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STUDY ON THE DIAGNOSTIC ACCURACY OF LEFT ATRIAL ENLARGEMENT BY RESTING ELECTROCARDIOGRAPHY AND ITS ECHOCARDIOGRAPHIC CORRELATION

ARCHANA MISHRA*[□], CHANDRAKANTA MISHRA**,
RAMA RAMAN MOHANTY* AND MRUTYUNJAY BEHERA**

*Departments of *Physiology and **Cardiology*
S.C.B. Medical College,
Cuttack – 753 007

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Abstract : M-mode echocardiography has been accepted as gold standard for measuring left atrial (LA) size. Electrocardiography (ECG) offers a simple, non-invasive, cost-effective and reproducible method to assess LA size and it is mostly in agreement with echocardiography though discrepancies exist. ECGs and echocardiograms were obtained in 100 consecutive patients suspected of having left atrial enlargement due to different underlying heart diseases. The diagnostic accuracy of six ECG criteria of LA enlargement were evaluated comparing with LA size in M-mode echo study. Various criteria were found to be poor to mildly sensitive (8% to 78%) but highly specific (85% to 100%) for left atrial enlargement. Morris Index (PTFV1) 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 electrocardiogram for left atrial enlargement is not encouraging.

Key words : left atrial enlargement electrocardiogram echocardiogram

INTRODUCTION

Left atrial (LA) enlargement is associated with a number of serious complications such as atrial fibrillation, 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 anti-coagulants or cardiac glycoside therapy. The ability to maintain normal sinus rhythm after cardio-version from atrial fibrillation similarly correlates with LA size (2). So the size of the left atrium 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, if reliable criteria were available. P wave changes of left atrial enlargement have been analysed in patients likely to have this condition due to underlying heart disease (2, 3) and have been compared with direct observations at the time of surgery (4, 5), measurement from various radiological views of the heart (6)

[□]Corresponding Author : Dr. Archana Mishra, Mishra Campus, Bhagatpur, Cuttack – 753 009; Tel. No. : 09437315049
Email : dr.archanamishra7@gmail.com

and in post-mortem studies (7–9). But X-Ray studies measure only gross changes in atria, post-mortem studies are static & non-physiological (6). Angiography is a better method of demonstration of left atrial contour and permits more accurate measurements (10, 11). But it has limited utility in evaluating large populations due to its invasive nature and complex procedure.

Echocardiography is comparable to angiography in assessing left atrial size (12). It is simple, non-invasive and reproducible. Being an accurate and non-invasive technique for obtaining anatomical measurements, it is the universally accepted DIAGNOSTIC STANDARD. But in the Indian setting ECG is widely used and has added advantage over echocardiography in being cost-effective, easily available and accessible.

Previous studies diagnosing LA enlargement have already reported discrepancies between electrocardiography and echocardiography (13–15). Many such studies used small patient population or evaluated only few ECG criteria, and many used diagnostic standards of left atrial enlargement that were of uncertain accuracy like radiography and post-mortem studies.

The present study has been undertaken to assess the diagnostic accuracy of six commonly used electrocardiographic criteria of left atrial enlargement. These criteria have also been evaluated in various ranges of LA sizes to see if ECG can also have utility as a quantitative or semi quantitative tool for estimation of left atrial size as assessed by M-mode echocardiography and can also act as a substitute to echocardiography.

MATERIALS AND METHODS.

This study was conducted in the departments of physiology and cardiology, S.C.B. Medical College, Cuttack from December 2000 to January 2005. The study group comprised of 100 consecutive patients (male=34, female=66) with suspected LA enlargement due to underlying disease like rheumatic heart disease, coronary artery disease, hypertension, dilated cardiomyopathy and hypertrophied obstructive cardiomyopathy. The age ranged from 17 to 70 years for males and 18 to 62 years for females. All patients were in normal sinus rhythm. Their medical records were reviewed specifically for information pertaining to their age, sex, height, weight, type of cardiovascular disease and drug therapy. The body surface area was calculated from Dubois Body Surface Chart (prepared by Boothby and Sandiford of the Mayo clinic) (16). They were subjected to both ECG and echocardiography within 48 hours of presentation and without knowledge of the result of the investigation done first.

Patients with atrial fibrillation, conduction defects, clinically evident left ventricular failure, patients on β blockers/ digitalis/verapamil , terminally sick patients and pediatric age group were excluded from the study.

Protocol :

ECG : Standard 12-lead electrocardiogram with 1 mv cm standardisation and paper speed of 25 mm/sec were obtained using BPL cardiart 6108 electrocardiograph. The record obtained was analysed for P wave configuration using a five power magnifying lens and calipers. The electrocardiographic criteria of left atrial enlargement (LAE) that were evaluated are in Table–I. *(Munuswamy et al*) (15). These criteria incorporate P wave characteristics as ascertained by examination of both the standard and precordial leads.

ECHOCARDIOGRAPHY : Transthoracic echocardiograms were performed using ATL Ultramark-9 cardiac imaging system using a 3.5 MHz transducer. Patient was placed in the left lateral decubitus position. 2D echocardiograms were obtained selecting the parasternal long axis view, by standard adjustment of position and angulation, through the aortic window. M-mode measurements of left atrial size and aortic root diameter were selected from the 2D parasternal long axis view and recorded at 50 mm/sec paper speed. Measurement of the left atrial dimension was made at end-systole and of the aortic root diameter at end-diastole as per the recommendations of the *American Society of Echocardiography*. All measurements were made from leading edge to leading edge i.e. the uppermost line of a structure. (The leading edge is not affected much by gain settings while the posterior trailing edge is widely variable). M-mode echocardiographic criteria consist of LA dimension (absolute value) > 38 mm, LA dimension/aortic root ratio > 120%, LA dimension corrected for body surface area > 20 mm/m^2.

During echocardiography, precautions were taken to make measurements through the aortic window, at the level of the aortic valve leaflets, avoiding extreme angulation of the transducer as it can give erroneous measurements of LA dimension.

Statistical analysis :

The individual electrocardiographic criteria of LA enlargement were evaluated using the echocardiographic finding as the diagnostic standard. The number of true positives, true negatives, false positives and false negatives were calculated for the individual ECG criteria and for ECG as a whole. As parameters of diagnostic accuracy, sensitivity, specificity, positive predictive value, negative predictive value, % of false negative and % of false positive were calculated.

The best possible combinations of criteria were made and in a similar manner the parameters of diagnostic accuracy were calculated for each combination. Also the sensitivity and specificity of these criteria were evaluated in different ranges of LA dimensions.

Then, intercriteria comparison for sensitivity and specificity was made using the *chi* square test, with Yates' correction wherever applicable. Then using standard table the 'P' value was found out. A $P<0.05$ was considered statistically significant.

Then, studies of correlation were done for absolute value of left atrium (obtained by echo) with P wave duration in lead II, duration of 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 (17, 18).

RESULTS

The study population comprised of 100 suspected cases of LA enlargement, in normal sinus rhythm, of which 66 (66%) were females and 34 (34%) were males. The mean age was 43.5 ± 13.64 years for males and 34.14 ± 12.86 years for females. The mean height for males was 161.76 ± 4.49 cm and that for females was 156 ± 5.07 cm. The mean weight was 53.56 ± 7.04 kg for males and 44.12 ± 5.79 kg for females. The mean body surface area was 1.56 ± 0.102 m^2 in males and 1.4 ± 0.096 m^2 in females.

The disease prevalence in the study population was rheumatic heart disease 64 (64%) of which male = 13, female = 51 (Mitral stenosis 50 cases, male = 8, female = 42; Mitral regurgitation 15 cases, male = 2, female = 13; Aortic stenosis 2 cases, both females; Aortic regurgitation 5 cases, all females); dilated cardiomyopathy 13 (13%), males = 7, female = 6; hypertrophied obstructive cardiomyopathy 4 (4%), male = 2, female = 2; Coronary artery disease 20 (20%) male = 12, female = 8; hypertension 2 (2%) male = 2, female = 0.

Table II shows that Criteria III has highest sensitivity (78%), closely followed by Criteria VI (76%). Criteria II has highest specificity (100%) [but extremely poor sensitivity (8%)], followed by Criteria IV and VI (92% each). *So, Criteria VI is the single best criteria, closely followed by Criteria III.*

Criteria III, IV and VI relate to the negative component of P wave in lead V_1. Criteria I, II and V relate to P wave in lead II. *So, Criteria relating to P wave in lead V_1 yield better accuracy.*

Table III shows the intercriteria comparison for sensitivity and specificity.

Table IV shows that the optimum combination for sensitivity is ECG (all criteria) (also % of false negative is minimized) and for specificity is Criteria III and IV (also % of false positive is minimized).

TABLE I : ECG criteria of left atrial enlargement.

Criteria no.	*P wave configuration in ECG*	*Normal*	*LAE**
I	P wave duration in lead II	80–110 ms	>110 ms
II	P wave notching in Lead II (interpeak distance)	< 40 ms	≥ 40 ms
III	Duration of negative phase of P wave in Lead V_1	≤ 40 ms	> 40 ms
IV	Depth of negative phase of P wave in Lead V_1	≤ 1 mm	> 1 mm
V	Macruz Index = P wave duration/PR segment	1–1.6 mm	> 1.6 mm
VI	Morris Index = Duration × Depth of negative phase of P wave in Lead V_1 (PTF V_1) ۞	≤ 40 mm ms	> 40 mm ms

*LAE – Left Atrial Enlargement.
۞PTFV_1 – P wave terminal force in lead V_1.

TABLE II : Diagnostic accuracy of ECG criteria of LA enlargement♯.

Criteria	*Sensitivity* (%)*	*Specificity* (%)*	*Positive* predictive value (%) (PPV)*	*Negative predictive value (%) (NPV)*	*% of* false negative (FN)*	*% of* false positive (FP)*
I	43	85	89	34	57	15
II	8	100	100	28	92	0
III	78	85	94	58	22	15
IV	65	92	96	48	35	8
V	49	85	90	37	51	15
VI	76	92	97	57	24	8
	$\chi^2 = 133.57$ P<0.001	$\chi^2 = 22.59$ P<0.001	$\chi^2 = 16.62$ P<0.001	$\chi^2 = 31.92$ P<0.001		

♯–Data derived from 100 patients in normal sinus rhythm.
*–Using all three echocardiographic criteria of LA enlargement.

TABLE III : Intercriteria comparison indiceswise.

Criteria	*Sensitivity*		*Specificity*	
	χ^2	*P value*	χ^2	*P value*
I vs. II	32.3	<0.001	16.66	<0.001
I vs. III	22.76	<0.001	0	>0.05
I vs. IV	9.4	<0.01	2.9	>0.05
I vs. V	0.59	>0.05	0	>0.05
I vs. VI	21.82	<0.001	2.9	>0.05
II vs. III	99.96	<0.001	16.66	<0.001
II vs. IV	70.08	<0.001	7.98	<0.01
II vs. V	40.45	<0.001	16.66	<0.001
II vs. VI	99	<0.001	7.98	<0.01
III vs. IV	3.18	>0.05	2.9	>0.05
III vs. V	16.34	<0.01	0	>0.05
III vs. VI	0.05	>0.05	2.9	>0.05
IV vs. V	5.22	>0.05	2.9	>0.05
IV vs. VI	2.8	>0.05	0	>0.05
V vs. VI	15.53	<0.01	2.9	>0.05

df = 1
P<0.001 : very highly significant.
P<0.01 : highly significant.
P<0.05 : significant.
P>0.05 : not statistically significant.

Table V shows that sensitivity shows variable response but specificity remains same in higher ranges of LA dimensions (occasional deviation).

Graph I shows that the P wave duration in lead II correlates best with LA dimension by echo (in mm). But it is only a moderately positive correlation.

DISCUSSION

Size of the left atrium is an important index of cardiac status. Left atrial enlargement has important implications like development of atrial fibrillation, thromboembolic phenomena and complications thereof (19, 20, 21). The left atrium 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

TABLE IV : Diagnostic accuracy of selected combinations of ECG criteria of LA enlargement♯.

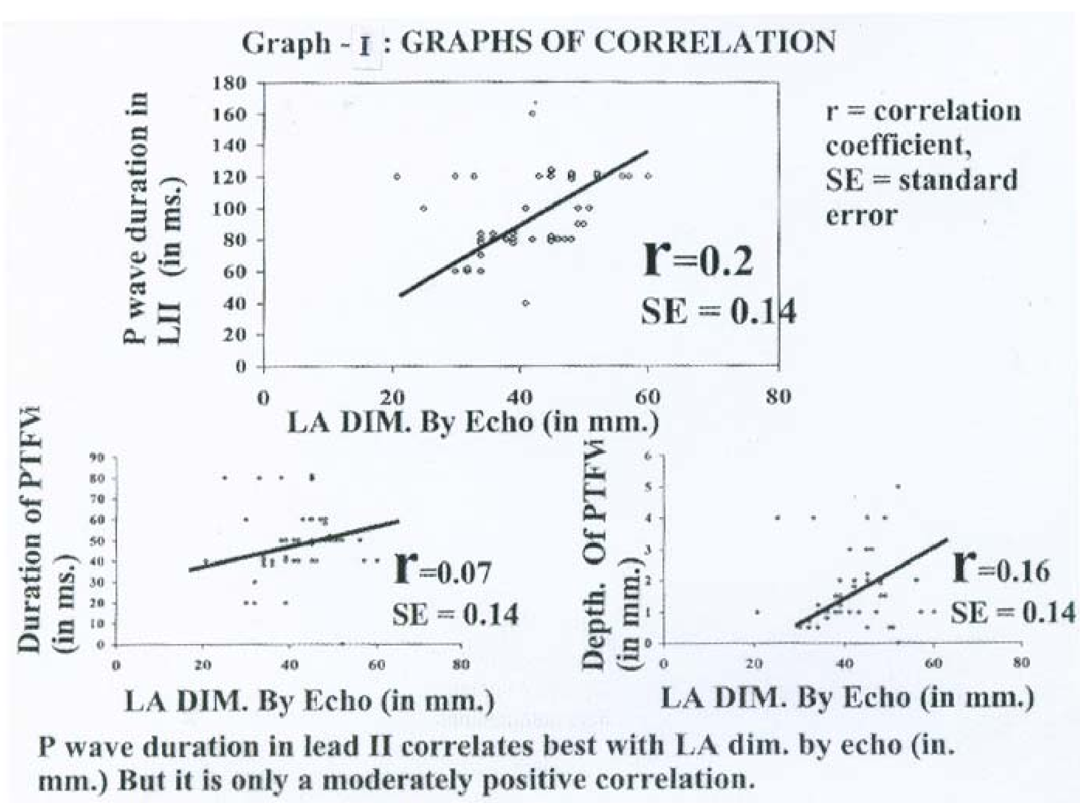
Combination of ECG criteria[#]	*Sensitivity* (%)*	*Specificity* (%)*	*Positive* predictive value (%)*	*Negative predictive value (%)*	*% of* false negative*	*% of* false positive*
II, III, IV	73	92	96	55	27	8
II, III, IV, VI	73	92	96	55	27	8
III & IV	73	92	96	55	27	8
III, IV, VI	73	92	96	55	27	8
I, II, III, IV, VI	81	77	91	59	19	23
I, II, III, IV	81	77	91	59	19	23
I, II, III	51	77	86	36	49	23
I & II	43	85	89	89	57	15
ECG (all criteria)	89	77	92	92	11	23

♯– Data derived from 100 patients in normal sinus rhythm.
#– Other combinations failed to produce values of accuracy indices as good as or better than those shown in this table.
*– Using all three echocardiographic criteria of LA enlargement.

TABLE V : Sensitivity and specificity of criteria of LA enlargement in different ranges of LA dimensions#.

Criteria		*Using all 3 echo criteria for LAE*	*LA dimension in mm*			
			(<40) (n=38)	*(41-45) (n=30)*	*(46-50) (n=20)*	*(>50) (n=12)*
I	Sensitivity	43	48	51	49	42
	Specificity	85	84	84	84	84
II	Sensitivity	8	5	0	0	14
	Specificity	100	100	100	100	100
III	Sensitivity	78	78	86	80	78
	Specificity	85	82	82	82	82
IV	Sensitivity	65	40	62	72	64
	Specificity	92	92	92	92	92
V	Sensitivity	49	44	30	56	52
	Specificity	85	85	85	85	85
VI	Sensitivity	76	75	75	52	86
	Specificity	92	90	90	90	90

#–Data derived from 100 patients in normal sinus rhythm.



left atrial enlargement 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 electrocardiographic abnormalities traditionally attributed to LA enlargement may occur in patients with LA pressure overload (13, 22) or defective atrial conduction (23) or both. Previously it had been established that LA thickening with or without dilatation could produce some of the electrocardiographic signs examined in this study (8, 24). These findings suggest that the diagnostic accuracy of previously described electrocardiographic criteria for LA enlargement may be more limited than was previously appreciated. Our study group comprised of 100 suspected cases of LA enlargement in normal sinus rhythm, 64 (64%) of them suffering from rheumatic heart disease of age 51 (80%) were females and 13 (20%) were males. In 50 patients mitral stenosis was present of which 42 (84%) were females and 8 (16%) were males. This finding well correlates with the previously documented higher incidence of rheumatic mitral stenosis in female population (25). This also explains the larger number of females (66%) among the 100 consecutive patients the suspected having LA enlargement since majority of them were suffering from rheumatic heart disease.

Analysis of individual ECG criteria of LA enlargement :

Table II shows *Criteria I* (P wave duration in lead II > 110 ms) has the sensitivity of 43% specificity 85%, positive predictive value 89% negative predictive value 34%, 57% false negative and 15% false positive. Previous studies assessing total P wave duration as a diagnostic marker of LA enlargement reported a sensitivity of 4% to 100% and specificity of 67% to 98% (1, 4, 11, 26, 27, 28, 29). *Lee KS* et al (30) have shown a sensitivity of 69% and specificity of 49%. The wide variation in sensitivity and specificity can be explained in part by the differing upper limits of normal among these studies (ranging from 105 ms to 120 ms) and by the required presence of notching in some cases but not in others. We selected 110 ms as the upper limit of normal. Shorter P wave duration were associated with marked decrease in specificity and larger duration did not appreciably change sensitivity. We included P wave with or without notching. In the present study, correlation of P wave duration in lead II with LA dimension obtained by echocardiography 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 to 0.74 (4, 5, 26, 27, 28, 29). Our lower degree of correlation may be due to exclusion of patients with atrial fibrillation, who usually have LA size > 45 mm. Also *Birkbeck JP* et al (31) have found moderately positive correlation (r = 0.49).

Also, LA dimension by echo correlates better with P wave duration in lead II than duration or depth of negative component of P wave in lead V_1 (graph I). Correlation of P wave duration with LA dimension by echo being moderately positive has limited clinical use as a semiquantitative tool as found by previous workers (4, 5, 26, 27, 28, 29).

Table II shows *Criteria II* (P wave notching with interpeak distance ≤ 40 ms) has sensitivity of 8%, specificity 100%, positive predictive value 100%, negative predictive value 28%, false negative 92%, false positive 0%. Notching of the P wave has traditionally been attributed LA enlargement, presumably reflecting prolonged conduction time within the left atrium. *Termini and Lee* (27) reported 24% false positive and 12% false negative results for this sign. *Munuswamy et al* (15) found sensitivity 15% and specificity 100%. They relate the discrepancy of their result to *Termini and Lee,* in their own failure to include P wave notching in precordial leads. *Hazen et al* (1) showed a sensitivity of 20% and specificity of 98%. All these results are in general agreement with our finding that P wave notching with interpeak distance ≤ 40 ms is poorly sensitive (8%–20%) and highly specific (98%–100%) criteria for diagnosis of LA enlargement.

Table II shows *Criteria III* (duration of negative phase of P wave in lead V_1 > 40 ms) has the highest sensitivity of single criteria studied (78%), specificity (85%), 94% positive predictive value, 58% negative predictive value, false negative 22%, and false positive 15%. *Munuswamy et al* (15) found sensitivity 83% and specificity 80% which are similar to value obtained from the present study.

Correlation of duration of negative phase of P wave in lead V_1 with LA size(graph I) yielded a mild positive correlation with correlation coefficient 0.07, after correction 0.49 (i.e.<2). So this has no clinical applicability as a semiquantitative tool for assessment of LA size.

Table II shows *Criteria IV* (depth of negative phase of P wave in lead V_1 > 1 mm) has sensitivity 65%, specificity 92%, positive predictive value 96%, negative predictive value 48%, false negative 35%, false positive 8%. *Munuswamy et al* (15) had found this criteria to have a sensitivity of 60% and specificity 93%. This criteria has a reported sensitivity of 25% and specificity 92% in children in a study by *Maok et al* (14).

Correlation with LA size obtained by echocardiography (graph I) yields a correlation coefficient of 0.16 (moderately positive correlation) and after correction 1.12 (i.e. < 2) which implies it has no clinical utility as a semiquantitative tool.

These correlation values of criteria III & IV with LA size by echocardiography further reinforce the findings of *Birkbeck JS* et al (31), who correlated $PTFV_1$ with LA volume and found poor correlation (r = 0.30–0.42). Most of the previous workers have not studied Criteria III and IV individually but as components of $PTFV_1$ (Criteria VI).

Table II shows *Criteria V* (Macruz Index > 1.6) yielded sensitivity 49%, specificity 85%, positive predictive value 90%, negative predictive value 37%, false negative 51%, false positive 15%. Most of the previous studies have reported sensitivity of 50% to 65% and specificity of 50% to 89% (2, 13, 15). *Chirife et al (25)* have obtained sensitivity of 58% and specificity 89%. *Munuswamy et al* (15) reported sensitivity 31% and specificity 64%. So our values of indices of diagnostic accuracy are in general agreement with previous workers. But this wide range of variation of sensitivity may be due to reasons such as susceptibility to alteration by digitalis preparation commonly given to patients with enlarged LA, drugs affecting PR interval can produce false positive or false negative values and small errors in measurement can significantly alter the Macruz Index.

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

Table II shows *Criteria VI* ($PTFV_1$ > 40 mm. ms) yielded sensitivity 76%, specificity 92%, positive predictive value 97%, negative predictive value 57%, false negative 24%, false positive 8%. Its value in detection of LA enlargement has been reasonably well established with sensitivity reported as 67% to 89% and specificity 83% to 94% (4, 5, 11, 26, 27, 28, 29) which is in general agreeable to our findings. On the other hand *Romhilt et al* (24) did not find $PTFV_1$ to be a sensitive criterion (only 44%). But the reason for this low value is unclear. *Aronow et al* (32) found the sensitivity to be 32% & 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* (33) have calculated its positive predictive value as 85% which is nearby the value obtained by our study. They have calculated accuracy as 86% but have not defined accuracy (In our study we have calculated 6 indices of diagnostic accuracy i.e. sensitivity, specificity, positive predictive value, negative predictive value, % of false negative and % of false positive (17)]. *Hazen et al* (1) have also calculated sensitivity and specificity of $PTFV_1$ (> 40 mm. ms indicating LA enlargement) in 2 different LA size ranges i.e. ≥ 40 mm and ≥ 60 mm. Such study could not be done by us as we have restricted number of patient with LA size > 45 mm due to exclusion of patients with atrial fibrillation.

The predictive value indicates the diagnostic power of a test. In our study the various ECG criteria of LA enlargement have positive predictive value of 90% to 100%, negative predictive value of 28% to 58%, % of false positive is low i.e. 0 to 15%. Criteria II has highest % of false negative (92%), others have moderate to low values. These indices of diagnostic accuracy have not been specifically mentioned in the available literature.

So, among the individual ECG criteria of LA enlargement, the highest sensitivity is yielded by Criteria III (78% closely followed by Crieria VI (76%). The difference is not statistically significant. Criteria II has the highest specificity 100% (but low sensitivity 8%), followed by 92% yielded by Criteria IV and Criteria VI. So individually Criteria VI is the best ECG criteria of LA enlargement closely followed by Criteria III. This finding well correlates with that of *Kasser and Kennedy (11), Chirife et al (26), Rubbler et al 28), Waggoner et al 29), Aronow et al (32).*

With the hope of improving diagnostic accuracy, selected combinations of criteria were assessed (Table IV) to find out the *optimum combination* (i.e. combination of minimum number of criteria yielding maximum accuracy). Combination of ECG criteria has a higher sensitivity of 89% but lower specificity 77%. On the other hand, combination of I, II, III and IV yields of sensitivity of 81% but same specificity 77%. Taking criteria III & IV, sensitivity falls to 73% where as specificity rises to 92%. Adding to it criteria IV/VI/both, diagnostic accuracy does not change. Combination of criteria I and II has sensitivity of 43% and specificity 85%. Adding to it criteria III increases sensitivity to 51% but reduces specificity to

77%. Criteria III individually has a higher sensitivity 78% and specificity 85%. Adding Criteria IV increases sensitivity to 81% specificity remaining 77%. *So the optimum combination for sensitivity is- all the Criteria of ECG* taken together. From *specificity* point of view the *combination III and IV* is the best combination. *But Criteria VI taken individually has a specificity of 92% and sensitivity of 76%*. Though Criteria II has the highest specificity 100%, it has poor sensitivity (only 8%). Other combinations tested showed sensitivity and specificity values that were lower than those noted for any of the above described combinations.

So Criteria VI or $PTFV_1$ is the individually studied *best Criteria*. With combination of criteria sensitivity is increased at the cost of specificity.

Previous studies examining various combinations of ECG criteria for LA enlargement have generally reported the same (4, 6, 29). *Munuswamy et al (15)* demonstrated that combination of criteria does not substantially improve diagnostic accuracy. Criteria I and II pertain to P wave in Lead II. Addition of Criteria III & IV (relating to $PTFV_1$) improves sensitivity significantly. This indicates that, cases not detected by P wave in lead II are detected by $PTFV_1$. This agrees to the postulation by *Kasser and Kennedy* (11).

Table VI shows sensitivity and specificity of different ECG criteria in *different ranges of LA dimensions*. We find that in higher range of LA dimension, the sensitivity shows variable change (generally rising trend) whereas the specificity remained constant. *Munuswamy et al (15)* also found similar results. In our study, in some higher ranges also we have obtained occasional low values of sensitivity. This may relate to exclusion of many positive cases by exclusion of patients with atrial fibrillation, who are expected to have larger atria.

Graph I shows correlation of LA size (obtained by echo) with P wave duration in Lead II, duration of negative phase of P wave in Lead V_1 and depth of negative phase of P wave in Lead V_1. The correlation coefficients (r) obtained were 0.2 (after correction 1.4) for Criteria I, 0.07 (after correction 0.49) for criteria III, 0.16 (after correction 1.12) for Criteria IV. The P wave duration in Lead II correlates best with LA size obtained by echo. But it is only a moderately positive correlation ($0 < r < 1$) and has limited clinical use as a semiquantitative tool [since corrected r value < 2 (18)]. Other workers have obtained r values between 0.56 to 0.74 (4, 5, 26, 27, 28, 29) (which is also a moderately positive correlation and limited clinical use as a semiquantitative tool). Our lower value may be due to exclusion of patients with atrial fibrillation and thereby exclusion of cases with larger atria in which ranges, better correlation may be expected.

The absence of hemodynamic and electrophysiologic data in this study is a major limitation in that it precludes categorical assignment of the observed sensitivity and specificity values to LA enlargement (dilatation) per se. However, previous studies (13, 28) have shown that many patients with LA enlargement 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 electrocardiographic criteria traditionally attributed to LA enlargement. *Lee KS et al* (30) have even suggested using the term ‘nonspecific LA abnormalities’. In our study, care has been taken to rule out effect of pressure overload and defective conduction per se by exclusion of patients with left ventricular failure, atrial fibrillation, other conduction defects, taking drugs like digitalis, β blockers, verapamil etc. that can affect PR interval. But certain aspects of hemodynamic alternations and conduction defects are part and parcel of the disease process.

Left arial enlargement is a frequent accompaniment of 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 primacy of either in the genesis of this electocardiographic pattern. The role of atrial inflammation or scaring or both (as part of the disease process) 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. In patients with coronary artery disease, the electrocardiographic pattern of LA enlargement produced may also be due to increased left ventricular end diastolic pressure or may be due to ischemia or infarction or both. The use M mode echocardiography 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 artefactual measurement by performing echocardiography 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.

Conclusion :

Criteria VI or Morris index (PTFV_1 is the best criterion having second highest sensitivity 76% and second highest specificity 92% (difference from highest value for both indices is not statistically significant). Combination of Criteria does not substantially enhance sensitivity or specificity. The sensitivity of various ECG criteria of LA enlargement shows variable response but specificity remains constant at progressively higher ranges of LA dimension. ECG has no clinical use as semiquantitative tool to assess LA size. The overall predictive index of ECG for left atrial enlargement is not impressive or encouraging, as described by most of the previous workers. But in case of non-availability of echocardiography, ECG can be used for diagnosis of left atrial enlargement with caution against false negative results— they can be misleading, multiplied by the grave consequences of LA enlargement.

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