CME Article

Misleading ECG recordings

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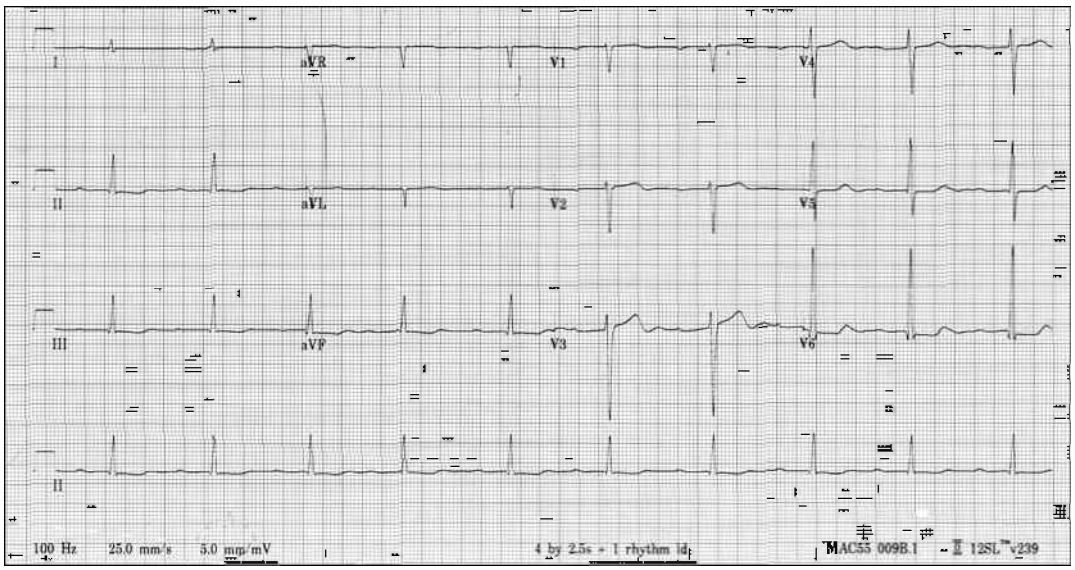

Fig. 1 Case 1. Initial 12-lead ECG.

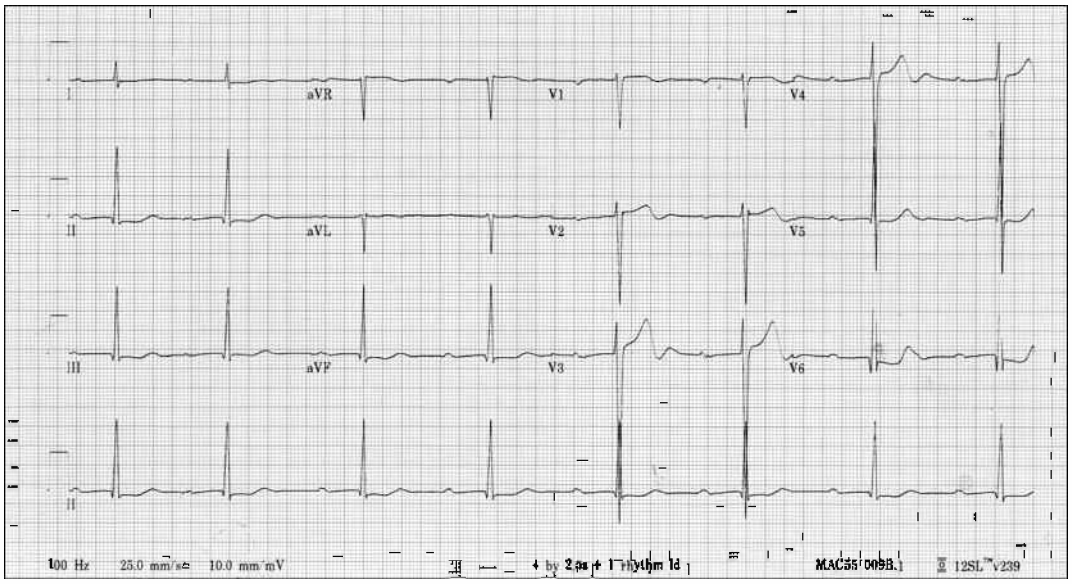

Fig. 2 Case 1. Subsequent 12-lead ECG taken 14 hours later.

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CASE 1

CLINICAL PRESENTATION

A 69-year-old Chinese man was admitted electively after an uncomplicated endoscopic duodenal polypectomy. The patient had a prior history of end-stage renal failure following a cadaveric renal transplant. He was admitted five months ago for fluid overload and non-ST-elevation myocardial infarction. Dipyrimidamole myocardial perfusion imaging subsequently demonstrated normal coronary flow reserve and a mildly depressed post-stress left ventricular ejection fraction of 48%. He was urgently referred to the cardiology service, as the managing team noted new ST segment elevation in the anterior leads on routine electrocardiogram (ECG). The patient was asymptomatic. Fig. 1 shows the initial ECG obtained, and Fig. 2 shows the subsequent ECG taken 14 hours later, when the referral was made. Is there an acute anterior ST segment elevation myocardial infarction?

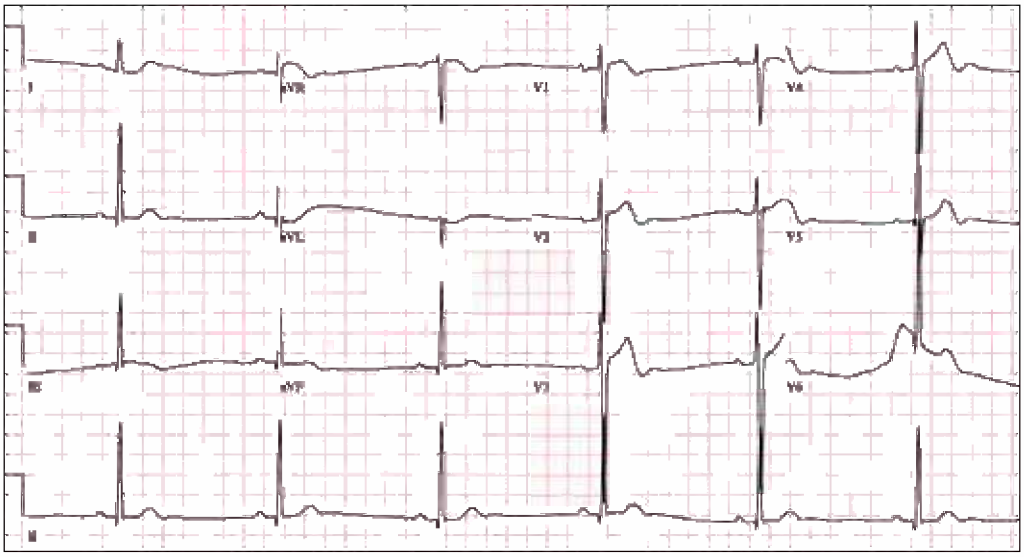

Fig. 3 Case 1. Previous 12-lead ECG done in 2005.

ECG INTERPRETATION

Both ECGs show sinus bradycardia with a first-degree atrioventricular block. There is a more marked ST elevation in leads V1 to V4 (Fig. 2). However, Fig. 1 was an ECG obtained with a vertical scale of 5 mm/mV, while Fig. 2 was obtained with a vertical scale of 10 mm/mV. Fig. 3 shows a previous ECG of the patient done in 2005 with a vertical scale of 10 mm/mV. The apparent ST elevation was in fact due to an amplification of the QRS complexes as a result of the different vertical scales.

CLINICAL COURSE

The patient was well, and there were no further changes on the repeat ECGs. Serial cardiac enzymes were also in the normal ranges.

CASE 2

CLINICAL PRESENTATION

A 64-year-old man presented to the emergency department with left shoulder pain and stiffness for one month. He had a prior history of diabetes mellitus on diet control and a personal history of smoking. This was apparently associated with diaphoresis. An ECG was performed (Fig. 4). A second ECG was repeated seven hours later (Fig. 5). The emergency medicine physicians were concerned with the new onset T inversions in the inferior leads (III and aVF), although the cardiac enzymes were within the normal ranges. The patient was admitted to the cardiology service for further evaluation. What is the significance of the T inversions in the inferior leads?

ECG INTERPRETATION

There is new T inversion in leads III and aVF (Fig. 5) compared to the initial ECG (Fig. 4). Also, the axis is clearly different, from −12° in the initial ECG to 72° in the second ECG. aVL is also negative in the second ECG. This is unusual in the setting of situs solitus. These are suggestive of incorrect lead placement. Repeat ECG with correct lead placement showed similar findings to the initial ECG (Fig. 4). The second ECG (Fig. 5) was obtained again when the left arm and left leg limb leads were switched. The T inversions were in fact due to inversion of the lead III tracing as a result of the lead switch.

CLINICAL COURSE

The patient was well, and there were no further 'changes' on the repeat ECGs. Serial cardiac enzymes were also in the normal ranges. Chest and shoulder radiographs were unremarkable. The patient was diagnosed to have mechanical shoulder pain likely due to rotator cuff syndrome. He was discharged with analgesia and scheduled for an outpatient orthopaedic review.

DISCUSSION

This report highlights a common pitfall in ECG interpretation. It is important to screen all ECGs for these problems, as errors in interpretation may lead to wrong diagnosis and further unnecessary investigations.

Voltage and time scale calibration

The standard ECG is recorded with time scale of 25 mm/s on the horizontal axis and a voltage sensitivity of 10 mm/mV on the vertical axis. Very often, the calibration setting for voltage sensitivity may be adjusted to allow amplification of low voltages or attenuation of high voltages. This gives rise to the potential of distorting the vertical components of the QRS tracing. A simple way to

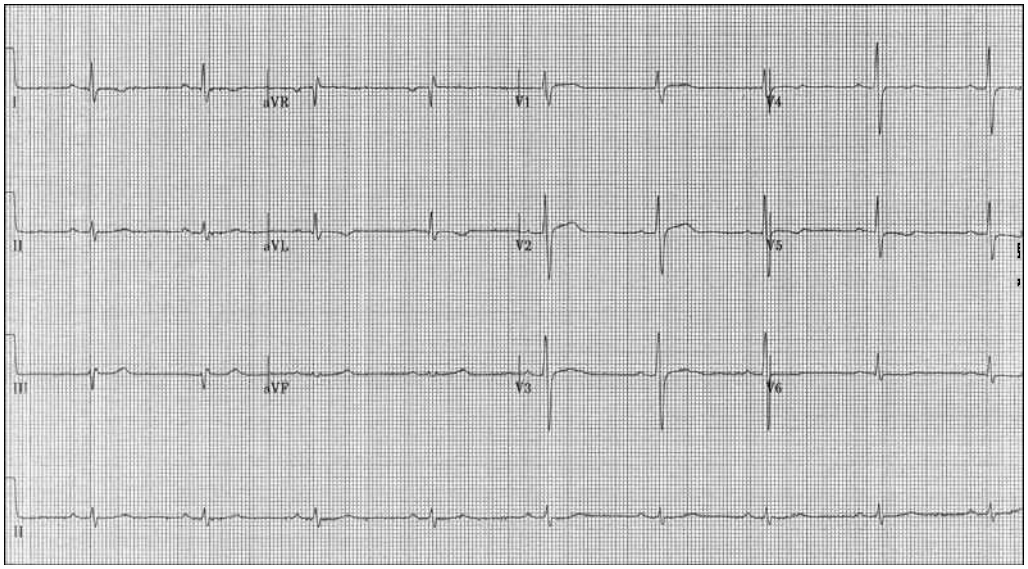

Fig. 4 Case 2. Initial 12-lead ECG.

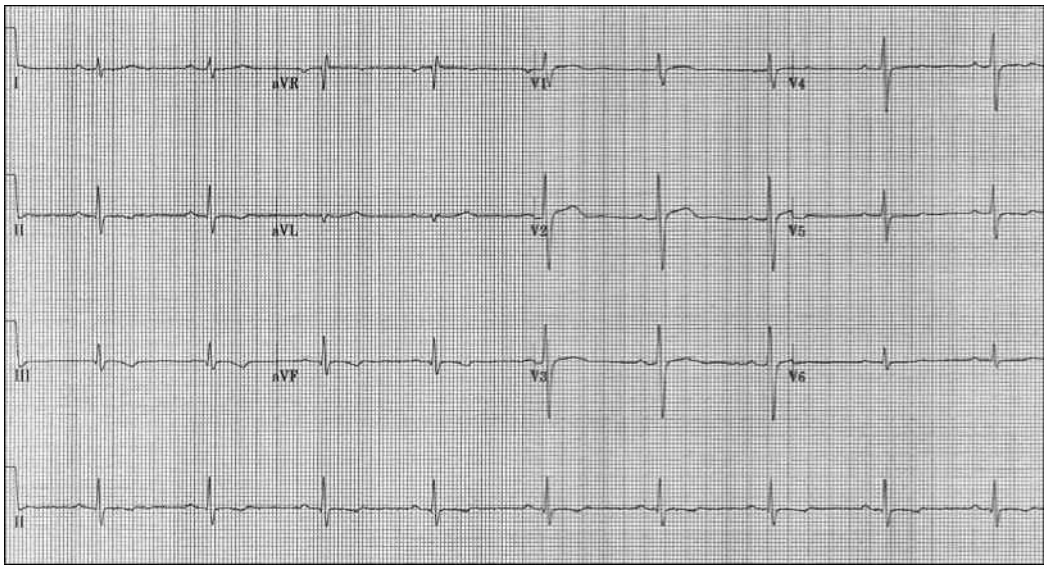

Fig. 5 Case 2. Subsequent 12-lead ECG taken 7 hours later.

screen for correct calibration is to look at the calibration marking at the beginning of the ECG tracing, as shown in Fig. 6. It should be 10 mm high and 5 mm broad for the standard calibration.

Lead switches

Lead switches (or more correctly, electrode cable switches) occur when a dedicated lead wire and electrode combination is misplaced, or when there is erroneous attachment of a dedicated lead wire to individually placed electrodes.[1] There are ten cables for the standard 12-lead ECG. Although colour coding of lead wires is a feature of manufacturing standards for ECGs,[2] even so, it is possible to misconnect the lead wires at the cable terminal. While computer algorithms are sometimes capable of detecting lead switches, there must first be a high index of suspicion. Reference to a prior or subsequent tracing with correct lead placement is key in detecting inadvertent lead switches.[1]

Transposition of the left arm and left leg lead wires, as demonstrated in Case 2, can be more difficult to recognise. This is because the main effects are often subtle shifts in axis and inversion of lead III.[3] Other common manifestations of lead transposition include: (a) Transposition of the left and right arm lead wires produces inversion of limb lead I, with a switch of leads II and III and a switch of leads aVR and aVL, whereas aVF remains unaltered;[1] (b) Transposition of the right arm and right leg lead wires is also easy to recognise, as lead II now records the nearly zero potential difference

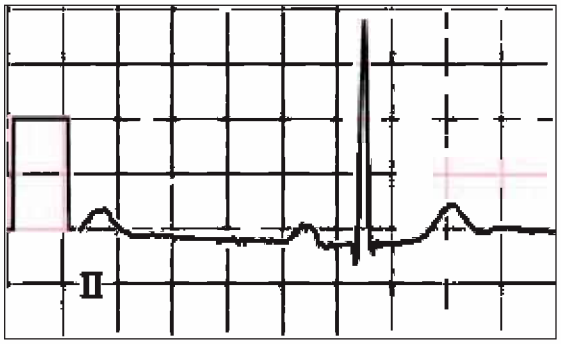

Fig. 6 Enlargement of lead II on the ECG in Fig. 3 shows the rectangular calibration signal measuring 10 mm tall and 5 mm broad. This indicates a standard calibration with time scale of 25 mm/s on the horizontal axis and a voltage sensitivity of 10mm/mV on the vertical axis.

that exists between the two legs,[4,5] which results in very low amplitude only in lead II, with inverted symmetry between standard lead I and lead III; (c) Transposition of the anterior chest lead wires can cause a reversal of R-wave progression that simulates anteroseptal wall infarction, but this misleading recording can often be recognised by distorted progression of the precordial P waves and T waves in the same leads.[1]

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ABSTRACT

Misleading electrocardiogram recordings are not uncommon, and can lead to misdiagnosis. This article highlights two examples and discusses the strategies to recognise them.

Keywords: calibration, electrocardiogram, lead switch

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REFERENCES

1. Kligfield P, Gettes LS, Bailey JJ, et al. Recommendations for the standardization and interpretation of the electrocardiogram: part I: the electrocardiogram and its technology a scientific statement from the American Heart Association Electrocardiography and Arrhythmias Committee, Council on Clinical Cardiology; the American College of Cardiology Foundation; and the Heart Rhythm Society endorsed by the International Society for Computerized Electrocardiology. J Am Coll Cardiol 2007; 49:1109-27.
2. American National Standards Institute. Diagnostic electrocardiographic devices (ANSI/AAMI EC11:1991/(R)2001). Arlington, VA: Association for the Advancement of Medical Instrumentation; 2000.
3. Abdollah H, Milliken JA. Recognition of electrocardiographic left arm/left leg lead reversal. Am J Cardiol 1997; 80:1247-9.
4. Haisty WK Jr, Pahlm O, Edenbrandt L, Newman K. Recognition of electrocardiographic electrode misplacements involving the ground (right leg) electrode. Am J Cardiol 1993; 71:1490-5.
5. Castellanos A, Saoudi NC, Schwartz A, Sodi-Pallares D. Electrocardiographic patterns resulting from improper connections of the right leg (ground) cable. Pacing Clin Electrophysiol 1985; 8 (pt 1):364-8.

SINGAPORE MEDICAL COUNCIL CATEGORY 3B CME PROGRAMME
Multiple Choice Questions (Code SMJ 201111A)

	True	False
Question 1. The standard ECG calibration scale is as follows:		
(a) Horizontal scale: 25mm/s; vertical scale: 5mm/mV.	☐	☐
(b) Horizontal scale: 50mm/s; vertical scale:10mm/mV.	☐	☐
(c) Horizontal scale: 25mm/s; vertical scale:10mm/mV.	☐	☐
(d) Horizontal scale: 50mm/s; vertical scale: 5mm/mV.	☐	☐
Question 2. The number of leads on a standard 12-lead ECG machine is:		
(a) 6.	☐	☐
(b) 10.	☐	☐
(c) 12.	☐	☐
(d) 24.	☐	☐
Question 3. The indications of lead switch on a 12-lead ECG include:		
(a) Abnormal QRS axis.	☐	☐
(b) T-inversion.	☐	☐
(c) Abnormal R wave progression.	☐	☐
(d) Negative aVL in a patient with dextrocardia.	☐	☐
Question 4. In the interpretation of ECGs:		
(a) Diagnoses given by ECG analysis programmes are always correct.	☐	☐
(b) There is no value in obtaining previous ECGs for comparison.	☐	☐
(c) The clinical context is vital to the correct interpretation of ECGs.	☐	☐
(d) It is important to ensure identical ECG calibration scale when comparing QRS complex morphologies.	☐	☐
Question 5. Regarding ECG manifestations of lead switches:		
(a) Transposition of the left arm and left leg lead wires causes ST segment depression in lead III.	☐	☐
(b) Transposition of the left and right arm lead wires causes inversion of limb lead I, with a switch of leads II and III and a switch of leads aVR and aVL.	☐	☐
(c) Transposition of the right arm and right leg lead wires causes inverted symmetry between standard lead I and lead III.	☐	☐
(d) Transposition of the anterior chest lead wires can simulate inferior wall infarction.	☐	☐

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