

Left or right atrium enlargement

*In this series, we investigate the diagnostic accuracy of a traditional ECG criteria in contemporary literature.

Introduction

• A normal atrial depolarization, which is originated from an SA node, conducts from right to left, superior to inferior side. It appears on ECG as a smooth rounded contour P wave with an P wave axis around 60°. P wave is usually best seen in lead II and V1.

- The right atrial conduction happens prior to the left atrial conduction. In lead V1, this resulted in anteriorly then posteriorly conduction.
- Abnormal P wave can be from enlargement, hypertrophy, atrial overload, atrial strain, inter/intraatrial conduction defect, or the origine of the signal is not from the SA node.
- In a non-sinus patient e.g. AF, Aflutter, atrial rhythm, these criteria are not applied.

Left atrial enlargement (LAE)

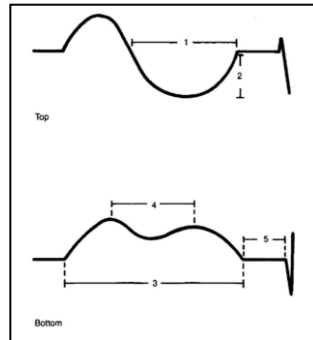
• Historically, these following criteria are suggestive of LAE

Lead II: - P wave duration > 0.11 sec

- Notched, bimodal P wave (P mitrale)
- Interpeak duration > 0.04 sec
- P wave/PR duration > 1.6 (Macruz index)

Lead V1, A P-terminal force (the later phase of P wave):

- Duration > 0.04 sec
- Depth > 1 mm
- Duration x depth > 0.04mms (Morris index)



Literature review

• Using M-mode echocardiogram as a gold standard in 99 patients (57% had LAE). The V1 criteria had better sensitivity at 60-83% (Am J Cardiol 1984;53:829)

• Using LAVI > 32 ml/m2 by echo as a gold standard in 261 patients (43% had LAE). See table. Meet at least 1 criteria have sens, spec, PPV and NPV of 77%, 33%, 47%, 65%, respectively. (Am J Cardiol. 2007;99:113)

ECG Criterion	Detection of LA Enlargement (≥ 32 ml/m ²)			
	Sensitivity	Specificity	Positive Predictive Value	Negative Predictive Value
P duration ≥ 110 ms in lead I, II, or III (criterion 1)	69%	49%	51%	68%
Biphasic P wave ≥ 40 ms in lead I, II, or III (criterion 2)	12%	92%	52%	58%
Negative terminal P force in lead V ₁ ≥ 40 ms · mm (criterion 3)	46%	64%	49%	61%

• Using LAVI of > 55 ml/m2 by MRI as a gold standard in 275 patients (28% had LAE). See table. (J Cardiovasc Magn Reson 2008;7:1)

ECG Criteria	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
LAE				
Any ECG Criteria for LAE	90	21	31	84
P > 0.11 s	84	35	34	85
P mitrale	8	99	86	74
P axis < 30°	8	90	23	71
NPTE-V1 > 0.04s·mm	37	88	47	76
PPTF-aVL > 0.5 mm	44	60	30	73

Interpretation

- Vary in sensitivity, The P wave duration criteria seems to have higher sensitivity.
- Meeting at least 1 criteria has sensitivity around 90%.
- P-mitrale, and negative terminal force in V1 is specific but not sensitive.
- With low PPV and NPV, ECG criteria may not reliably reflect LAE.

Right atrial enlargement (RAE)

- Historically, these following criteria are suggested of RAE
 - Peaked P waves height ≥ 2.5 mm in leads II, III, aVF
 - Positive deflection of the P wave in lead V1 or V2 > 1.5 mm
 - Right axis deviation of the P wave $> 75^\circ$

Reference		Criteria
First Author (no.).	Year	
Reynolds (34).	1971	Prominent, pointed negative P wave <40 ms in duration in lead V ₁ ; P wave initial force >0.06 mm·s in lead V ₁ ; any P wave height >1.5 mm
Surawicz (37).	1978	The increase in amplitude of the anteriorly directed P wave vector and the less specific inferiorly directed deviation of the P wave vector . . . known as P pulmonale
Reeves (3).	1983	QR, Qr, qR or qRS in lead V ₁ or V ₂ without clinical coronary artery disease; QRS amplitude ≤ 6 mm in lead V ₁ ; P wave initial force >0.06 mm·s in lead V ₁
Friedman (32).	1985	P wave height >2.5 mm in leads II, III and aVF; P wave duration <0.11 s; P wave axis >75°; P wave height >1.5 mm in lead V ₁ or V ₂
Surawicz (2).	1986	Tall, wide P waves in the limb and right precordial leads
Dunn and Lipman (35).	1989	P wave height >3 mm in lead II; P wave axis 60° to 90°
Chou (36).	1991	P wave height >2.5 mm in leads II, III and aVF; P wave axis >75°; P wave >1.5 mm in lead V ₁ or V ₂
Fisch (33).	1992	P wave tall, peaked or pointed in leads II, III, aVF; P wave axis >90°

Literature review

• 1994, Using echocardiogram as a gold standard in 99 patients (80% had RAE). Most previously reported ECG criteria have low predictive power. See table. The best predictors of RAE were a P wave height > 1.5 mm in lead V2 and other ECG findings of RVH (QRS axis > 90 degrees, R/S ratio > 1 in V1). Jacc 1994;23:747)

Interpretation

- The smooth, rounded contour of the P wave is changed by RAE, which gives the wave a peaked appearance.
- P wave duration does not affect by RAE
- "P pulmonale" from hanging heart due to low diaphragm causes rightward shift of the P wave axis.

• ECG criteria may not reliably reflect RAE but more reliable in pulmonary disease with RV pathology.

Suggested Readings

- Electrocardiographic diagnosis of left atrial enlargement. Arch Intern Med. 1989;149(5):116.
- Electrocardiogram in chronic cor pulmonale. British Heart Journal, 1972, 34, 658-667.
- Accuracy of electrocardiographic criteria for atrial enlargement: validation with cardiovascular magnetic resonance. J Cardiovasc Magn Reson. 2008;10:7.
- AHA/ACCF/HRS Recommendations for the Standardization and Interpretation of the ECG. Part V: ECG Changes Associated With Cardiac Chamber Hypertrophy. Jacc 2009;53:992–1002.

Criterion	Sensitivity (%)	Specificity (%)	Odds Ratio†
Frontal plane QRS axis >90°*	34	100	12.4
P wave height >1.5 mm in lead V ₂	33	100	11.7
R/S ratio >1 in lead V ₁ (no RBBB)*	24	100	7.6
QRS amplitude <6 mm in lead V ₁	33	92	5.9
Q in lead V ₁ (no MI or LBBB)	19	100	5.7
P wave height >1.5 mm in lead V ₁	17	100	5.0
PIF >0.06 mm·s in lead V ₂	50	76	3.2
Total QRS amplitude >3 in leads V ₂ /V ₁	11	100	3.0
PIF >0.06 mm·s in lead V ₁	38	80	2.5
P wave height >2.5 mm in lead II	6	100	1.5