |

IHD: Ischemic heart disease

**Table 3: Duration of negative phase of P-wave in lead $V_1$ in ECG and LA size in 2D ECHO**

| ECG | 2D ECHO positive | 2D ECHO negative | Total |
|---|---|---|---|
| ECG positive | 70 | 6 | 76 |
| ECG negative | 10 | 34 | 44 |
| Total | 80 | 40 | 120 |

ECG: Electrocardiogram, ECHO: Echocardiography, LA: Left atrial, 2D: Two-dimensional

## DISCUSSION

Size of the LA is an important index of cardiac status. LAE has important implications such as the development of AF, thromboembolic phenomena, and complications thereof.

The LA is affected directly by increased ventricular filling pressure, increased resistance across the mitral valve, or volume overload caused by mitral valve regurgitation. ECG could offer a simple, cost-effective, readily available, non-invasive means to diagnose LAE if reliable criteria were available.

The criteria used in the present study are the ones most frequently used clinically and received attention in the existing literature either individually or in groups.

However, certain ECG abnormalities traditionally attributed to LAE may occur in patients with LA pressure overload or defective atrial conduction or both.

Previously, it had been established that LA thickening with or without dilatation could produce some of the ECG signs examined in this study. These findings suggest that the diagnostic accuracy of previously described ECG criteria for LAE may be more limited than was previously appreciated.

Our study group comprised 120 suspected cases of LAE in normal sinus rhythm; 54 of them suffering from rheumatic heart disease; 40 were females and 14 were males. This finding well correlates with the previously documented higher incidence of rheumatic heart disease in female population.

This also explains the larger number of females among the 120 consecutive patients suspected having LAE since the majority of them were suffering from rheumatic heart disease.

P-wave duration in lead II >110 ms has the sensitivity of 62.5%, specificity 80%, positive predictive value 86.2%, and negative predictive value 51%.

In the present study, correlation of P-wave duration in lead II with LA dimension obtained by ECHO has yielded a moderately positive correlation with a correlation coefficient of 0.2. In most others studies, correlation with LA size has been positive with correlation coefficients of 0.56-0.74.

Our lower degree of correlation may be due to the exclusion of patients with AF, who usually have LA size >45 mm.

In our study, age of the patients ranged from 17 to 90 years with mean age of 49.21 years. There were 60% females and 40 males with a ratio of 1:1.5 showing female preponderance. Waggoner *et al.* in their study involving 339 patients; 58.99% were females and 41.01% were males.

Hazen *et al.* study ECGs and surface ECHO obtained within 1 week of each other were evaluated in 551 patients (140 normal and 411 study subjects). The various P-wave morphologies were found to be poorly sensitive (30-60%) but very specific (90%) for LAE. Combinations of P-wave morphologies did not improve sensitivity or specificity. ECG features did give an estimate of the degree of LAE. When P-terminal force in precordial lead $V_1$ ($PTFV_1$) is ce imsec mm, 95% of patients had LA size ≥40 mm; and when this parameter was ivitmsec mm, 75% had LA size ≥60 mm. These criteria for LAE on the ECG are specific and predictive of the degree of LAE measured by ECHO.

In Mishra *et al.* (2008) study, ECGs and ECHO were obtained in 100 consecutive patients suspected of having LAE due to different underlying heart diseases.

The diagnostic accuracy of six ECG criteria of LAE was evaluated comparing with LA size in M-mode ECHO study. Various criteria were found to be poor to mildly sensitive (8-78%) but highly specific (85-100%) for LAE.

Morris index ($PTFV_1$) was found to be the best criterion having 76% sensitivity and 92% specificity. Combination of criteria enhances the sensitivity at the cost of specificity. Overall predictive index of ECG for LAE is not encouraging.

A study by Chirife *et al.* showed that ECG positivity of 89% when P-wave duration was considered alone, ECG positivity of 83% when Morris index was considered alone, and ECG positivity of 89% when Macruz index alone was considered.

Waggoner *et al.*[16] showed that overall ECG predictability of LAE was 80% and showed 100% positivity when LA size was >50 mm, 70.83% positivity when LA size was 46-50 mm, and 56.41% positivity when LA size was 41-45 mm. Hence, our study is comparable to these studies.

$PTFV_1$ >40 mm yielded sensitivity 85%, specificity 90%, positive predictive value 94.4%, and negative predictive value 75%. Its value in detection of LAE has been reasonably well established with sensitivity reported as 67-89% and specificity 83-94% which is in general agreeable to our findings.

On the other hand, Romhilt *et al.* did not find $PTFV_1$ to be a sensitive criterion (only 44%). However, the reason for this low value is unclear. Aronow *et al.* found the sensitivity to be 32% and specificity 94%. This low sensitivity is probability related to a higher mean age of their study population, i.e., 82 ± 8 years.

Jose *et al.* have calculated its positive predictive value as 85% which is nearby the value obtained by our study.

In the present study, we have minimized error by excluding sources of error like patients with AF and conduction defects. Furthermore, errors of measurement have been minimized by taking some complexes at higher paper speed, i.e., 50 mm/s and measuring through five power magnifying lens.

The predictive value indicates the diagnostic power of a test.

In our study, the various ECG criteria of LAE have positive predictive value of 90%-100% and negative predictive value of 28-58%. These indices of diagnostic accuracy have not been specifically mentioned in the available literature.

The correlation coefficients (*r*) obtained were 0.2 for P-wave duration >0.11 s, 0.51 for criteria duration of the negative phase of P-wave in lead $V_1$, and 0.17 for criteria depth of negative phase of P-wave in lead $V_1$.

The duration of the negative phase of P-wave in lead $V_1$ correlates best with LA size obtained by ECHO.

Abnormalities in atrial conduction resulting from hypertension, elevated pulmonary capillary wedge pressure, or intrinsic conduction defects are associated with abnormalities in the P-wave and may be independent of atrial size. However, previous studies have shown that many patients with LAE also have LA pressure overload or defective atrial conduction. Thus, in many patients, it may be difficult to sort out the exact origin of the ECG criteria traditionally attributed to LAE. Lee *et al.* have even suggested using the term "non-specific LA abnormalities."

LAE is a frequent accompaniment of rheumatic mitral valve disease, where LA pressure is also increased.

So, the mere presence of an enlarged LA or elevated LA pressure does not establish the primacy of either in the genesis of this electrocardiographic pattern. The role of atrial inflammation or scaring or both (as part of the disease process) can also produce ECG abnormalities of LAE by causing conduction defects. In our set up, the majority of patients suspected of having LAE had rheumatic mitral valve disease.

In patients with IHD, the ECG pattern of LAE produced may also be due to increased LV end diastolic pressure or may be due to ischemia or infarction or both.

## CONCLUSION

The use M-mode ECHO as a diagnostic standard represents a minor limitation because extreme angulation of the transducer may produce alteration in LA diameter.

We sought to minimize such artifactual measurement by performing ECHO only from windows in the third or fourth intercostal spaces (left sternal border) and by measuring LA size only at the level of the aortic valve leaflets.

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