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Case Report

Lead AVR: Under-appreciated and Often Overlooked

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Abstract

Electrocardiography (ECG) is one of the most common investigations carried out to evaluate the initial functional status of the heart. It is simple, generally reliable and rapid, providing critical information that can drastically alter diagnostic probabilities. Its sensitivity and specificity for diagnosing different clinical conditions do vary and is context specific.

Key works: electrocardiography; . st-elevation acute myocardial infarction; acute coronary syndromes

Introduction

Electrocardiography (ECG) is one of the most common investigations carried out to evaluate the initial functional status of the heart. It is simple, generally reliable and rapid, providing critical information that can drastically alter diagnostic probabilities. Its sensitivity and specificity for diagnosing different clinical conditions do vary and is context specific. [1] ECG is done in various healthcare settings for the evaluation of numerous conditions. Some may be linked to time-dependent diagnoses, eg. ST-Elevation Acute Myocardial Infarction (STEMI) and thus requires quick recognition and familiarity. Early recognition of specific patterns on the electrocardiogram can make the difference between life and death. As such, the skill of interpreting an electrocardiogram is essential to any medical professional.

The traditional reading of the ECG often did not place much emphasis on lead aVR. [2] With the explosion of medical knowledge and research in recent times, the previously neglected aVR has been gaining prominence and importance. First and foremost, there has been much interest in how aVR can be useful in the localization of obstruction in acute coronary syndrome: specifically looking at left main coronary artery occlusion, proximal left anterior descending artery stenosis, as well as severe triple vessel disease [2]. Besides its utility in acute coronary syndromes, aVR could potentially provide valuable information regarding other non-coronary artery disease conditions. These other conditions are wide ranging, from acute pericarditis to tricyclic antidepressant poisoning, often not getting as much attention as the acute coronary syndromes. We aim to summarize several pertinent non-coronary artery disease applications of lead aVR, and to highlight the key electrocardiographic features of each condition. (Table 1)

Category	Condition
Ischemia	Acute coronary syndromes: Triple Vessel Disease
	Left main coronary artery stenosis
	Left anterior descending coronary artery stenosis
Arrhythmia	Atrial tachycardia
	Narrow QRS tachycardia
	Wide QRS tachycardia
	Brugada syndrome
Others	Acute pericarditis
	Acute pulmonary embolism
	Tricyclic antidepressant toxicity

Table 1: *Summary of conditions where Lead aVR may be useful*

Acute Pericarditis (Figure 1)

The electrocardiogram is a key tool in the evaluation of acute pericarditis. Clinicians classically look for widespread concave ST segment elevations accompanied by PR segment depression throughout both the precordial and limb leads [2]**.** Another feature that has often been cited is Spodick's sign which is characterized by a downsloping TP segment. [3] Lead aVR offers important diagnostic utility for patients with acute pericarditis: the pattern of reciprocal PR elevation and ST depression in the right clinical context is suggestive.[4-6]

Given that ST elevations are commonplace in both acute pericarditis and STEMI, it is paramount to look for clues to differentiate between the two conditions. Lead aVR provides key information in this aspect. Features suggestive of STEMI include ST elevation in lead III > II, ST depressions in leads other than aVR or V1, upward convexity of ST segment elevation. [7] These patterns should always raise suspicion of a STEMI and efforts need to be undertaken to rule out a STEMI accordingly. Clinical correlation is also useful.

Another potential mimic is the entity known as Benign Early Repolarization (BER), which can also present with generalised concave ST segment elevations. Features more suggestive of BER include ST elevations localized to the precordial leads, notched J point (known as a 'fish hook' appearance), absence of PR depression and an ST segment elevation/T wave ratio of less than 0.25. [8] It is important to note that the ST segment elevation amplitude is measured from the end of the PR segment to the J point.

Acute Pericarditis ECG Features
1. Widespread concave ST elevations
2. PR segment depression in precordial and limb leads
3. Downsloping TP segment (Spodick's sign)
4. PR elevation and ST depression in lead aVR

Table 2: *Key ECG features of acute pericarditis*

Acute Pulmonary Embolism (Figure 2)

While there are many different electrocardiogram findings that may be observed in a patient with acute pulmonary embolism (PE), none of them are sensitive enough to rule out or specific enough to rule in the condition. [1, 9] Features that may be present include sinus tachycardia, nonspecific ST segment and T wave changes, partial or complete right bundle branch block, right axis deviation, T wave inversions in V1-V4 and inferior leads suggestive of right ventricular strain, and P pulmonale suggestive of right atrial enlargement. [10] The 'classical' finding of S1Q3T3 is in fact uncommon in PE, and so is ST elevation in lead aVR. Some patients with PE have an entirely pristine or normal ECG. [10, 11]

The usefulness of electrocardiography in PE is in raising the suspicion of the condition in the right clinical situation; as well as in prognosticating the severity of PE as well as in risk stratification. [12] ST elevation in lead aVR has recently been linked to cardiopulmonary instability [13] and right ventricular (RV) dysfunction in patients diagnosed with acute pulmonary embolism. This may have implications on anticipating RV dysfunction early in the course of PE which may impact management decisions. [11] In addition, studies have also shown that patients with ST elevation also have a higher risk of overall mortality, and in-hospital complications. [12] Evidently, ST elevation in aVR has major prognostic value for acute PE patients.

Acute Pulmonary Embolism ECG Features
1. Sinus tachycardia
2. Right bundle branch block
3. Right axis deviation
4. T-wave inversions in V1-V4 and inferior leads
5. P pulmonale
6. S1Q3T3
7. ST elevation in lead aVR
8. Normal ECG

Table 3: *Key ECG features of acute pulmonary embolism*

Tricyclic Antidepressant (TCA) overdose (Figure 3)

TCAs are still used in clinical medicine today despite the widespread adoption of Selective Serotonin Reuptake Inhibitors (SSRIs) for the treatment of clinical depression. Beyond depression, TCAs are used in other conditions, ranging from psychiatric conditions such as obsessive compulsive disorder to chronic pain disorders such as migraine and neuropathic pain. [14-16] Overdose is a potentially lethal condition that needs to be rapidly picked up and treated. TCAs can be fatal at doses as low as ten times the daily dose. [17] Failure to detect TCA overdose in a timely manner may result in significant risk of cardiovascular toxicity (hypotension and arrhythmias) and neurological toxicity (mental status changes and seizures). The ECG is helpful in determining the extent of TCA overdose. [18]

The classic ECG findings of TCA overdose were coined in 1995 by Liebelt et. al, which include R wave in aVR > 3mm and R/S ratio in aVR > 0.7, and QRS duration >100ms. [19] It was found that the findings of the R wave and R/S ratio in aVR were better predictors of the severity of TCA poisoning than the QRS duration [20]. However, reports on TCA overdose have mainly used the QRS duration of >100ms as an indication

for sodium bicarbonate therapy [21]. One postulation would be the relative ease of assessment of the QRS duration compared to the R/S ratio and the R wave. Further studies can be considered to elucidate any possible clinical implication of the R wave and R/S ratio in clinical practice.

Tricyclic Antidepressant Overdose ECG Features
1. R wave in aVR > 3mm
2. R/S ratio in aVR > 0.7
3. QRS duration >100ms

Table 4: *Key features of Changes in Lead aVR with TCA overdose*

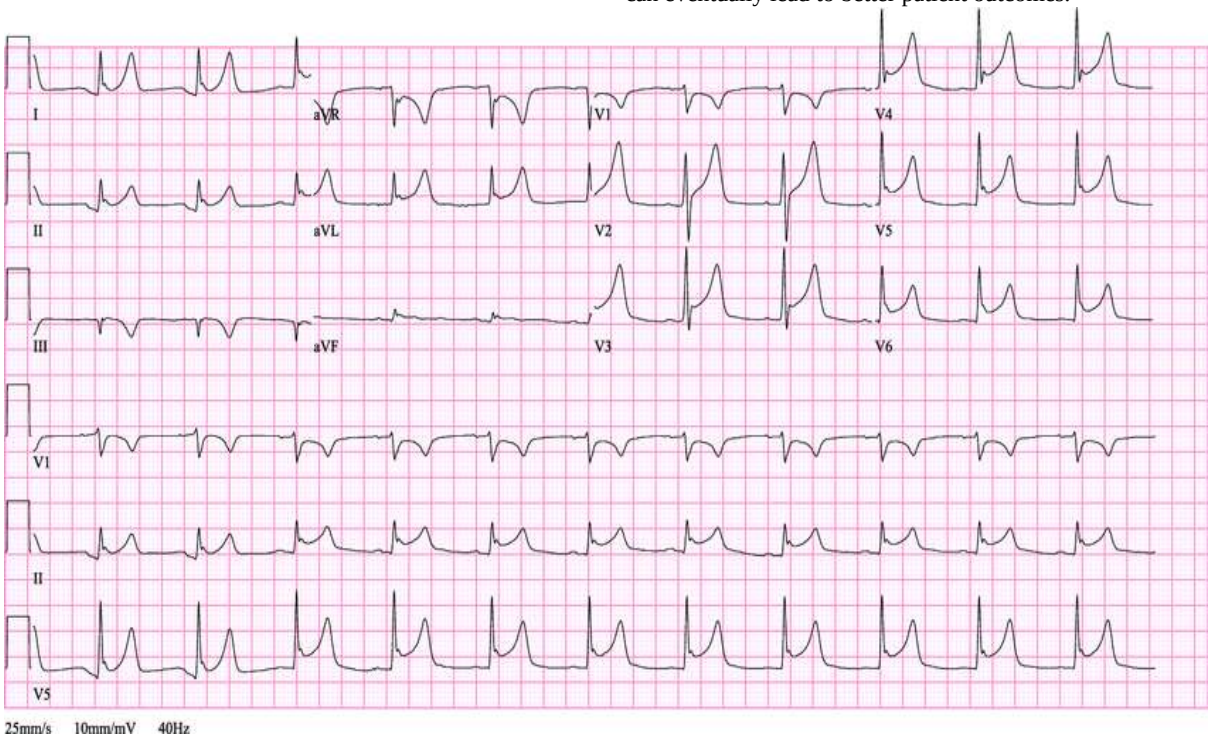
Regular Wide QRS Complex Tachycardias (WCT)

For the scope of this paper we have chosen to focus on regular WCT in view of clinical relevance. A fundamental question to answer in the approach to such an arrhythmia is whether the patient has a ventricular tachycardia (VT) or a supraventricular tachycardia (SVT) with aberrancy or a bundle branch block. This dichotomy, while critical, is not simple to make. [22, 23]

The urgent need to differentiate between both reliably has given birth to the development of several criterias over the years, the most widely adopted and practiced being the Brugada criteria. [24] Other approaches have surfaced such as the Vereckei approach and the Limb Lead Algorithm [25], with merits of their own. In 2007, Vereckei proposed an update to his earlier algorithm, emphasizing the central role of the aVR lead in the analysis of WCT, which showed better sensitivity and negative predictive value compared to the Brugada algorithm. [26] In 2017, a prospective study by Jain et al found that the updated aVR Vereckei algorithm was indeed more sensitive for the differential diagnosis of WCT compared to the Brugada criteria. [27] That being said, there has been some doubt regarding the practical utility of the Vereckei criteria based on a study in 2012 done by Baxi et al where emergency medicine residents achieved only fair-to-good individual accuracy and moderate agreement while using the Vereckei criteria, with a suggestion of further simplification of the criteria before clinical implementation. [28] More studies are required to compare the utility of different WCT algorithms in various clinical settings. [23, 29]

Conclusion

aVR is a lead that is relatively overlooked when approaching ECGs. Besides its increasing recognition and importance in acute coronary syndrome [Fig 4], practitioners reading ECGs should make it a point to screen lead aVR as part of their standard ECG reading approach. With the emergence of new evidence and increasing interest in aVR, it is increasingly recognized to have much diagnostic and prognostic significance of certain patterns in aVR across various conditions. It would be both useful and interesting to further investigate its use in clinical decision making, especially specific to certain cohorts of patients. This can eventually lead to better patient outcomes.



Widespread concave ST elevation
PR segment depression in Leads 1, II, V5, V6
Spodik Sign of downsloping TP segment best seen in Leads II, V2 to V6
In Lead aVR: Elevation of the PR segment and depression of the ST segment

Figure 1: *ECG in a Patient with Acute Pericarditis: Note the changes:*

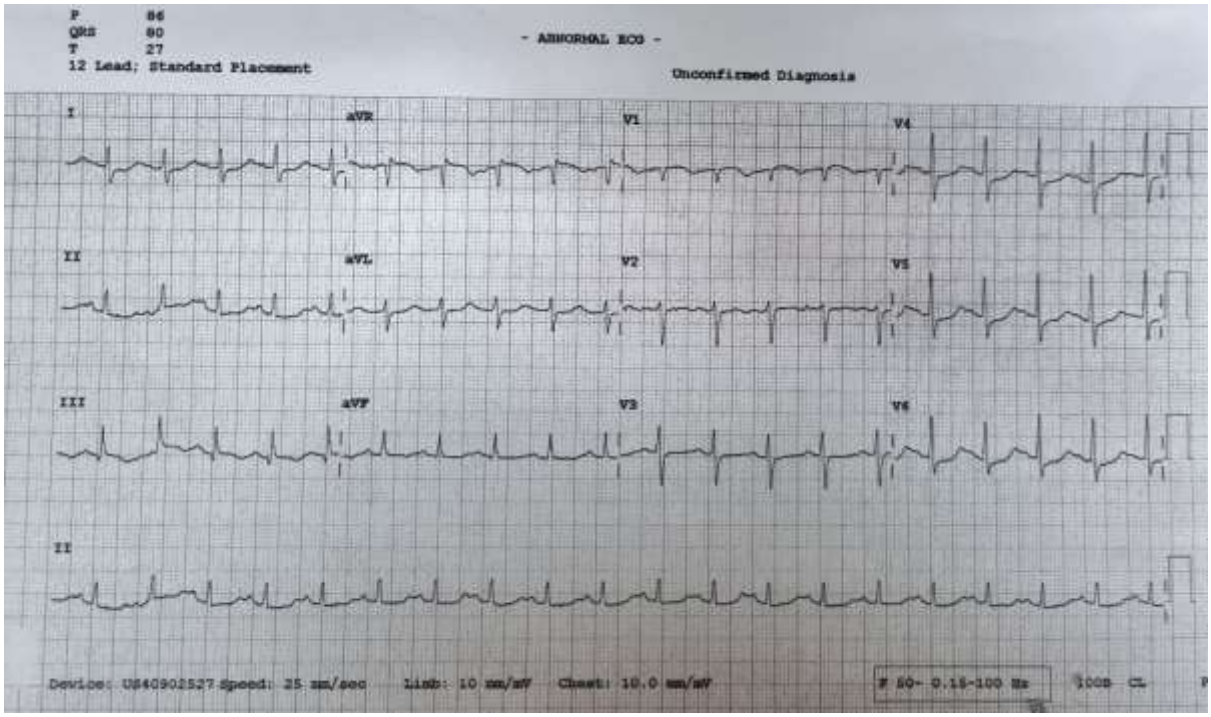


Figure 2: *ECG of a Patient with Acute Pulmonary Embolism Note the sinus tachycardia, ST segment elevation in aVR, S1T3 (not S1Q3T3)*

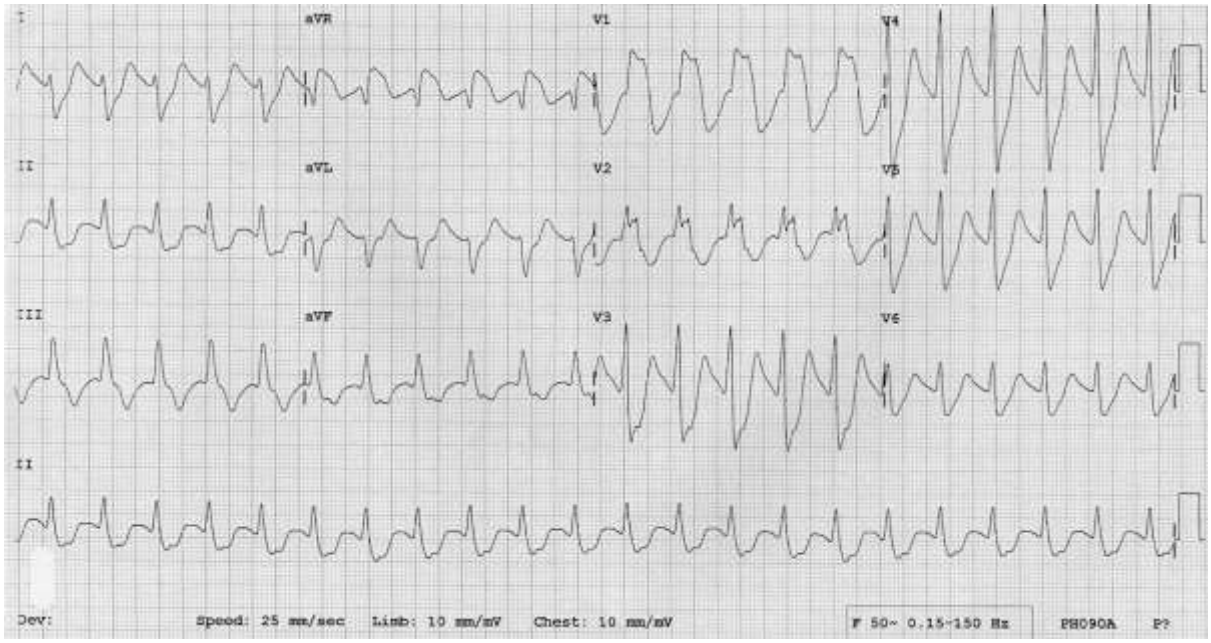


Figure 3: *Acute TCA Overdose: The changes noted in Lead aVR include: R > 3 mm R/S Ratio of >0.7 mm QRS duration > 100ms*

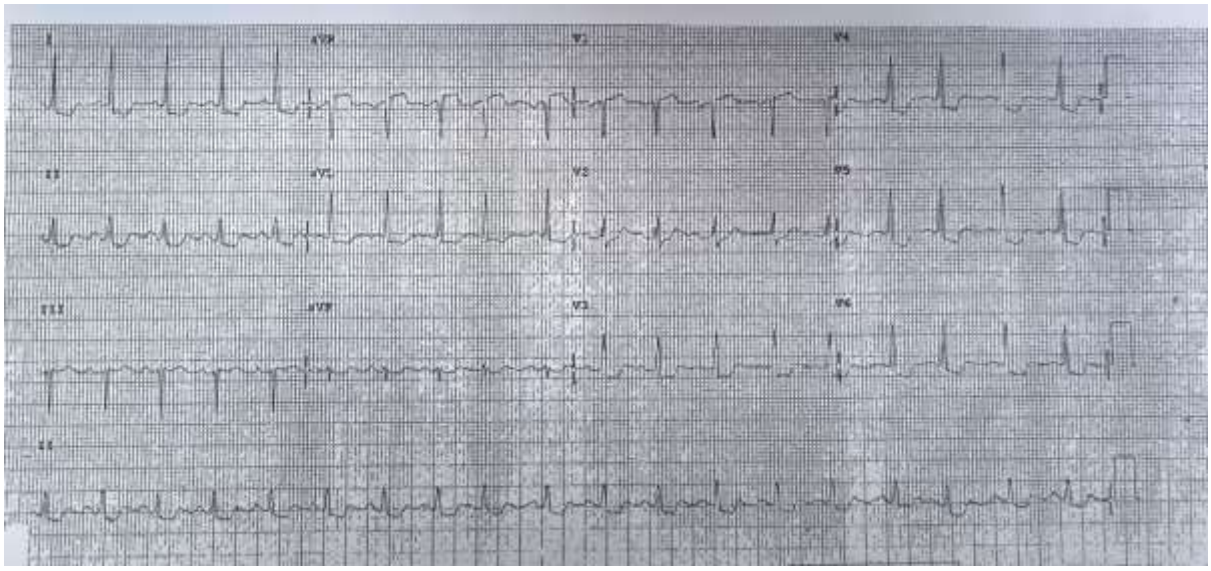


Figure 4: *ECG is a patient whose PCI (percutaneous coronary intervention) showed Left Main Coronary Artery Disease. Note the ST segment elevation in Lead aVR, with widespread ST depression in the other leads.*

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