

Section 4 Cardiology

Chapter 22

Lead aVR: The Neglected Lead

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INTRODUCTION

Lead aVR, one of the 12 electrocardiographic leads, is frequently ignored in clinical medicine. In fact, many clinicians refer to the 12-lead electrocardiogram (ECG) as the 11-lead ECG, noting the commonly held belief that lead aVR rarely offers clinically useful information.¹ The augmented limb leads were developed to derive more localized information than the bipolar leads I, II and III could offer. For this purpose from the existing limb electrodes, new leads aVR, aVF and aVL were constructed, being unipolar leads looking at the right, left and lower part of the heart with the reference electrode constructed from the other limb electrodes. Thus, the purpose of lead aVR was to obtain specific information from the right upper side of the heart, such as the outflow tract of the right ventricle and the basal part of the septum. In practice, however, most electrocardiographers consider lead aVR as giving reciprocal information from the left lateral side, being already covered by the leads aVL, II, V5 and V6. This has been the reason that lead aVR has become largely ignored.^{2,3}

Moreover as all the depolarization are going away from this lead, all waves are negative (P, QRS, T) in this lead (Figure 1).

ELECTROCARDIOGRAPHIC SIGNIFICANCE OF aVR

Coronary Artery Disease

Localizing the Level of Obstruction in Acute Coronary Syndrome

Lead aVR can be very useful in identifying left main coronary artery (LMCA) obstruction.⁴ Ischemia of the basal part of the interventricular septum is the electrocardiographic explanation for the occurrence of ST-segment elevation (STE) in this lead. In this situation, owing to the dominance of the basal ventricular mass, the ST-segment vector in the frontal plane points in a superior direction, leading to STE in leads aVR and ST depression in the inferior leads⁵ (Figure 2). Lead aVR also helps in differentiating between LMCA and

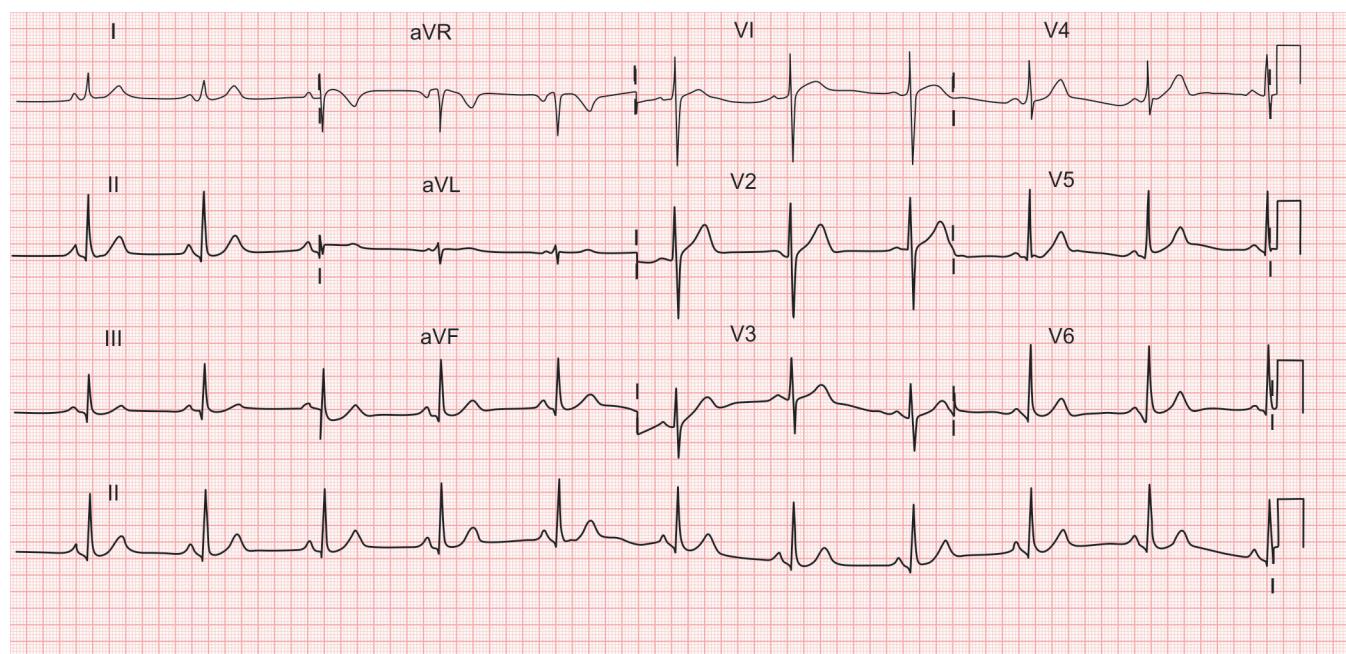


Figure 1: Normal electrocardiogram showing all complexes negative in aVR

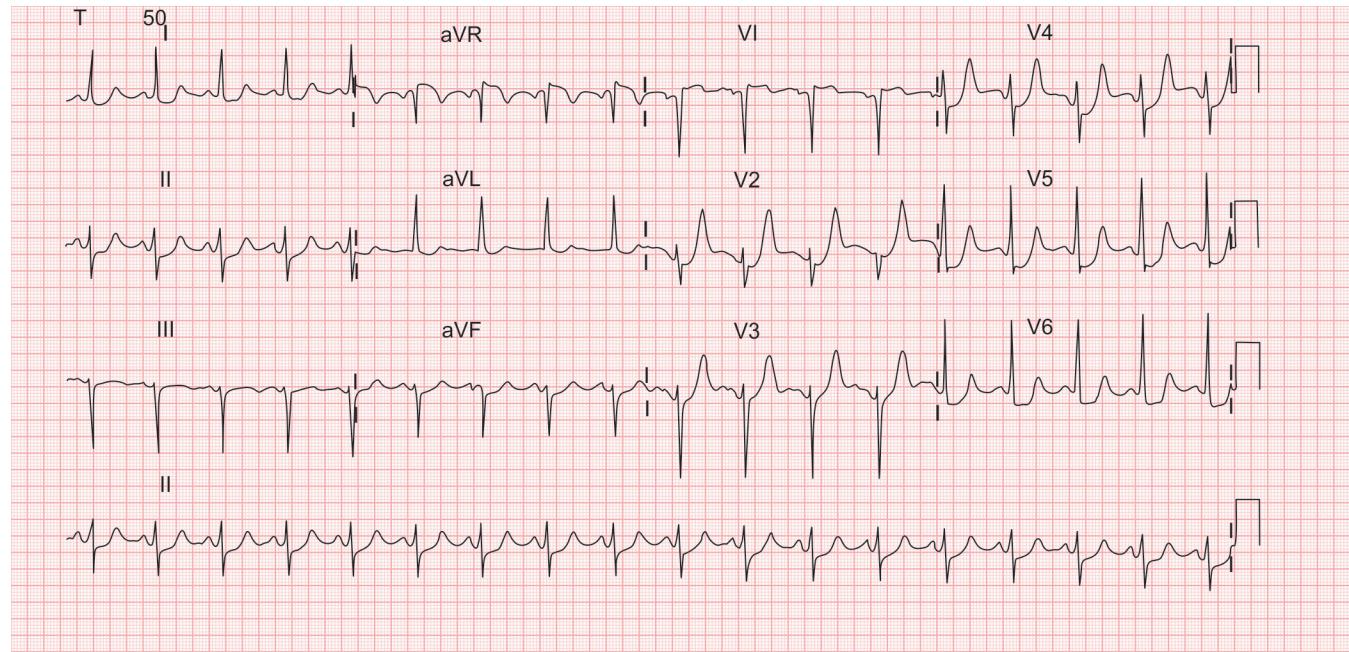


Figure 2: Left main coronary artery disease showing ST elevation in lead aVR more than V1

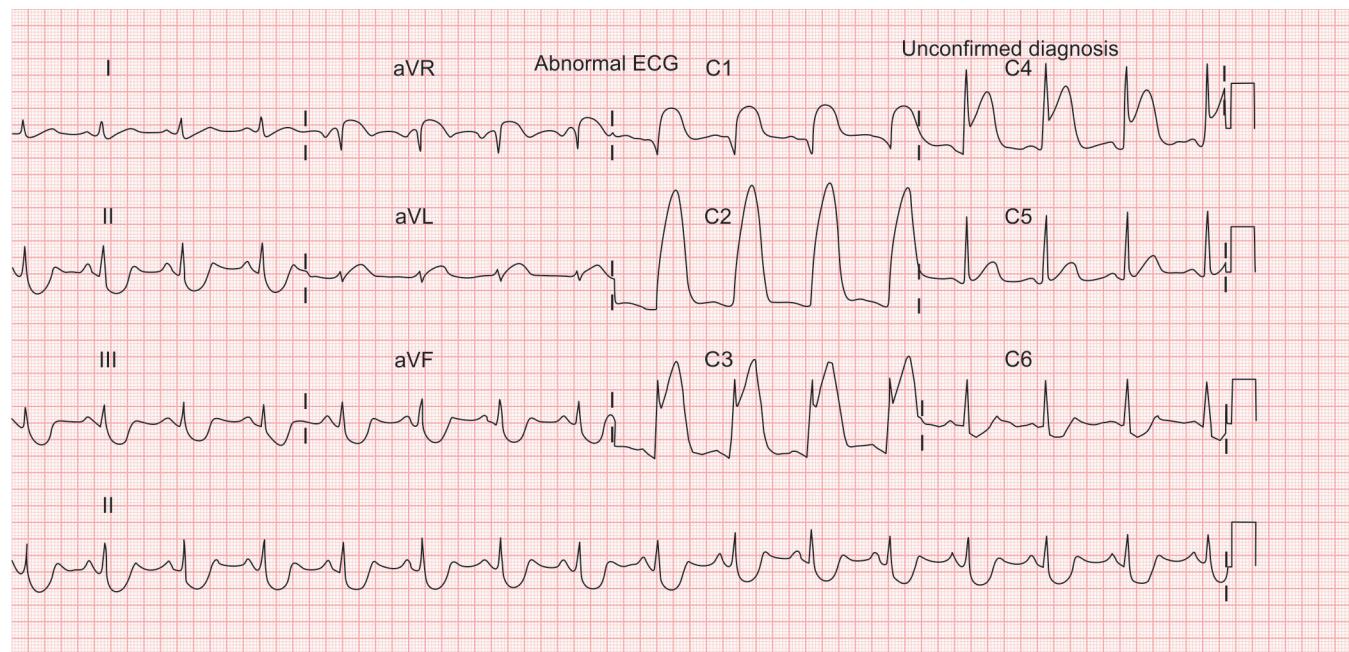


Figure 3: Proximal left anterior descending artery disease, lead V1 showing ST elevation more than lead aVR

proximal left anterior descending artery (LAD) disease. ST elevation in aVR more than in V1 is suggestive of LMCA disease and vice versa is suggestive of proximal LAD disease⁶ (Figure 3). In distal occlusion of the LAD, not involving the proximal septal area, no ST elevation but rather depression in lead aVR is observed⁷ (Figure 4).

Atrial Infarction

In the presence of acute inferior wall myocardial infarction (MI) PR-segment elevation in inferior leads and PR-segment depression in lead aVR are suggestive of atrial infarction (Figure 5).

Left Ventricular Aneurysm (Goldberger's Sign)

In patients with anterior wall MI with persistent ST elevation in chest leads and tall R in lead aVR are indicative of ventricular aneurysm (Goldberger's sign). In acute ST elevation lead aVR usually shows negative QRS⁸ (Figure 6).

Left Anterior Fascicular Block and Inferior Wall Myocardial Infarction

When there is predominantly negative QRS in inferior leads the dilemma is whether it is Inferior MI or left anterior fascicular block

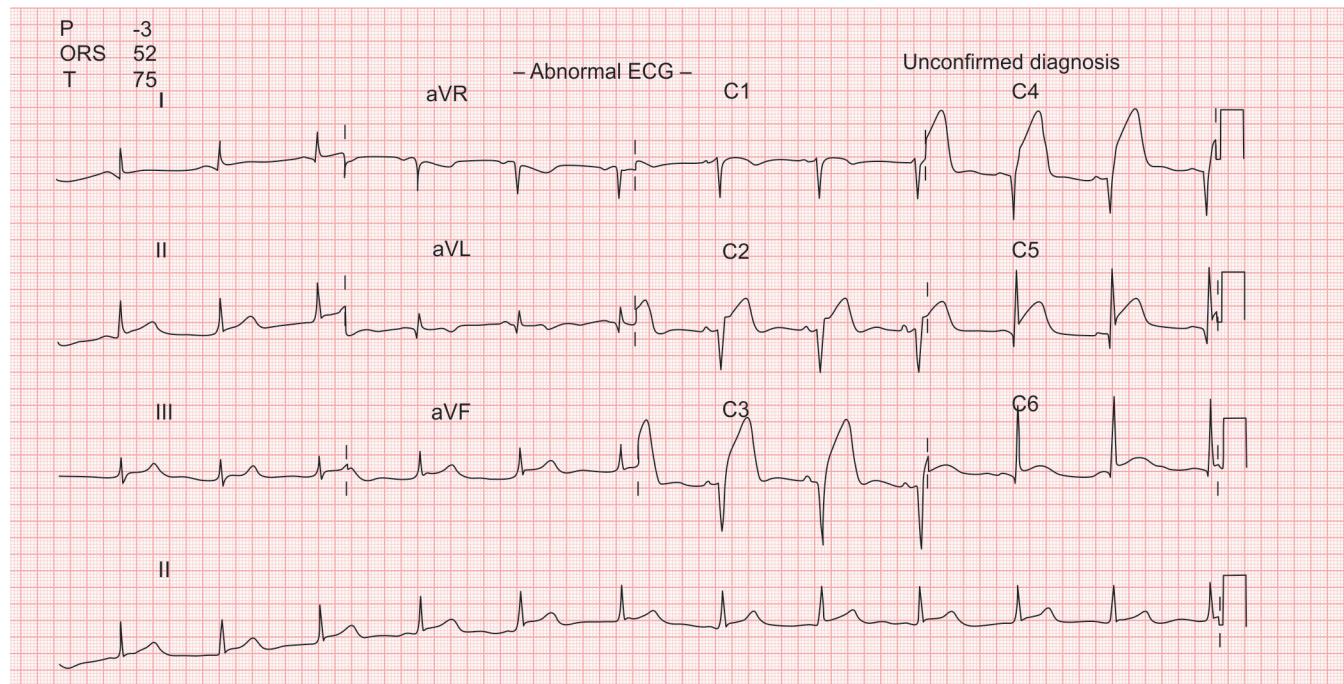


Figure 4: Distal left anterior descending artery disease showing ST-depression in aVR

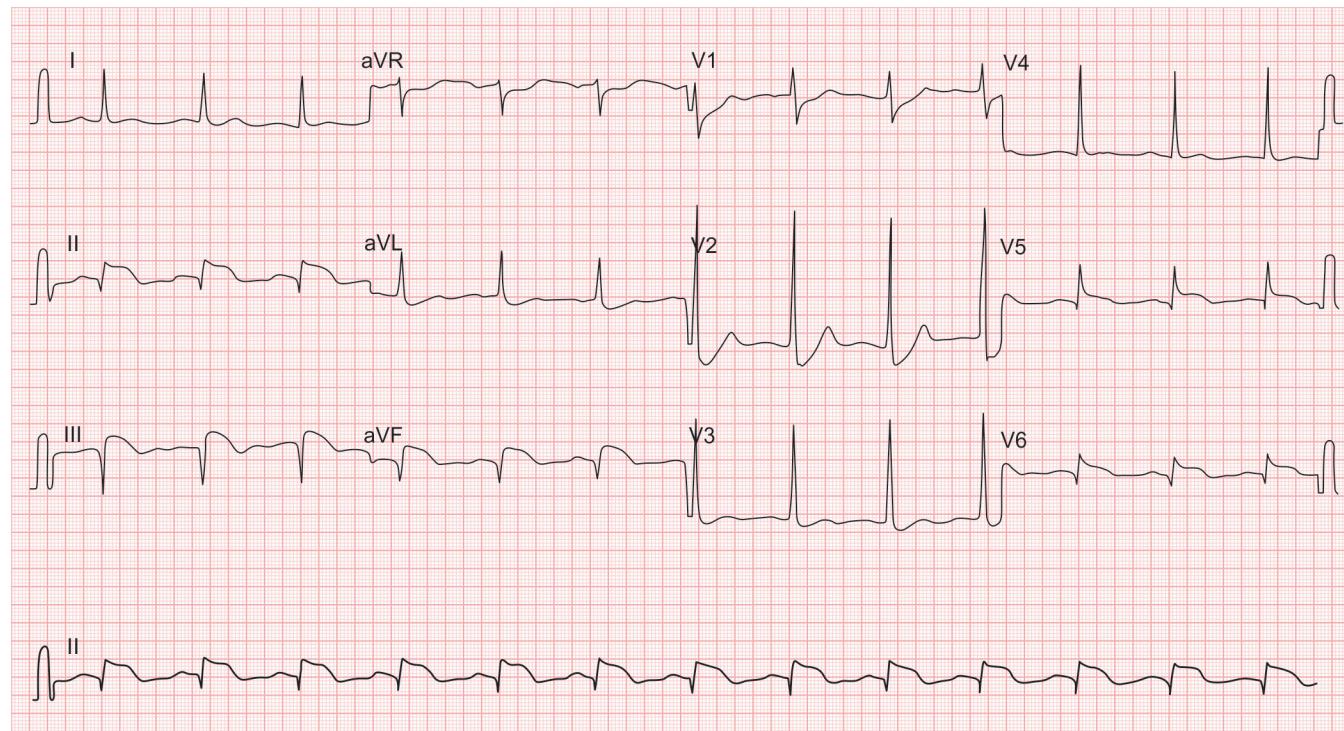


Figure 5: Atrial infarction showing PR elevation in inferior leads and PR depression in aVR

(LAFB). If lead aVR shows initial 'r' it is inferior MI; if there is a terminal 'R' in lead aVR it is LAFB (Figures 7 and 8).

Ventricular Tachycardia

A dissociated negative P wave in lead aVR is especially useful in the wide QRS tachycardia in diagnosing a ventricular origin of the arrhythmia.⁹ In ventricular tachycardia, there is a tall R in lead aVR (due to caudocranial activation), which is not usually seen in supraventricular tachycardia (SVT) with aberrancy (Figure 9).

Arrhythmias

Identification of the presence, configuration of the P wave and its relation to QRS is of particular importance in the diagnosis of tachycardia.

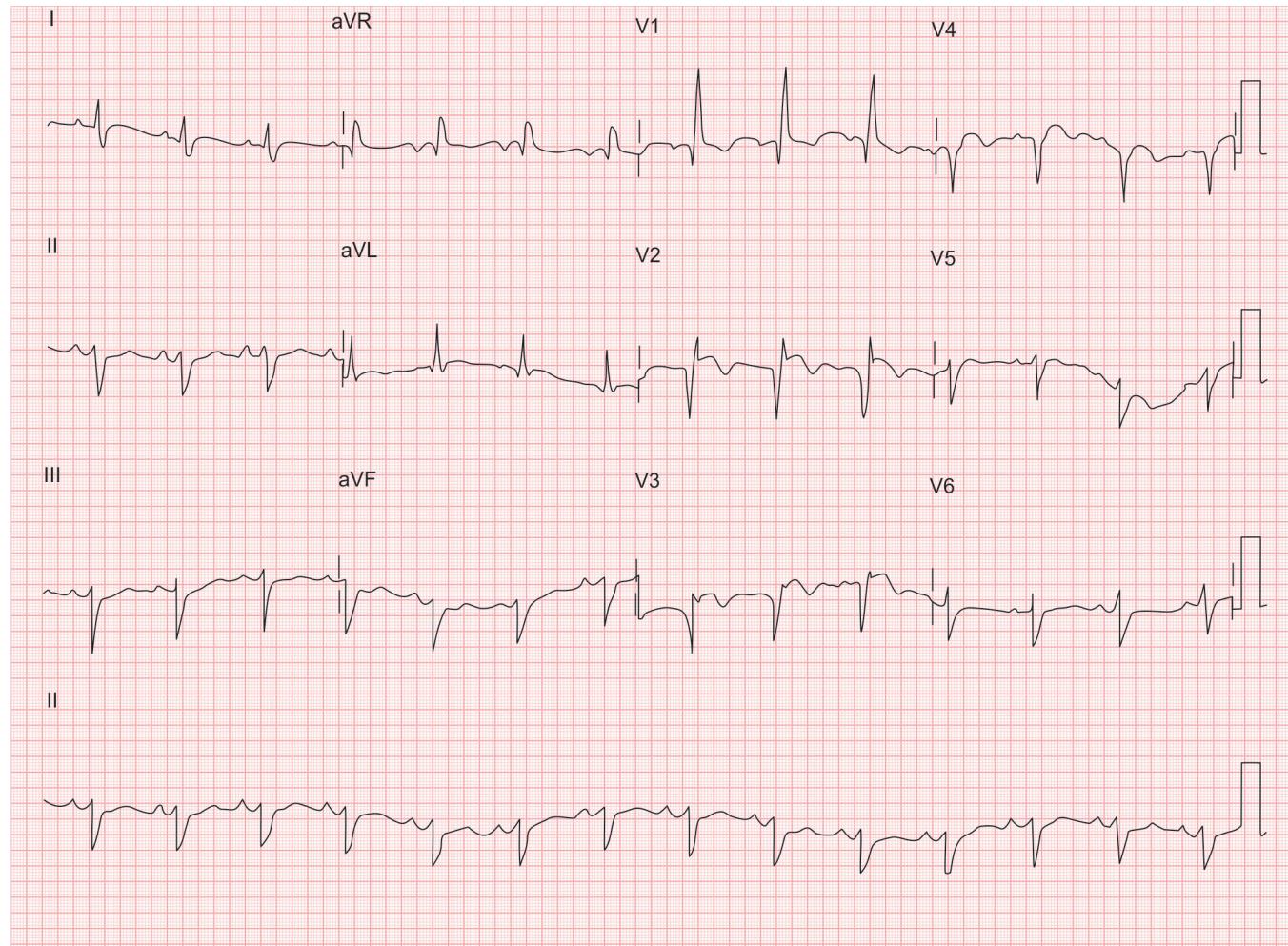


Figure 6: Left ventricular aneurysm showing Q, persistent ST elevation in chest leads and tall R in aVR

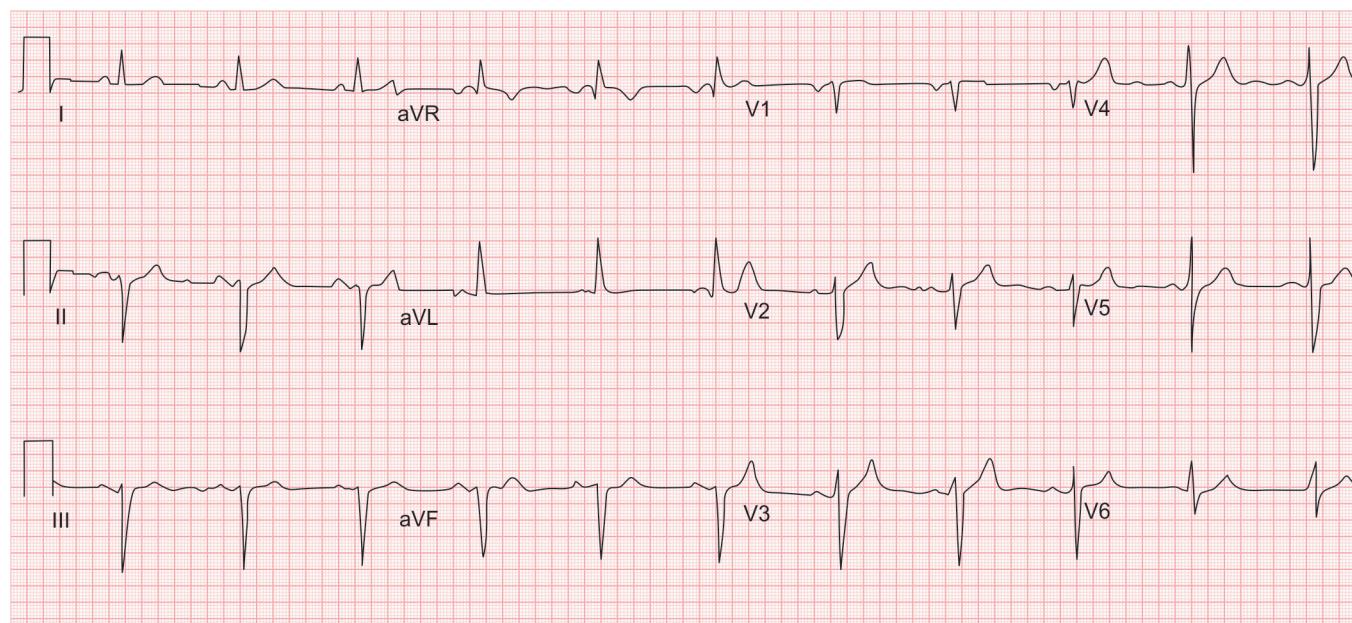


Figure 7: Left anterior fascicular block showing terminal R in aVR

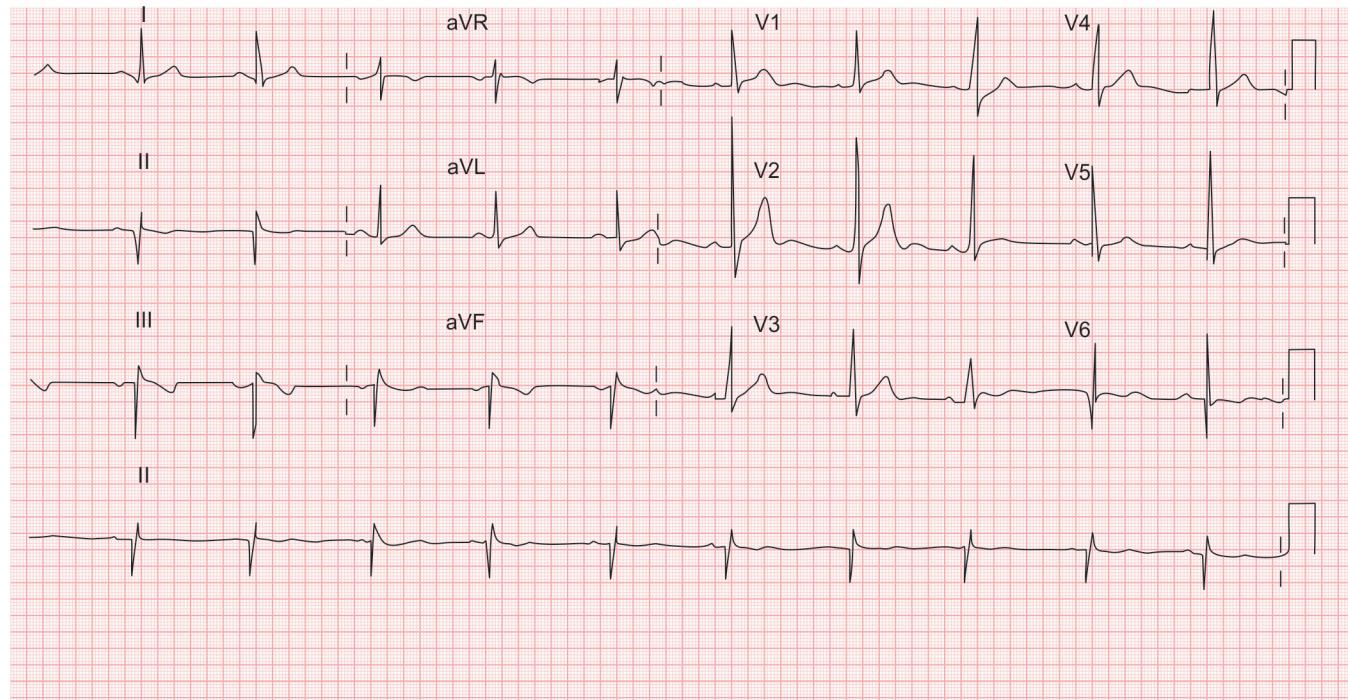


Figure 8: Inferior wall myocardial infarction showing initial R in aVR

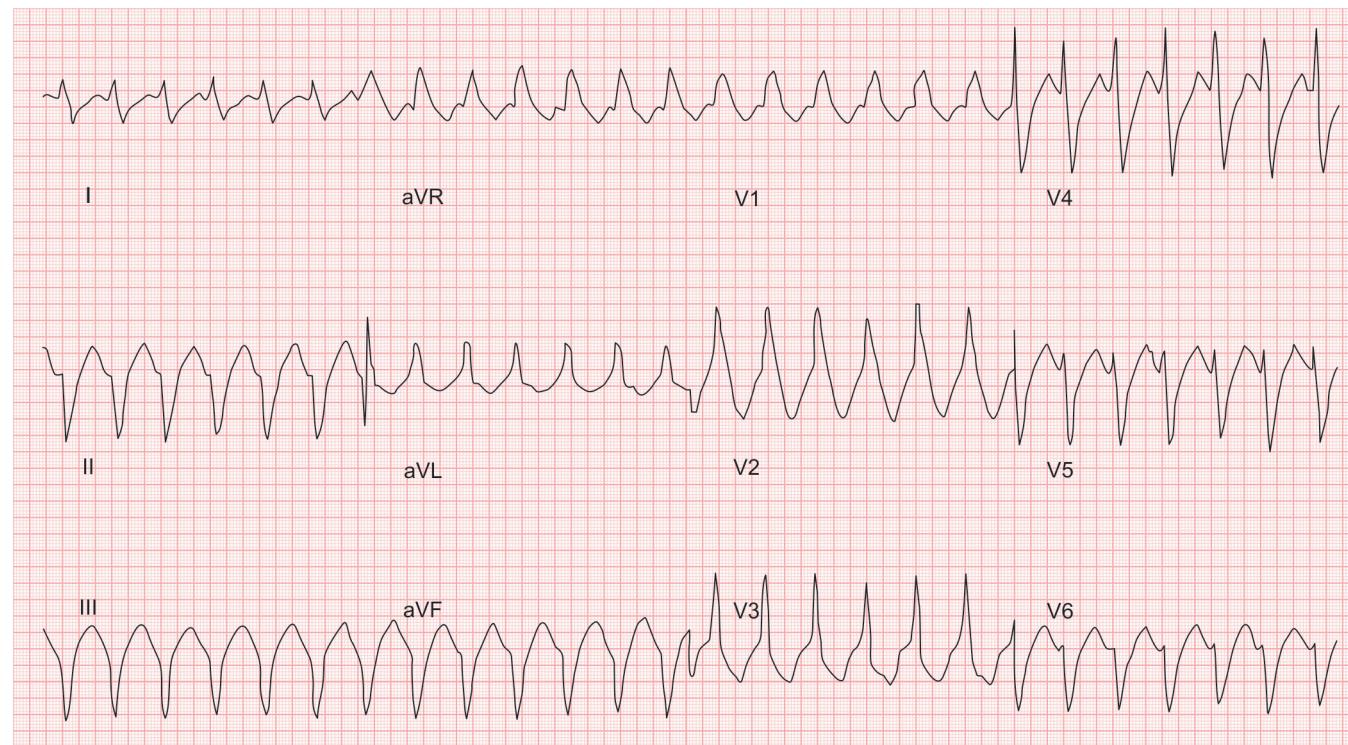


Figure 9: Ventricular tachycardia showing tall R in aVR

Supraventricular Tachycardia

During SVT lead aVR is helpful in determining the site of origin of the tachycardia or the tachycardia pathway.¹⁰ Any SVT with atrial activation in a caudocranial direction, such as atrioventricular nodal tachycardia [atrioventricular reciprocating tachycardia (AVRT)], left atrial tachycardia (AT) or a circus movement tachycardia using a paraseptally located accessory pathway for ventriculoatrial activation will typically show positive P waves in lead aVR.

Pre-excitation Syndrome-related Narrow Complex Tachycardia

In a report, Ho et al. reported that STE in lead aVR assists in the ultimate identification of the mechanism of these narrow QRS complex tachycardia, including atrioventricular nodal re-entrant tachycardia (AVNRT, i.e. typical paroxysmal SVT), AVRT [i.e. Wolff-Parkinson-White (WPW)-related narrow-complex tachycardia]

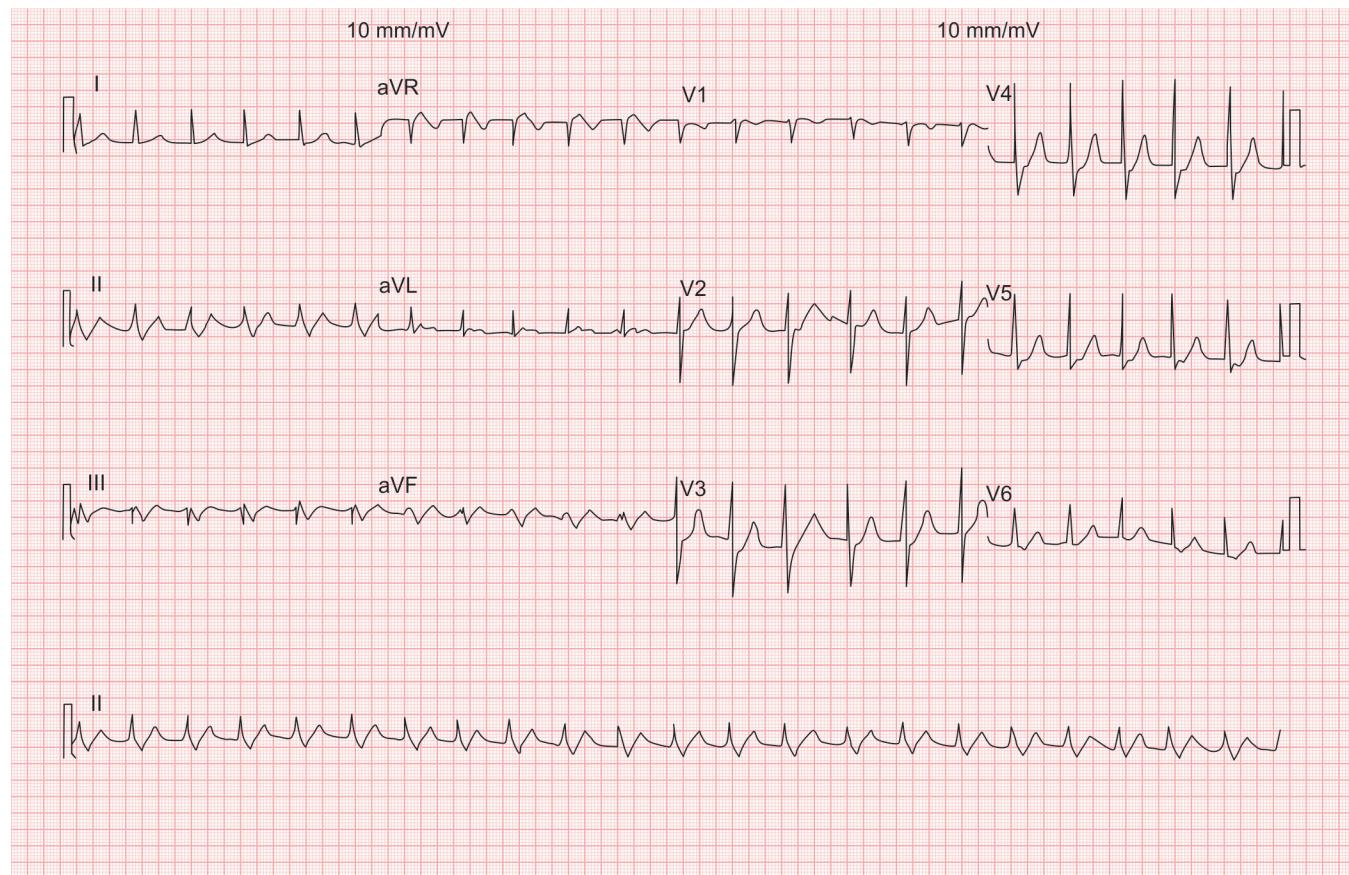


Figure 10: Atrioventricular reciprocating tachycardia due to pre-excitation showing positive retrograde p in aVR resulting in apparent ST elevation

and AT. Atrioventricular reciprocating tachycardia (WPW-related tachycardia) was differentiated from AVNRT and AT with a sensitivity of 71% and a specificity of 70%—STE in lead aVR was found to be strongly suggestive of WPW-related narrow complex tachycardia¹¹ (Figure 10).

Left Atrial Tachycardia and Rhythm

During ATs and ectopic atrial rhythm, a positive 'p' in lead aVR with negative 'p' in V5, V6 are suggestive of left atrial origin¹² (Figure 11).

Acute Pericarditis

Lead aVR can also be useful in the patients with suspected acute pericarditis.¹³ Two electrocardiographic findings in this lead are of diagnostic significance, including reciprocal ST-segment depression and PR-segment elevation. PR-, ST-segment discordance is suggestive of acute pericarditis where as in acute MI there is PR-, ST-segment concordance (Figure 12).

Tricyclic Antidepressant Ingestion

Early electrocardiographic findings in tricyclic overdose include sinus tachycardia, QRS complex widening greater than 100 milliseconds, right axis deviation, and characteristic R wave changes in lead aVR.¹⁴ The R wave changes in lead aVR that are indicative of tricyclic poisoning include an increased amplitude of the terminal R wave and an increased R wave to S wave ratio.¹⁵ QTc prolongation in this condition is primarily due to QRS widening. Progressive QRS widening identifies high-risk patients for *Torsade de Pointes*.

Malpositions and Technical Errors

Dextrocardia

Dextrocardia is a type of cardiac malposition in which the major axis of the heart (base to apex axis) points to the right. Hence, the P wave and QRS complex in lead aVR would be positive and there is nonprogression of "R" from V1 to V6 on left side and progression R waves in right-sided chest leads (Figure 13).

Dextroversion or Shifting of Mediastinum

In dextroversion or in shifting of mediastinum the heart is pushed to the right with the chambers in their normal positions (left ventricle on the left and right ventricle on the right). Here lead aVR shows negative "P" and negative QRS with nonprogression of R from V1 to V6.

Technical Dextrocardia

When the limb placement is wrong (right arm-left arm lead reversal) it can cause technical dextrocardia in the ECG. Lead aVR will show positive "P" and positive QRS but there will be normal progression of R from V1 to V6¹⁶ (Figure 14).

Tension Pneumothorax

The electrocardiographic changes are more common in left pneumothorax, with or without tension, including a right QRS axis deviation, low QRS voltage, reduced precordial R-wave voltage, and anterior T-wave inversion.¹⁷ Marked PR-segment elevation in inferior leads and reciprocal PR-segment depression in lead aVR had been

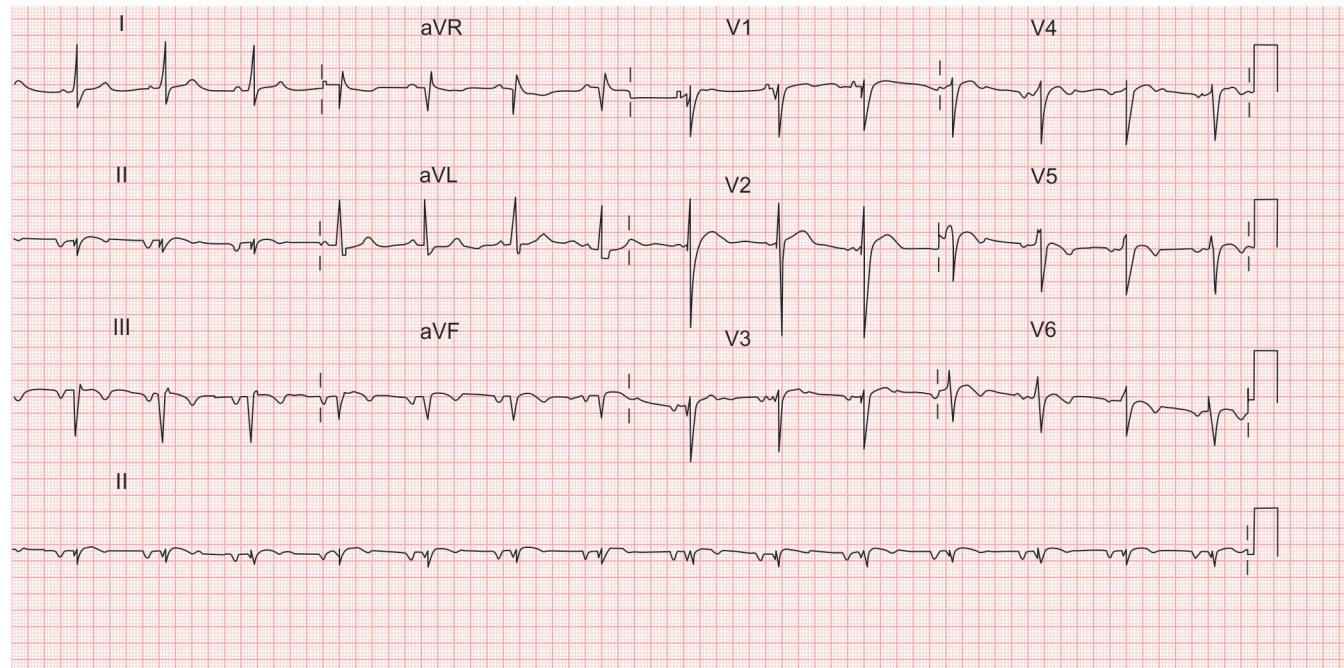


Figure 11: Left atrial rhythm showing positive P waves in aVR and dome and dart p in V1

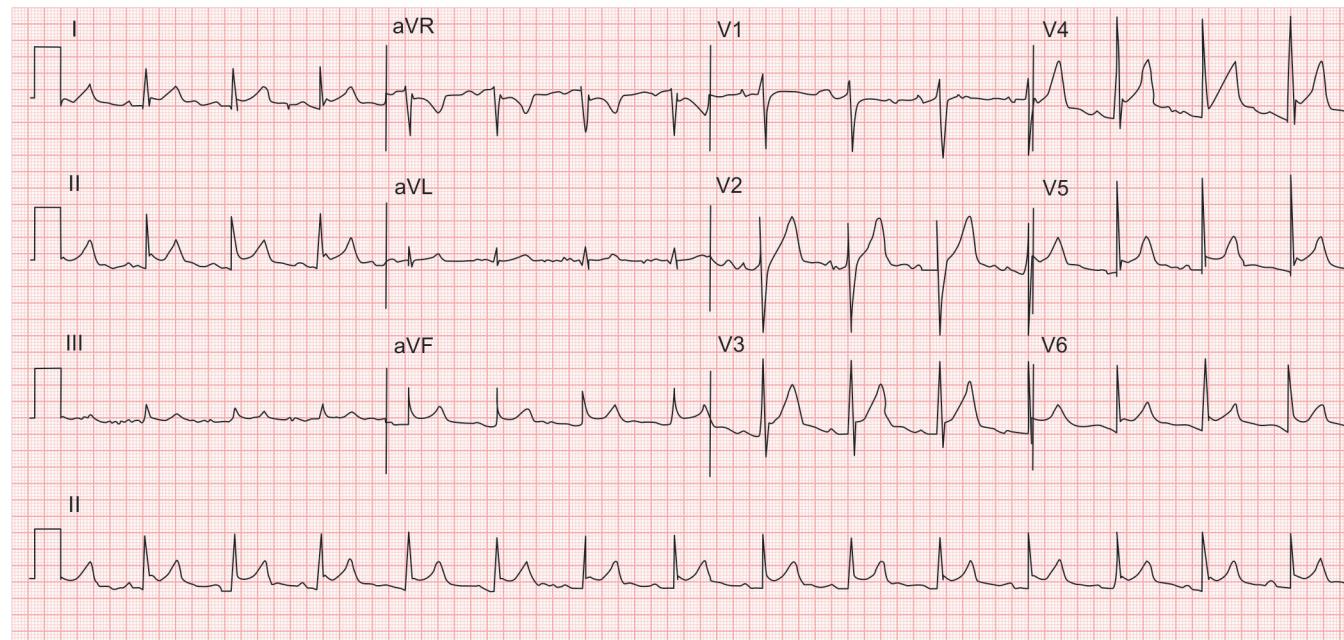


Figure 12: Acute pericarditis showing PR elevation and ST depression in aVR

reported left tension pneumothorax.¹⁸ Right tension pneumothorax less frequently presents with abnormal ECG findings.

Acute Pulmonary Embolism

Although most patients with pulmonary embolism present with only sinus tachycardia or normal findings, it is well-known that acute pulmonary embolism may give rise to certain electrocardiographic changes, including arrhythmias, alteration in conduction, a shift in axis of the QRS complex, and changes in morphology of the P wave, QRS complex, ST segment, and T wave as well as the "classical" S1Q3T3 electrocardiographic pattern.¹⁹ Acute right ventricular overload could also manifest as STE in lead aVR and terminal R wave (Figure 15).

Predictive Value of ST-Segment Elevation in aVR

In the context of widespread ST depression + symptoms of myocardial ischemia:

- ST-segment elevation in aVR greater than or equal to 1 mm indicates proximal LAD/LMCA occlusion or severe 3VD
- ST-segment elevation in aVR greater than or equal to 1 mm predicts the need for coronary artery bypass graft
- ST-segment elevation in aVR greater than or equal to V1 differentiates LMCA from proximal LAD occlusion
- Absence of ST elevation in aVR almost entirely excludes a significant LMCA lesion.

Section 4

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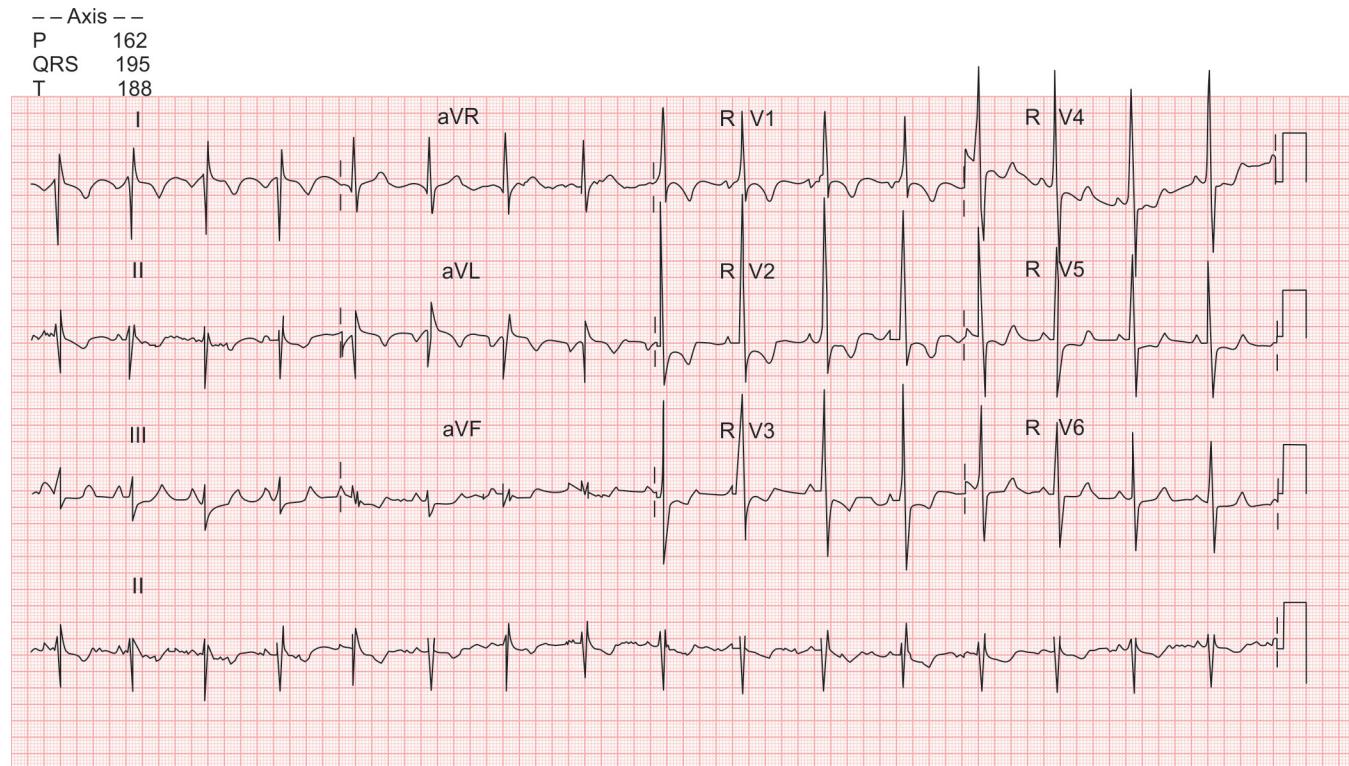


Figure 13: Lead aVR showing tall R and positive P in mirror-imaged dextrocardia. Note the progression of R waves in right-sided chest leads

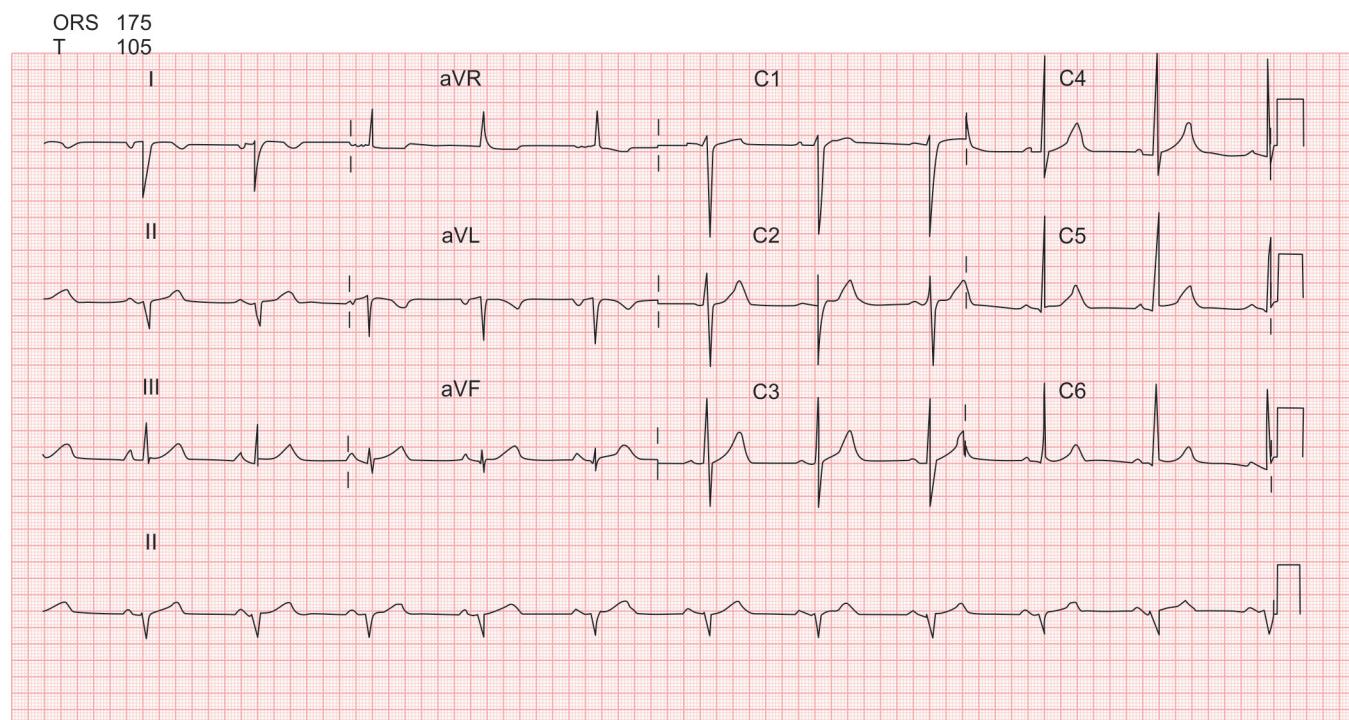


Figure 14: Technical dextrocardia showing positive P and tall R in aVR but normal progression of R waves in left-sided leads

In the context of anterior ST-elevation MI:

- ST elevation in aVR greater than or equal to 1 mm is highly specific for LAD occlusion proximal to the first septal branch.

In patients undergoing exercise stress testing:

- ST elevation of greater than or equal to 1 mm in aVR during exercise stress testing predicts LMCA or ostial LAD stenosis.

Magnitude of ST elevation in aVR is correlated with mortality in patients with acute coronary syndromes:

- ST-segment elevation in aVR greater than or equal to 0.5 mm was associated with a fourfold increase in mortality
- ST-segment elevation in aVR greater than or equal to 1 mm was associated with a 6-7-fold increase in mortality

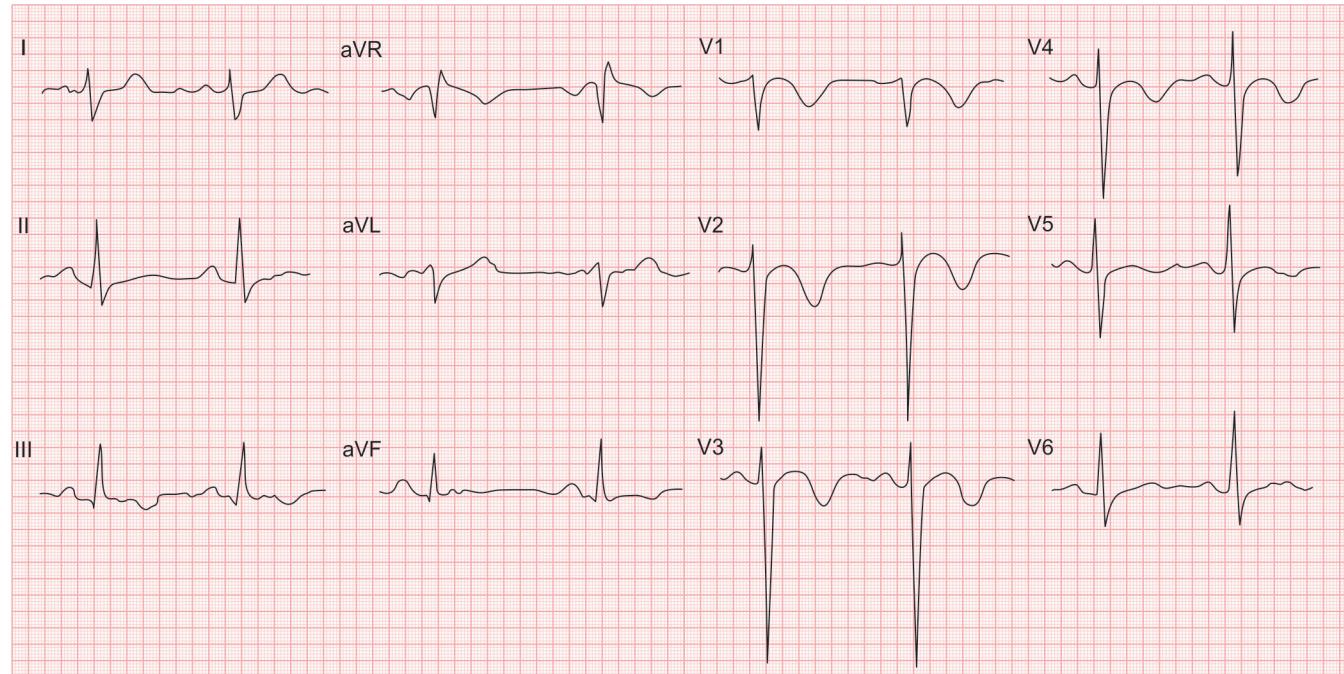


Figure 15: Acute pulmonary embolism showing ST elevation and terminal R wave in aVR

- ST-segment elevation in aVR greater than or equal to 1.5 mm has been associated with mortalities ranging from 20 to 75%.

CONCLUSION

Since its entry in the late 19th century, the ECG has emerged as a clinical tool, providing valuable diagnostic information in many situations, which has helped the physician not only in diagnosis but also to plan appropriate management in acute and chronic situations. Many physicians are tuned to look at routine things, but subtle changes in the most neglected lead aVR give a crucial information in many situations which otherwise is not evident in the routine leads. So, in addition to routine evaluation of ECG, one should pay a careful attention to lead aVR which provides essential diagnostic and prognostic informations not only in cardiac situations but also in many noncardiac situations.²⁰

REFERENCES

1. Hurst JW. Methods used to interpret the 12-lead electro-cardiogram: Pattern memorization versus the use of vector concepts. *Clin Cardiol.* 2000;23(1):4-13.
2. Gorgels AP, Engelen DJ, Wellens HJ. Lead aVR, a mostly ignored but very valuable lead in clinical electrocardiography. *J Am Coll Cardiol.* 2001;38(5):1355-6.
3. Pahlm US, Pahlm O, Wagner GS. The standard 11-lead ECG. Neglect of lead aVR in the classical limb lead display. *J Electrocardiol.* 1996;29(Suppl):270-4.
4. Gorgels AP, Vos MA, Mulleneers R, et al. Value of the electrocardiogram in diagnosing the number of severely narrowed coronary arteries in rest angina pectoris. *Am J Cardiol.* 1993;72(14):999-1003.
5. Yamaji H, Iwasaki K, Kusachi S, et al. Prediction of acute left main coronary artery obstruction by 12-lead electrocardiography: ST segment elevation in lead aVR with less ST-segment elevation in lead V1. *J Am Coll Cardiol.* 2001;38(5):1348-54.
6. Engelen DJ, Gorgels AP, Cheriex EC, et al. Value of the electrocardiogram in localizing the occlusion site in the left anterior descending coronary artery in acute anterior myocardial infarction. *J Am Coll Cardiol.* 1999;34(2):389-95.
7. Gorgels APM, Engelen DJ, Wellens HJJ. The electrocardiogram in acute myocardial infarction. In: Fuster V, Alexander RW, O'Rourke RA (Eds). *Hurst's the Heart*, 10th edition. New York: McGraw-Hill; 2000. pp.1361-71.
8. Kosuge M, Kimura K, Ishikawa T, et al. ST-segment depression in lead aVR predicts predischarge left ventricular dysfunction in patients with reperfused anterior acute myocardial infarction with anterolateral ST-segment elevation. *Am Heart J.* 2001;142(1):51-7.
9. Wellens HJ, Bar FW, Lie KI. The value of the electrocardiogram in the differential diagnosis of a tachycardia with a widened QRS complex. *Am J Med.* 1978;64(1):27-33.
10. Bar FW, Brugada P, Dassen WR, et al. Differential diagnosis of tachycardia with narrow QRS complex (shorter than 0.12 second). *Am J Cardiol.* 1984;54(6):555-60.
11. Ho YL, Lin LY, Lin JL, et al. Usefulness of ST-segment elevation in Lead aVR during tachycardia for determining the mechanism of narrow QRS complex tachycardia. *Am J Cardiol.* 2003;92(12):1424-8.
12. Saoudi N, Cosio F, Waldo A, et al. A classification of atrial flutter and regular atrial tachycardia according to electrophysiological mechanisms and anatomical bases; a Statement from a Joint Expert Group from The Working Group of Arrhythmias of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. *Eur Heart J.* 2001;22(14):1162-82.
13. Spodick DH. Diagnostic electrocardiographic sequences in acute pericarditis. Significance of PR segment and PR vector changes. *Circulation.* 2003;108:814-9.
14. Singh N, Singh HK, Khan IA, et al. Serial electrocardiographic changes as a predictor of cardiovascular toxicity in acute tricyclic antidepressant overdose. *Am J Ther.* 2002;9(1):75-9.
15. Liebeld EL, Francis PD, Woolf AD. ECG lead aVR versus QRS interval in predicting seizures and arrhythmias in acute tricyclic antidepressant toxicity. *Ann Emerg Med.* 1995;26(2):195-201.
16. Rudiger A, Hellermann JP, Mukherjee R, et al. Electrocardio-graphic artifacts due to electrode misplacement and their frequency in different clinical settings. *Am J Emerg Med.* 2007; 25(2):174-8.
17. Strizik B, Forman R. New ECG changes associated with a tension pneumothorax: a case report. *Chest.* 1999;115(6):1742-4.
18. Janssens U, Koch KC, Graf J, et al. Severe transmyocardial ischemia in a patient with tension pneumothorax. *Crit Care Med.* 2000;28(5):1638-41.
19. Sreeram N, Cheriex EC, Smeets JL, et al. Value of the 12-lead electrocardiogram at hospital admission in the diagnosis of pulmonary embolism. *Am J Cardiol.* 1994;73(4):298-303.
20. Van Mieghem C, Sabbe M, Knockaert D. The clinical value of the ECG in noncardiac conditions. *Chest.* 2004;125(4):1561-76.