Case Report

Lead-Reversal ECG Simulating Myocardial Infarction – A Case Report and Literature Review

Mohammad Gaffar Amin[1], Abdul Wadud Chowdhury[2], Mohsin Ahmed[3], Khandker Md Nurus Sabah[4], Hasna Fahmima Haque[5], Syed Rezwan Kabir[6], Kazi Nazrul Islam[7], Mohammad Abaye Deen Saleh[8]

Abstract:

Electrocardiogram (ECG) is one of the most important and time-tested tool for appropriate interpretation and diagnosis of coronary artery disease (CAD) and other structural & electrical cardiac abnormalities. Erroneous misplacement of surface ECG-leads (lead reversal) may result in wrong interpretation as well as unnecessary investigations, admission to hospital and improper treatment. Early & prompt recognition of lead-reversal is imperative to avoid inappropriate & harmful therapeutic interventions to the patients. This case-report focuses on an interesting scenario of ECG-lead misplacement, which will aid in detection, exclusion and further prevention of ECG lead misplacement.

Key words: Electrocardiogram diagnosis, Myocardial infarction

(Bangladesh Heart Journal 2016; 31(2) : 104-108)

Introduction

The electrocardiogram (ECG) is one of the most important and most frequently requested investigations in the management of patients in medical practice. It is both inexpensive and very efficacious in many different clinical scenarios. Proper & meticulous recording is of utmost importance in order to ensure an accurate interpretation of this time-tested diagnostic tool. Due to structural variation of different health-care programs, ECGs may not be recorded by expert technicians at all times; this leads to multiple errors in interpreting results. ECG-lead misplacement or reversal, that occurs in 0.4–4% of all 12-lead surface ECGs acquired in various clinical settings, results in erroneous interpretation as well as unnecessary investigations, admission to hospital and improper treatment.[1,2] As a result incorrect ECG-Lead placement can result in signiûcant harm to the patient if essential treatment is withheld or unnecessary treatment is delivered solely on the basis of ECG ûndings.[2] An interesting case of ECG-lead misplacement is presented here, which would have resulted in signiûcant harm to the patient had it not been identiûed in time.

1. Assistant Professor, Department of Cardiology, Dhaka Medical College Hospital, Dhaka, Bangladesh.
2. Professor & Head. Department of Cardiology, Dhaka Medical College Hospital, Dhaka, Bangladesh.
3. Associate Professor, Department of Cardiology, Dhaka Medical College Hospital, Dhaka, Bangladesh.
4. Assistant Professor, Department of Cardiology, Dhaka Medical College Hospital, Dhaka, Bangladesh.
5. Registrar, Dept. of Medicine, BIRDEM, Dhaka, Bangladesh.
6. Junior Consultant, Department of Cardiology, Dhaka Medical College Hospital, Dhaka, Bangladesh.
7. Junior Consultant, Department of Cardiology, Dhaka Medical College Hospital, Dhaka, Bangladesh.
8. Registrar, Department of Cardiology, Dhaka Medical College Hospital, Dhaka, Bangladesh.

Address of Correspondence: Dr. Mohammad Gaffar Amin, Assistant Professor, Dept. of Cardiology, Dhaka Medical College Hospital, Dhaka, Bangladesh. E-mail: gaffaramin@gmail.com

Case report

A 30 years old young man attended the cardiac out-patient department (OPD) of Dhaka Medical College Hospital (DMCH) with the complaints of non-specific chest-pain and occasional palpitation for two months. The pain was burning in nature, centered to lower chest and upper abdomen, non-radiating, occurring several times a day having no obvious precipitating factors but used to relieve by taking antacids & PPIs. The pain was associated with occasional palpitation which was of short duration & self-limiting. He complained of abdominal fullness but no history of nausea or vomiting. He was non-smoker & non-alcoholic. His father died of cardiac disease at 65 years of age. The patient was hemodynamically stable with pulse 80 beats/min, regular, normal in volume & character and BP 110/70mmHg. His precordial examination was normal and other systems revealed no abnormality. To evaluate the chest pain the attending doctor suggested a 12 lead

surface ECG (Figure 1) and later labeled the ECG as old myocardial infarction (MI) involving the inferior wall of heart. He immediately referred the patient to cardiac in-patient department (IPD) for further management. The attending consultant cardiologist reviewed the ECG thoroughly and found that the OPD-doctor interpreted the ECG on the basis of deep QS complexes & inverted T waves in leads II,III & aVF but he missed the inverted p waves in those leads; he also missed the completely inverted lead I and completely upright lead aVR (P wave, QRS complex and T wave).The attending consultant advised a repeat & supervised ECG (Figure 2)which was found completely normal. Transthoracic echocardiography was done later, which was unremarkable. The patient's initial ECG abnormalities were finally diagnosed as erroneous misplacement of limb leads of ECG and he was sent to Gastro-enterology department for further management.

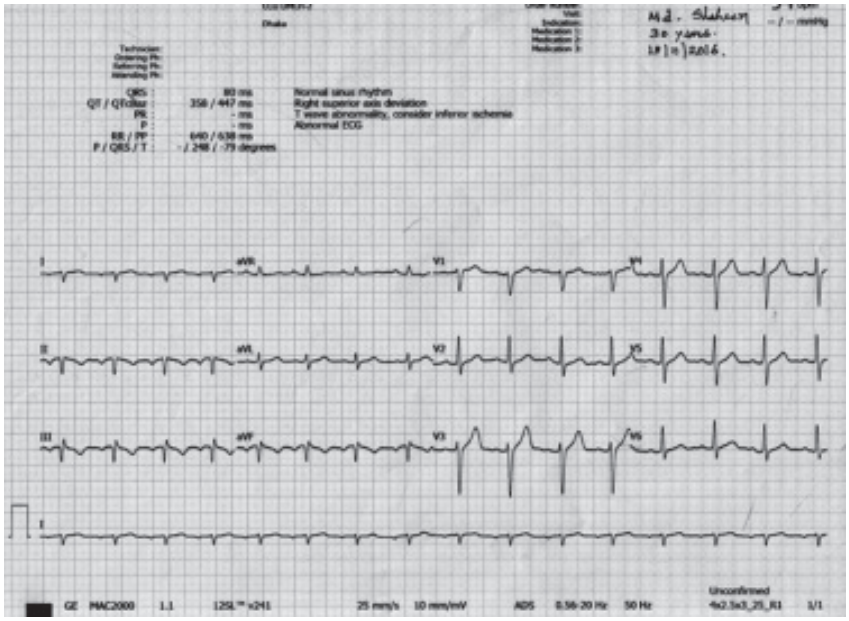

Fig.-1: *Initial ECG done at Cardiac OPD of DMCH*

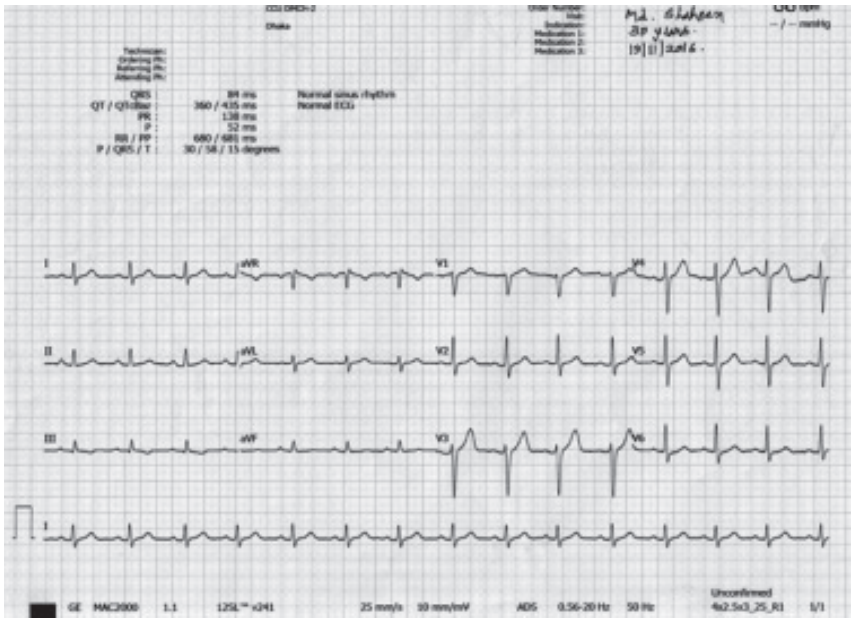

Fig.-2: *Repeat supervised ECG done at Cardiac IPD of DMCH*

Discussion:

Cardiovascular diseases are the leading cause of death world-wide, accounting for 30% of all deaths.[3] Of these, 42% are due to coronary artery disease (CAD).[4]Proper ECG recording facilitates appropriate interpretation and diagnosis of CAD and other structural & electrical cardiac abnormalities. Electrode misplacements can lead to morphological changes on ECG that may potentially be interpreted as ischemic or arrhythmogenic in origin or may conceal the ECG features altogether. Therefore, recognition of the patterns seen in improper lead positioning is essential to avoid incorrect diagnoses and unnecessary treatments.[5-9]The frequency of electrode misplacement has been shown to increase with increasing acuity of patient care and urgency of recording. Rudiger et al. reported a 0.4% rate of lead misplacement on ECGs performed on patients attending cardiac outpatient clinics and a 10-fold increased rate (4%) among patients in intensive care units.[1] Several key findings on an ECG can help clinicians identify potential signs of electrode misplacements. In order to systematically identify these telltale clues, mnemonics to remember common errors and recognize their findings have been previously proposed. The REVERSE mnemonic is one such tool that outlines the most frequent abnormal findings on ECG (Table 1).[10]

The 12-lead ECG is recorded by placing 10 electrodes (4 limb & 6 precordial) on predetermined anatomical locations. The terms electrode and lead are often used interchangeably. However, electrodes attach to the skin while leads are the vectors between the electrodes.[2]The four limb electrodes [right arm (RA), left arm (LA), right leg (RL), left leg (LL)] generate six limb leads (leads I, II, III, aVR, aVL, and aVF). The right leg electrode (RL) is the grounding electrode and can be placed anywhere on the body without affecting the ECG appearance.[11,12]ECG ûndings due to limb electrodes misplacement can be difûcult to detect despite producing characteristic appearances in most cases (Table2).[2]

With reversal of the RA and LL electrodes, Einthoven's triangle rotates 180 degrees vertically, from normal, around an axis formed by aVL (Figure 3 & Figure 4).[11,13,14]

Table-I

REVERSE mnemonic: an easy approach to remember the most frequent causes of ECG lead placement errors and artifacts.

	Abnormal Finding	Significance
R	R wave is positive in lead aVR (P wave also positive)	Revarsal of left arm and right arm electrodes
E	Extreme axis deviation: QRS axis between +180^o and -90^o Negative R wave in lead I, positive R wave in aVF	Reversal of right leg and left arm or rigt arm electrodes
V	Very low (<0.1 mV(amplitude in an isolated limb lead (isolated "flat" lead)	Reversal of right left and left arm or right arm electrodes
E	Exchanged amplitude of the P waves (P wave in lead I Greager	Reversal of left arm and left leg electrodes
R	R wave abnormal progression in the precordial leads (predominant R wave in V1, predominant S wave in V6	Reversal of precordal electrodes (V1 through V6)
E	Eliminate noise and interference (artifact mimicking tachycardias or ST-T changes)	

Table-II

ECG changes resulting from interchange of the limb leads.

Leads	RA-LA reversal	RA-LL reversal	RA-RL reversal	LA-RL reversal	LA-LL reversal	LL-RL reversal
I	Inverted	Inverted III	Inverted III	II	II	Unchanged
II	III	Inverted II	Flat line	Unchanged	I	Unchanged
III	II	Inverted I	Unchanged	Flat line	Inverted III	Unchanged
aVR	aVL	aVF	Same as aVF (1/2 size III)	Inverted II	Unchanged	Unchanged
aVL	aVR	Unchanged	Inverted III	Same as aVF (1/2 size II)	aVF	Unchanged
aVF	Unchanged	aVR	Same as aVR (1/2 size III)	Same as aVF (1/2 size II)	aVL	Unchanged

RA, right arm; LA, left arm; RL, right leg; LL, left leg.This describes what the ECG output actually represents for each case of reversal. For example, in RA-LA reversal lead II actually represents lead III. Note: aVR and aVF are never the same in correct electrode placement.

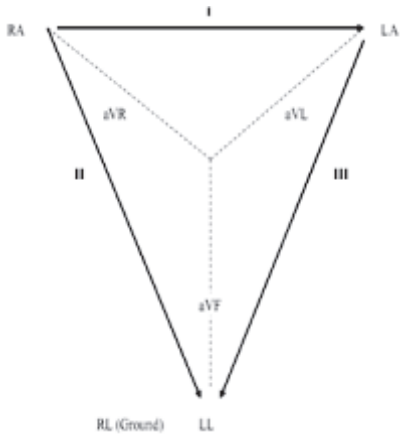

Fig.-3: *Normal Einthoven's triangle formed by six limb leads*

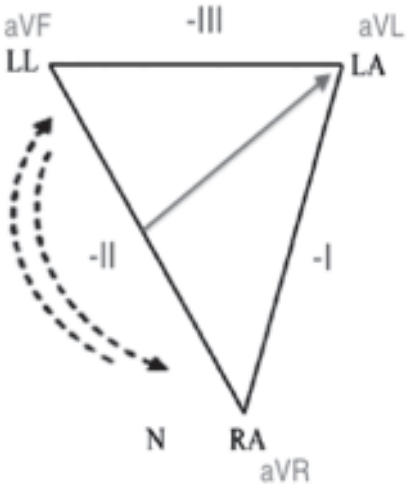

Fig.-4: *Rotation of Einthoven's triangle due to RA-LL reversal*

This produces the following effects on the ECG (Figure5):[11,13,14]

- Lead II becomes inverted.
- Leads I and III become inverted and switch places.
- Leads aVR and aVF switch places; as a result Lead aVR becomes upright & Lead aVF becomes inverted.
- Lead aVL is unchanged.

These ECG changes can closely mimic a chronic phase inferior myocardial infarction due to inverted T waves and QS complexes in leads II, III and aVF. However, a high index of suspicion is required to detect lead reversal, as lead I and aVR will not be inverted from baseline in an inferior myocardial infarction.[15]

In our case, the initial ECG of the patient done in cardiac OPD showed deep QS complexes & inverted T waves along with inverted p waves in leads II, III & aVF; lead I was also completely inverted and lead aVR was completely upright (P wave, QRS complex and T wave). These findings were consistent with reversal of right arm and left leg electrodes. However the subsequent supervised ECG done at CCU was completely normal which confirmed the diagnosis of an interesting case of ECG limb-leads reversal.

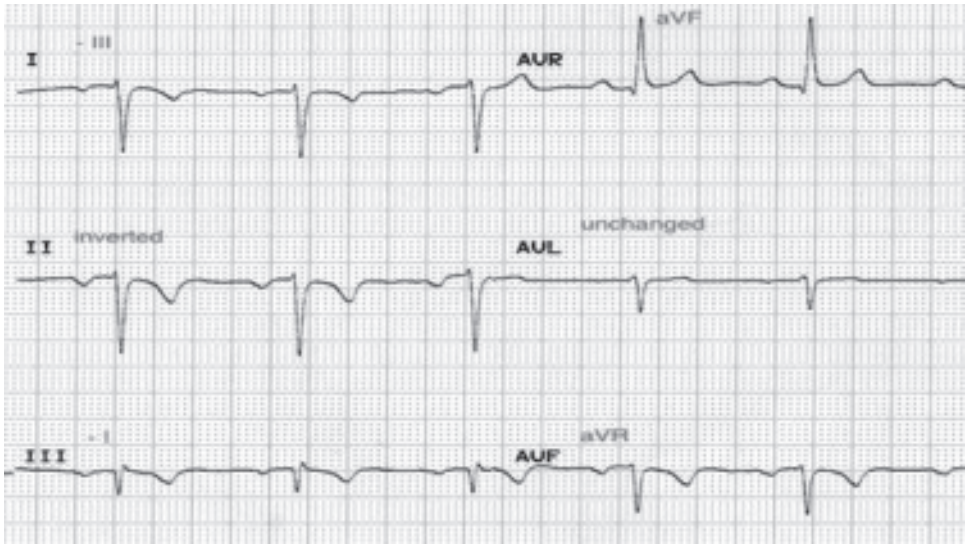

Fig.-5: *12 lead ECG depicting right arm and left leg reversal.*

Conclusion:

ECG lead misplacement is a common and under-reported technical error. Most ECG interpretation books devote little if any space to this extremely important topic. Early & prompt recognition is imperative to avoid unnecessary, inappropriate & harmful therapeutic interventions to the patients. The 12-lead ECGs should always be interpreted in the context of patient's history and clinical ûndings not relying solely on the ECG tracing. Measures like - ongoing education, obtaining repeat & supervised 12-lead ECG, double checking of lead placement by two staff members, reviewing old ECGs of the same patient and preserving ECG-strips containing the error for training purpose should be encouraged to aid in the detection, exclusion and further prevention of lead misplacement.

References:

1. lectrocar-Rudiger A, Hellermann JP, Mukherjeec R, Follath F, Turina J. Electrocardiographic artifacts due to electrode misplacement and their frequency in different clinical settings. Am J Emer Med. 2007;25: 174–8.
2. Lynch R. ECG lead misplacement: A brief review of limb lead misplacement. African Journal of Emergency Medicine. 2014;4:130–139.
3. Global status report on non-communicable diseases 2010. Geneva. World Health Organisation. 2011.
4. Global atlas on cardiovascular disease prevention and control. Geneva. World Health Organisation. 2011.
5. Knight BP, Pelosi F, Michaud GF, Strickberger SA, Morady F. Clinical consequences of electrocardiographic artifact mimicking ventricular tachycardia. N Engl J Med. 1999;341(17):1270-4.
6. Srikureja W, Darbar D, Reeder GS. Tremor-induced ECG artifact mimicking ventricular tachycardia. Circulation. 2000;102(11):1337-8.
7. Knight BP, Pelosi F, Michaud GF, Strickberger SA, Morady F. Physician interpretation of electrocardiographic artifact that mimics ventricular tachycardia. Am J Med. 2001;110(5):335-8.
8. Rudiger A, Schob L, Follath F. Inûuence of electrode misplacement on the electrocardiographic signs of inferior myocardial ischaemia. Am J Emerg Med. 2003;21(7):574–7.
9. Jowett NI, Turner AM, Cole A. Modiûed electrode placement must be recorded when performing 12-lead electrocardiograms. Postgrad Med J. 2005;81:122–5.
10. Baranchuk A, Shaw C, Alanazi H, Caupbell D, Bally K, Redfearn DP, et al. Electrocardiography pitfalls and artifacts: The 10 commandments. Crit Care Nurse. 2009;29(1):67-73.
11. Batchvarov VN, Malik M, Camm J. Incorrect electrode cable connection during electrocardiographic recording. Europace. 2007;9:1081–90.
12. Harrigan RA, Chan TC, Brady WJ. Electrocardiographic electrode misplacement, misconnection, and artifact. J Emerg Med. 2012;43(6):1038–44.
13. Chan TC, Brady WJ, Harrigan RA, Ornato JP, Rosen P. ECG in Emergency Medicine and Acute Care. Elsevier Mosby. 2005.
14. Surawicz B, Knilans T. Chou's Electrocardiography in Clinical Practice (6th edition), Saunders. 2008.
15. Ho KK, Ho SK. Use of the sinus P wave in diagnosing electrocardiographic limb lead misplacement not involving the right leg (ground) lead. J Electrocardiol. 2001;34(2):161-71.