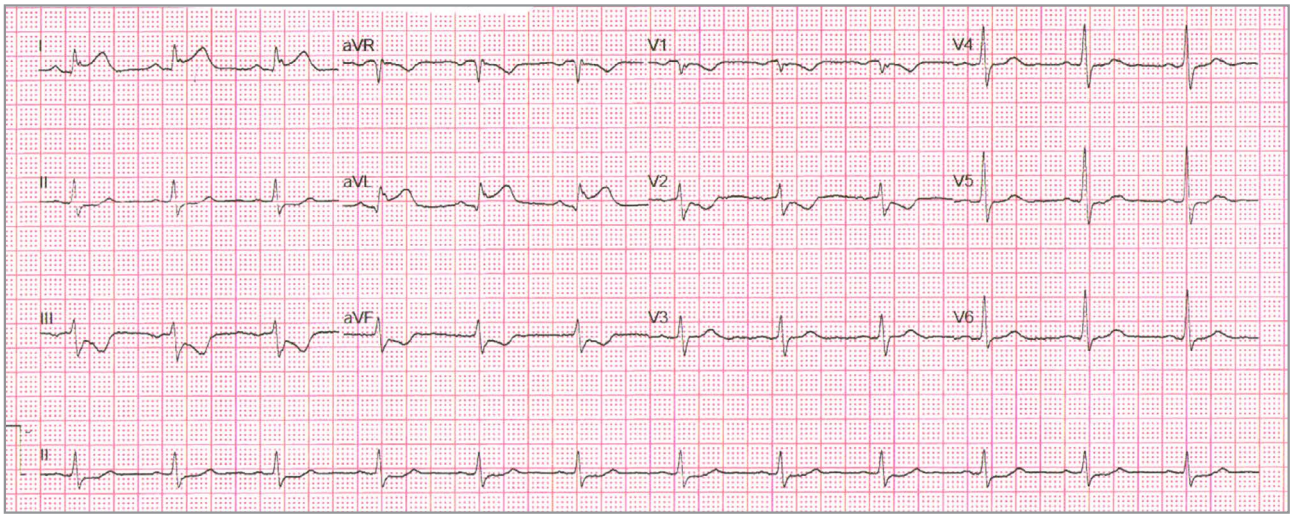
ECG Quiz 69

CASSA
CARDIAC ARRHYTHMIA SOCIETY OF SOUTHERN AFRICA
A SPECIAL INTEREST GROUP OF SA HEART®

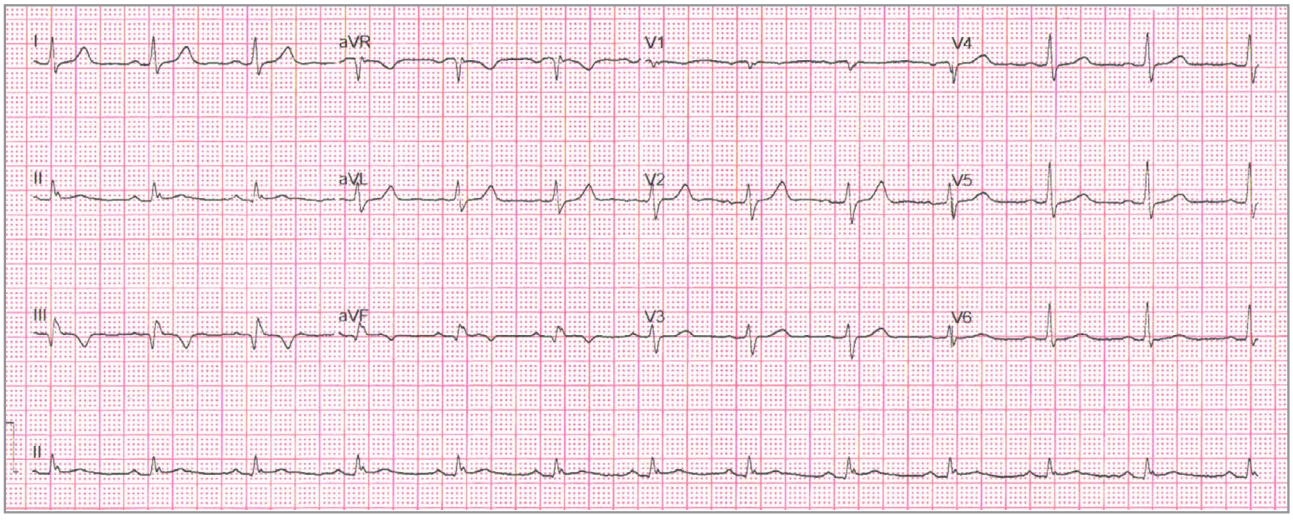
A Chin and RS Millar
Cardiac Clinic, University of Cape Town / Groote Schuur Hospital
Cardiac Arrhythmia Society of Southern Africa (CASSA)

A Chin https://orcid.org/0000-0001-6930-3673
RS Millar https://orcid.org/0000-0002-5608-0623
DOI: https://doi.org/10.24170/22-3-7668 / https://doi.org/10.24170/22-3-7705

A 64-year-old man presents to the emergency room with an acute episode of chest pain.



A 90-minute electrocardiogram (ECG) is performed post-thrombolytic therapy.



QUESTION: What is the diagnosis?

a. Acute high lateral ST-segment elevation myocardial infarction (STEMI).

b. Acute high lateral STEMI and inferior/posterior STEMI.

c. Acute inferior/posterior STEMI.

QUESTION: What is the best explanation for the findings?

a. The patient had 2 STEMIs in 2 coronary territories.

b. Coronary anomaly.

c. Lead reversal.

Please analyse the ECG carefully and commit yourself to an answer before checking the explanation.

ANSWER on page 198

ECG Quiz 69

CASSA
CARDIAC ARRHYTHMIA SOCIETY OF SOUTHERN AFRICA
A SPECIAL INTEREST GROUP OF SA HEART®

ANSWER

OVERVIEW OF THE ECGS

The presenting ECG shows a regular rhythm, with a rate of 72 bpm. The P wave axis is at 0 degrees. There is 1.5–2 mm ST-segment elevation in leads I and aVL, and a 1–2 mm ST-segment depression in leads III, aVF, V1, and V2. The 90-minute ECG shows a regular rhythm, with a rate of 78 bpm. The P wave axis is +45 degrees. The ST-segment elevation and depression have resolved. Q waves are visible in leads III and aVF, with T wave inversion.

MORE DETAILED ANALYSIS OF THE ECGS

The presenting ECG shows features of an acute high lateral STEMI with ST-segment elevation in leads I and aVL. ST-segment depression in leads III and aVF may be due to reciprocal change. The P wave axis is not compatible with a sinus rhythm and suggests an ectopic atrial rhythm. An acute high lateral STEMI may have isolated ST-segment elevation in V2 (the so-called "South African flag sign").[1] In this ECG, ST depression is present in V1 and V2, which cannot be explained by reciprocal change alone. A concomitant posterior STEMI in the absence of an acute inferior STEMI is a possible explanation; however, it is unusual with an acute high lateral STEMI. Posterior leads were not performed in the acute setting and would have been useful.

The 90-minute ECG post-lytic therapy shows apparent resolution of ST-segment elevation in leads I and aVL. The ST-segment depression in leads III, aVF, V1, and V2 have also resolved. Notably, there are now pathological Q waves present in leads III and aVF, with T wave inversion, suggesting an evolved acute inferior STEMI. There is also a change in the P wave axis to 45 degrees (now compatible with a sinus rhythm). No Q waves are seen in leads I and AVL to suggest an evolved high lateral STEMI. A dominant R wave in V1 is not present to suggest an evolved posterior STEMI.

In summary, this patient appears to have ST-segment elevation and depression compatible with high lateral STEMI (presenting ECG), inferior STEMI (90-minute ECG), and a possible posterior STEMI (presenting ECG). While an inferior and posterior STEMI can occur together, usually due to an occlusion in a dominant right coronary artery, a high lateral STEMI is usually due to an occlusion in the first diagonal branch artery, implying concomitant occlusions in 2 different coronary arteries, which is highly unlikely. A coronary anomaly or collateral supplying both these territories is also very unlikely.

So, did this patient have a high lateral STEMI and/or an inferior/posterior STEMI? A big clue is the change in the P wave axis and the unchanged aVR in both ECGs. Incorrect placement of the limb lead electrodes can account for the change in the P wave axis. It can result in the apparent change in ST-segment elevation/depression in different territories. The abnormal P wave axis suggests that an incorrect lead placement occurred on the presenting ECG.

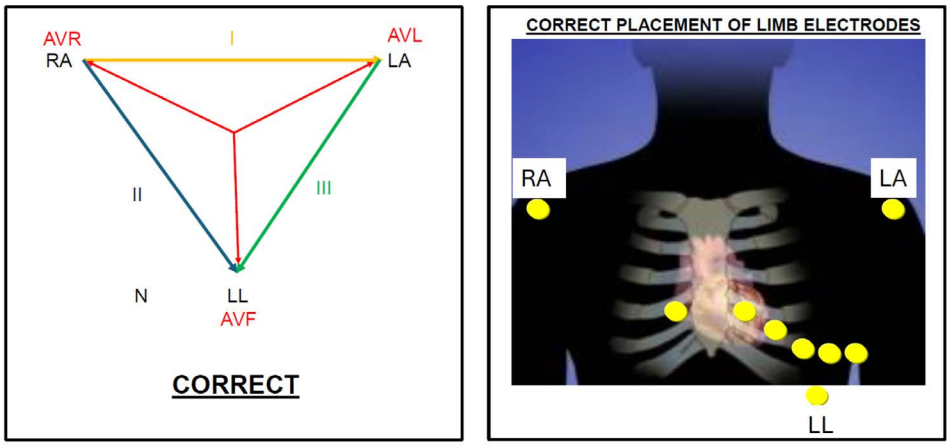


FIGURE 1: Einthoven's triangle showing the vectors for bipolar and augmented leads (left) and correct placement of limb electrodes (right).

In this case, the left arm (LA) and left leg (LL) electrodes have been swapped on the presenting ECG (incorrect lead placement). The right arm (RA) electrode is in the same place for both ECGs, as aVR is unchanged. To understand how these changes can take place, an understanding of the normal lead electrode placements and Einthoven's triangle is needed (Figure 1).

The 3 bipolar leads are leads I, II, and III:

- Lead I is the voltage difference between the LA and RA electrodes directed towards the LA at 0 degrees.
- Lead II is the voltage difference between the LL and RA electrodes directed towards the LL at +60 degrees.
- Lead III is the voltage difference between the LL and LA electrodes directed towards the LL at +120 degrees.

The 3 augmented unipolar leads are leads aVL, aVF, and aVR (directed from Wilson's central terminus):

- Lead aVL is directed towards the LA electrode (-30 degrees).
- Lead aVF is directed towards the LL electrode (+90 degrees).
- Lead aVR is directed towards the RA electrode (-150 degrees).

When the LA and LL lead electrodes are swapped (LA/LL reversal), Einthoven's triangle changes (Figure 2):

- aVR remains unchanged.
- Leads I and II are swapped.
- Leads aVL and aVF are swapped.
- Lead III becomes inverted.

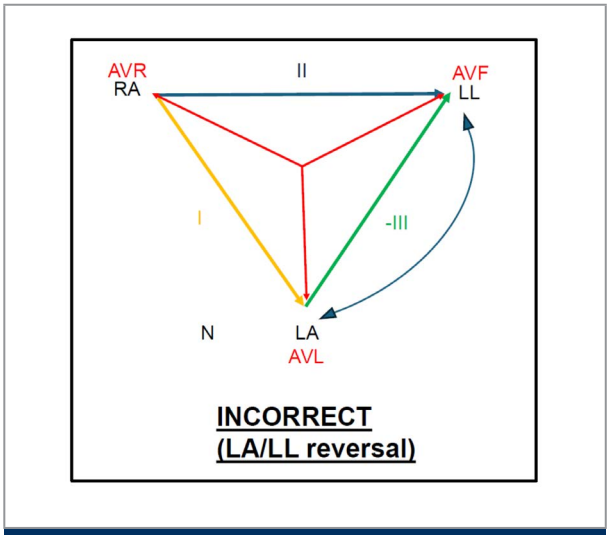


FIGURE 2: Incorrect lead positions and vectors with left arm (LA) and left leg (LL) reversal with the change in vectors; note that lead III is inverted.

We can now look at the presenting ECG where the lead swap occurred and compare it with the "corrected" lead positions (Figure 3). It becomes clear when the leads are corrected that the patient has an acute inferior/posterior STEMI with ST-segment elevation in II, III, and aVF, with reciprocal ST-segment depression in aVL.

Therefore, the answers are c) acute inferior/posterior STEMI, and c) lead reversal. An occlusion in a coronary anomaly (e.g. a "wrap-around" LAD [left anterior descending] that supplies the anterior and inferior wall of the left ventricle) can produce an acute anterior/inferior STEMI with ST-segment elevation in V1–V3, II, III, and aVF. This patient had a coronary angiogram the

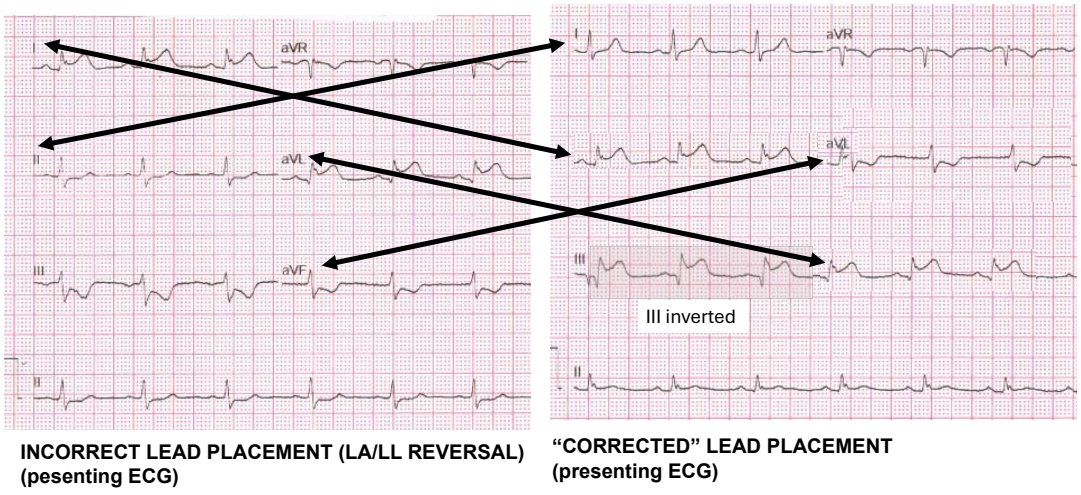


FIGURE 3: Presenting ECG with incorrect left arm (LA) and left leg (LL) reversal (left ECG), and "corrected" lead placement confirming an acute inferior/posterior STEMI (right ECG)

following day, which confirmed a severe stenosis in the proximal right coronary artery, which was stented.

DISCUSSION

Many different combinations of limb lead reversal can occur (including LA/RA, LA/LL, and RA/LL). In addition, clockwise rotation of leads (RA becomes LA, LA becomes LL, and LL becomes RA) or anticlockwise rotation of leads can occur (RA becomes LL, LL becomes LA, and LA becomes RA) – which can be quite confusing! Obviously, the chest leads will not change with limb lead reversal.

The most common lead reversal is RA/LA reversal. With RA/LA reversal:

- aVF remains unchanged.
- Leads II and III are swapped.
- Leads aVL and aVR are swapped.
- Lead I becomes inverted.

Think of lead reversal when an abnormal P wave axis is present on an ECG, and whenever there are unexplained changes in QRS/ST or T wave morphologies between ECGs performed at different times.

REFERENCE

1. Littmann L. South African flag sign: A teaching tool for easier ECG recognition of high lateral infarct. Am J Emerg Med. 2016;34(1):107-109.