Ministry of Health of Ukraine
Kharkiv National Medical University

ECG SIGNS OF HYPERTROPHY OF HEART ATRIUMS AND VENTRICLES

Methodical instructions for students

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Diagnostic Electrocardiographic Signs of Atrial and Ventricular Hypertrophy

Left Atrial Enlargement

Left atrial enlargement is now seen most commonly in the patients with mitral valvular diseases, aortic insufficiency, and in systemic hypertension.

With the left atrium enlargement, the frontal plane P vector is oriented more horizontally and is of longer duration because the left atrial activation is prolonged. Therefore, the P wave duration is greater than 0,1 second, and amplitude of the left atrial phase of P wave increases that can cause splitting of this wave (Fig. 4.67).

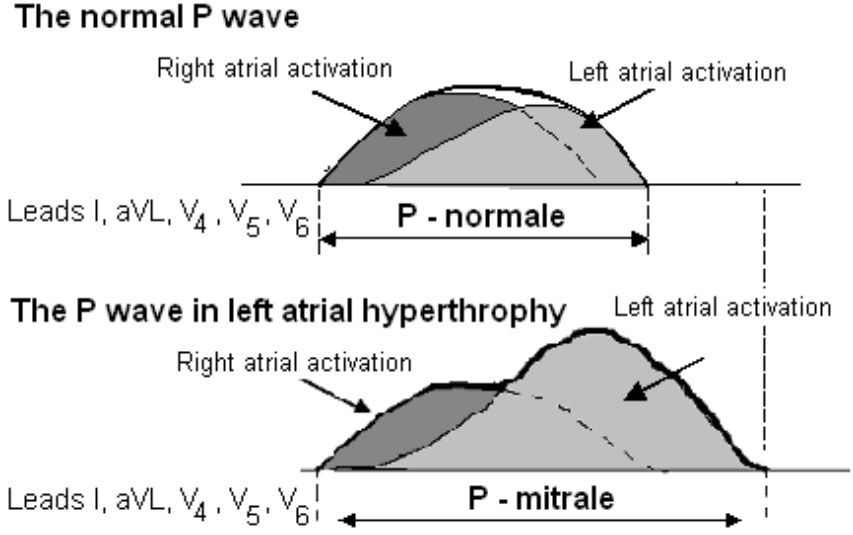


Fig. 4.67. Left atrial enlargement.
Note increased duration and amplitude of left atrial phase of the P wave.

The left atrial enlargement occurred most commonly in the patients with mitral stenosis. For this reason, this type of the P wave morphology if often termed **P – mitrale (**Fig. 4.68).

Various indices have been established for the diagnosis of left atrial enlargement. The Macruz index measures the ratio between the duration of the P wave and P – R segment. In normal persons this is between 1,0 and 1,6. in the left atrial enlargement, the P wave duration increases but P – R interval tends to remain constant. Thus Macruz index becomes larger than 1,6.

Diagnostic Electrocardiographic Signs of Left Atrial Enlargement

1. High-amplitude and two-peaked P wave in leads I, II, aVL, V_4, V_5, V_6.
2. In lead V_1 (rarer in V_2) P wave is initially positive and terminally negative or negative P wave in V_1 is formatted.
3. In lead III negative or two-phased (+ -) P wave (inconstant sign).
4. The P wave duration is more than 0,1 second.

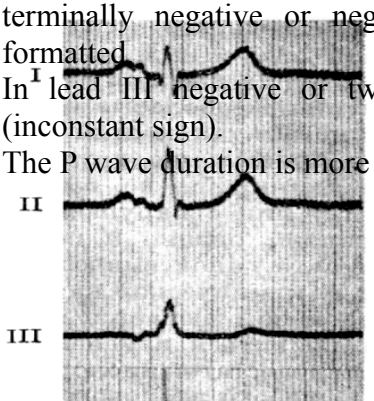


Fig. 4.68. P – mitrale.

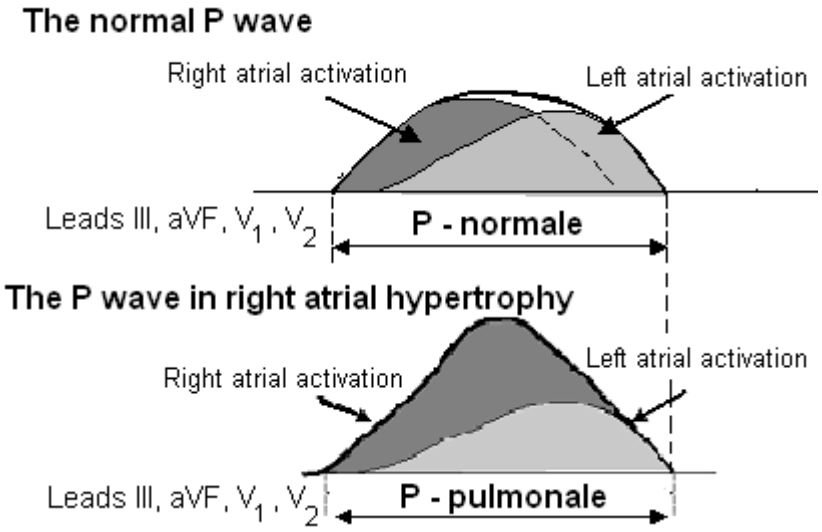
Right Atrium Enlargement

Right atrium hypertrophy usually observes in diseases, which are accompanied by hypertension in the lesser circulation. Right atrial enlargement causes the frontal plane P wave axis to shift vertically. Since the right atrium if the first to be activated, prolongation of its activation time as a result of enlargement does not cause widening of the P wave, but only increased amplitude (Fig. 4.69).

Diagnostic Electrocardiographic Signs of Right Atrial Enlargement

1. High-amplitude, peaked P wave more than 2 mm, higher than ¼ of the R wave amplitude in leads II, III, aVF.
2. Positive, peaked P wave (or its initial right atrial phase) in leads V_1, V_2.
3. Low-amplitude P wave in leads I, II, aVL, V_4, V_5, V_6, in lead aVL it may be negative (inconstant sign).

4.



The P wave duration is not more than 0,1 second.

Fig. 4.69. Right atrial enlargement.

Note increased amplitude of right atrial phase of the P wave.

Since right atrial enlargement is often due to pulmonary diseases, the terms **P – pulmonale** is used to describe this P wave morphology (Fig. 4.70).

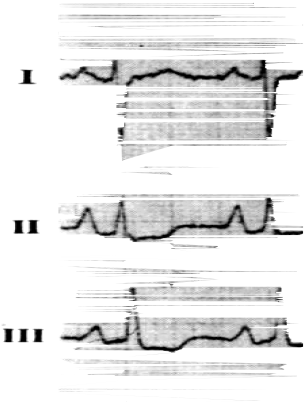


Fig. 4.70. P – pulmonale.

Left Ventricular Hypertrophy

Left ventricular hypertrophy is initially a useful compensatory process that represents an adaptation to chronic hemodynamic overload. However, left ventricular hypertrophy is also the first step toward the development of overt clinical diseases such as congestive heart failure, cardiac arrhythmias, and coronary heart disease.

Diagnostic Electrocardiographic Signs of Left Ventricular Hypertrophy

1. Increased voltage of QRS deflection. In the presence of ventricular hypertrophy the increased magnitude of the left ventricular forces from the hypertrophied left wall results in

increased magnitude of the main QRS vector. The increased QRS vector if therefore oriented more posteriorly, superiorly, and to the left than normally, and projected on the positive half of the axes of leads I, aVL, V_4, V_5, V_6, and on negative half of the axes of leads III, aVF,V_1,V_2,V_3. Therefore, the left leads **I, aVL, V_4, V_5, V_6** show **high-amplitude R waves** and the right leads **III, aVF, V_1, V_2, V_3** show a **deep S wave.**

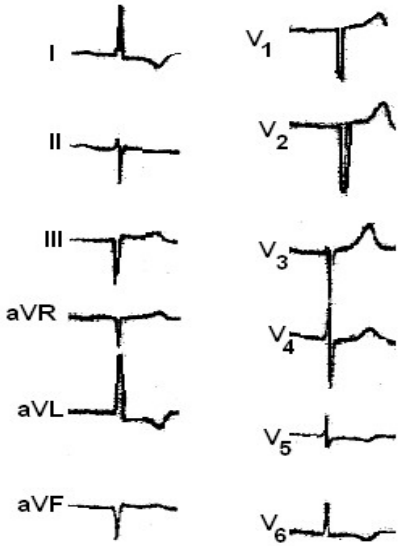
2. Increased duration of the QRS complex as a consequence of the increased muscle mass, the activation wave must travel a longer than normal course, and the **QRS complex is widened to 0,12 second**. However, it may also be 0,10 second or less and still be compatible with the diagnosis of the left ventricular enlargement.

3. ST segment and T wave changes. **The ST segment is depressed and the T wave is inverted in the leads I, II, aVL, V_4, V_5, V_6.** In the right precordial leads (V_1, V_2) the T wave is upright and the ST segment may be slightly elevated. ST segment and T wave changes are result from the altered ventricular depolarization and repolarization processes in the presence of left ventricular hypertrophy. The ST segment is normally isoelectric for the following reason. Repolarization begins shortly before ventricular activation is completed; however the potential of early repolarization does not reach sufficient magnitude at the completion of ventricular activation to be recordable. When the repolarization forces reach sufficient potential to be registered, the T wave is inscribed. In the left ventricular hypertrophy, left ventricular activation is prolonged; hence, by the time ventricular activation is completed, the potential of repolarization is of sufficient magnitude to produce a deviation of the ST segment. There are two possible explanations for the inverted T wave: 1 – the T wave chance may be primary, due to myocardial ischemia resulting from

the relative disproportion between the increased ventricular muscle mass and the available blood supply; or 2 – the changes may be secondary. Since activation of the left ventricle is prolonged, and the direction of repolarization is reversed (endocardium toward epicardium rather than normal direction of epicardium to endocardium), the overall balance of T forces in the hypertrophied ventricle causes the T vector to be oriented away from the QRS vectors to produce inverted T wave.

4. **Left axis deviation**. In the left ventricular hypertrophy electrical axis of the heart have a leftward orientation because the left ventricular mass is greatly increased and there may be an anatomical change in the position of the heart. **$R_I \geq 15mm$, $R_{aVL} \geq 11mm$, or $R_I + S_{III} > 25mm$.**

5. **The transition zone is displaced to the right (V_2)**. In marked hypertrophy, the enlarged left ventricle as moves a little the right ventricle to the right, and heart turns around its vertical axis against clock hand.



6. **The deep S wave is preserved in lead III during deep inspiration**. During deep inspiration the diaphragm lowers, and if axis deviation is positional, deep S wave disappears because the heart assumes normal position. And, if axis deviation is caused by enlarged left ventricle, deep S wave preserves in lead III during deep inspiration.

Fig. 4.71. Left ventricular hypertrophy.

Right Ventricular Hypertrophy

Right ventricular hypertrophy is initially a compensatory process that represents an adaptation to longstanding hemodynamic overload in the patients with mitral stenosis, and in chronic pulmonary diseases, which are accompanied by hypertension in the lesser circulation.

Diagnostic Electrocardiographic Signs of Right Ventricular Hypertrophy

1. **Right axis deviation.**
2. The right leads **III, aVF, V_1, V_2, V_3** show **high-amplitude R waves** and the left leads **I, aVL, V_4, V_5, V_6** show a **deep S wave.** $R_{V1} \geq 7$ mm or $R_{V1} + S_{V5,6} \geq 10,5$ mm.
3. Duration of the QRS complex. In contrast to the pattern in left ventricular hypertrophy, the QRS duration seldom is prolonged (to 0,12 second), because even with hypertrophy, the thickness of the right ventricle does not exceed that of the left.
4. In leads **III, aVF, V_1, V_2, V_3 the ST segment** may be **depressed** and the **T wave inverted** over the hypertrophied right ventricle. When ST – T wave changes are present, it is often indicate of more severe right ventricular hypertrophy.
5. **The transition zone is displaced to the left ($V_5 – V_6$).** In the right ventricular the muscle mass is increased, and the heart tends to rotate on its longitudinal axis in

a clockwise manner, so that the right ventricle becomes more anterior and the left ventricle rotates posteriorly. The septum rotates similarly, becoming more parallel to the frontal plane of the body.

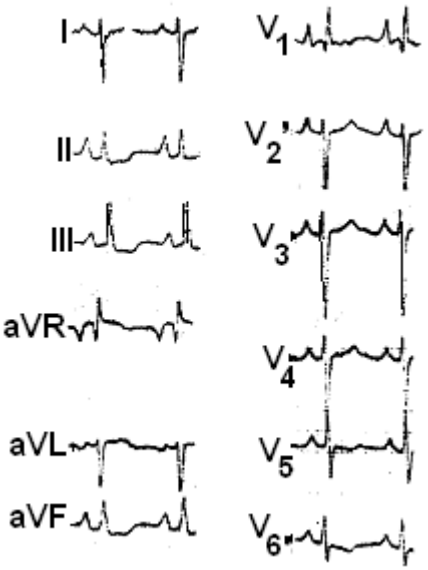


Fig. 4.72. Right ventricular hypertrophy.

1. When the ECG rhythm is called regular?
A. R-R interval differ by more than 10%;
B. R-R interval differ by no more than 0.1 s;
C. R-R interval differ by more than 0.1 s;
D. R-R interval differ by more than 0, 2 s;
E. R-R interval differ by no more than 10%
2. Which P wave is of sinus origin?
A. P wave is before each QRS, singles in shape and size, positive;
B. P wave is before each QRS, varies in amplitude;
C. P wave is hidden in complex QRS;
D. P wave is negative before each QRS;
E, P wave is not proceed each QRS;
3. Which standard ECG lead is normally has the highest voltage?

A. I;
B. II;
C. III;
D. III at the height of expiration;
E. II at height of inspiration.
4. What is the value of the angle alpha of the ECG in humans normosthenic type constitution?
A. 0 - 30
B. 31 - 70
C. 71 - 90
D. 91 - 180
E. 0 - (- 180)
5. In which lead T wave normally always negative?
A. I standard;
B. II standard;
C. III standard;
D. AVR;
E. AVF.
6. Which interval is called the electrical systole of the heart?
A. P-Q;
B. QRS;
C. Q-T;
D. R-R;
E. P-P.
7. What does the increase in systolic performance?
A. Functional weakness infarction;
V. Tachycardia;
S. Polytopic rhythm;
D. Intracardiac conduction disorders;
E. Myocardial hypertrophy.
8. Where V4 chest electrode is located?
A. Right sterna border in 1V intercostal spaces;
B. Left sterna border in 1V intercostal spaces;
C. On the left anterior axillary line;

D. At the apex of the heart;
E. On the posterior left axillary line.
9. What is a sinus rhythm?
A. P wave is positive before each complex QRS, duration of R-R ranges, P-Q interval ranges from 0.25 to 0, 35 sec; within 0,15-0,45 sec;
B. P wave is before each QRS, not uniform amplitude and shape;
C. P wave before each complex QRS, duration of R-R ranges to 0.10 sec;
D. P wave before each QRS complex is negative;
10. What does the high voltage ECG mean?
A. Functional weakness infarction;
B. tachycardia;
C. polytopic rhythm;
D. inflammatory changes in the myocardium;
E. myocardial hypertrophy.
11. What does lowering voltage ECG mean?
A. electrical axis of the heart deviation;
B. tachycardia;
C. polytopic rhythm;
D. inflammatory and sclerotic changes in the myocardium;
E. myocardial hypertrophy
12. Electrical axis of the heart deviation to the left:
A. The highest R wave in lead I, the deepest S wave in lead III;
B. The highest R wave in lead III, the deepest S wave in lead I;
C. The highest R wave in lead I;
D. The highest R wave in lead II;
E. The highest R wave in lead III;
13. Potential of which wall mainly registers III standard leads?
A. Right atrium

B. Right ventricular
S. Ventricular septum
D. The anterior wall of the left ventricle
E. Posterior wall of the left ventricle
14. ECG signs of the right atrium hypertrophy?
A. Negative P wave in lead I
B. Negative T wave in lead II
C. Two pointed P wave in lead I
D. Pointed P wave in lead III
E. Two pointed P wave in lead II
15. ECG signs of the left atrium hypertrophy?
A. Negative P wave in lead I
B. Increased amplitude of T wave in lead I
C. Two pointed P wave in lead I
D. Pointed P in lead II
E. Two pointed P wave in lead II
16. ECG signs of right ventricular hypertrophy?
A. P wave duration > 0.11-0.12 sec
B. $\angle\alpha > +90^0$, R_{III}/S_I.
S. Syndrome $TV_1 > TV_6$.
D. Syndrome $TV_1 < TV_6$
E. In leads III, aVF dominated "P-pulmonale" wave.
17. ECG signs of left ventricular hypertrophy?
A. P wave duration > 0.11-0.12 sec
B. $\angle\alpha > +90^0$, R_{III}/S_I.
S. Syndrome $TV_1 > TV_6$.
D. Syndrome $TV_1 < TV_6$
E. In leads III, aVF dominated "P-pulmonale" wave.
18. ECG signs of left ventricular hypertrophy?
A. Index Makruza = 1
B. $\angle\alpha > +90^0$, R_{III}/S_I.
C. Increasing the amplitude of S wave in leads I, aVL, V5-V6.
D. Syndrome $TV_1 < TV_6$

E. Increased R wave amplitude in leads I, aVL; Rv5-6> Rv4; Rv4 <Rv6.

19. ECG signs of right ventricular hypertrophy?

A. Index Makruza> 1

B. $\angle\alpha > -30^0$

C. Increasing the amplitude of S wave in leads I, aVL, V5-V6.

D. Syndrome Tv1> Tv6

E. Increased R wave amplitude in leads I, aVL; Rv5-6> Rv4; Rv4 <Rv6

Standards of answers: 1V. 2A. 3B. 5D 6C 4B. 7A 9C 8d. 10E. 12A 11D 13E. 14D. 15C. 16B. 17C. 18E. 19C.

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