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Brief Communication

ECG Mishaps, Artifacts and Operator Faults

Kaja Mohammad Rasheed

Abstract

Electrocardiography is one of the most frequent bedside investigations in clinical practice. Often they are performed and interpreted by less experienced personnel with inadequate expertise.Equipment settings, proper technique and standardizations are prerequisites which may be overlooked, leading to costly and dangerous misinterpretations. This article highlights operational faults in ECG and emphasises that clinical staff must be equipped with necessary knowledge to identify these mistakes. It also tries to classify the common errors arising due to artifacts, electrode misplacement and improper standardization along with providing possible remedial measures. An awareness of these often neglected aspects and incorporating them in clinical discussions would not only enhance ECG interpretation but also improve patient safety.

Key words: *lead reversal, ECG artifacts, electrocardiogram, EKG.*

Introduction:

Electrocardiography has risen as an indispensable tool for the hospital physician. Not just cardiac emergencies like arrhythmias and MI but the diagnosis and management of several non-cardiac conditions like electrolyte abnormalities, pulmonary embolism, thyroid abnormalities, hypothermia etc. rely on it.

Although specialists in electrophysiology and cardiology master its science and art, yet it is common place that the patients in the sickest state, in most need of accurate and prompt ECG diagnosis have the least experienced medical or paramedical staff by their side. Clinicians in areas of acute patient care like Emergency rooms, Intensive care units, acute medical units etc. need to be experts in ECG interpretation.

Before an electrocardiogram is printed we assume standards have been maintained ranging from proper working of the electrocardiograph with accurate settings, appropriate recording technique and several other factors, the minor alteration of which may lead to annoying, costly and dangerous misinterpretation. This was appropriately described by Marriot[1] as 'Heart disease of electrocardiographic origin' which are not infrequent.

Aim:

This article aims to apprise the possibility of errors that may occur due to operational inadequacies while recording an ECG and to suggest possible remedies specifically in relation to artifacts, lead misplacement and paper standardization.

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Discussion:

Operational errors may be classified as:

I. ECG Artifacts

II. Errors in electrode placement

III. Errors of standardization

I. ARTIFACTS:

1. **Internal artifacts/ Somatic tremors** (Fig 1)

   Electrical signals from non-cardiac tissues picked up on the ECG.

2. **External artifacts:**

   a) 60 Hz AC interference (electrical interference) (Fig 2)

      The source for this current is the wall AC power electric outlets.

   b) Offset signal stored by electrodes (Fig 3)

      This used to be a problem with older electrode materials like stainless steel but in newer electrodes the silver-silver chloride used does not allow significant build-up of offset potential.

   c) Electrode movement due to body fluid and gel (wandering baseline) (Fig 4)

   d) Lead wire and cable problems

Breaks in wires and connections, poor contact, loose pins at the cable end of the lead wire, and breaks in the conductors of lead wire or patient cable can cause intermittent loss of ECG tracing leading to the so called 'flat line artifact' (Fig 5).

Special issues:

1. Pseudo ventricular tachycardia[3] (Fig 6)

   It is a condition of sustained somatic tremor causing artifact raising suspicion of a VT.

2. Artifact to diagnose hypothermia (Fig 7)

   The ECG diagnosis of hypothermia is suggested by a triad of Osborne waves, bradycardia and tremor artifact.

Fig 1 Internal artifacts

Muscle signals

Signals from Epidermis

External artifacts

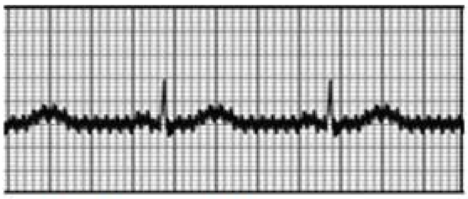


Fig 2 Electrical interference

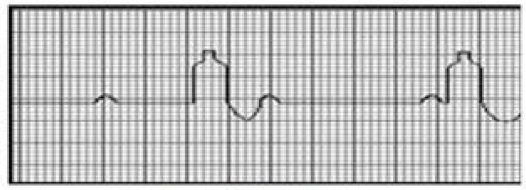


Fig 3 Offset signal

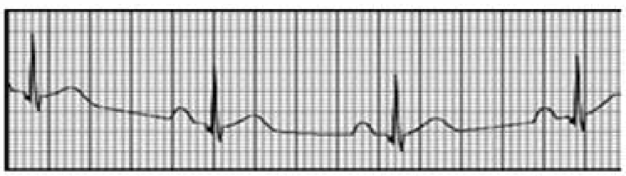


Fig 4 Electrode movement

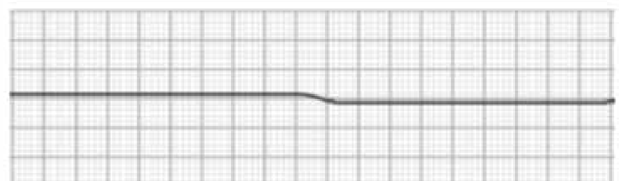
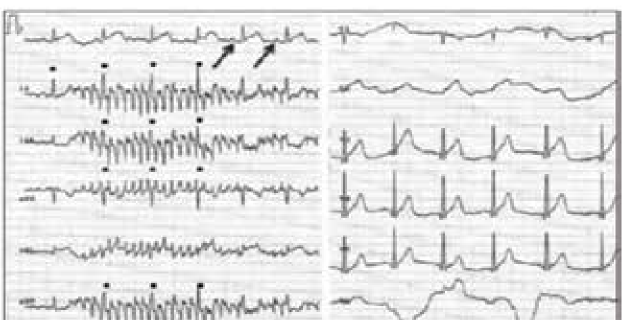


Fig 5 Flat line artifact

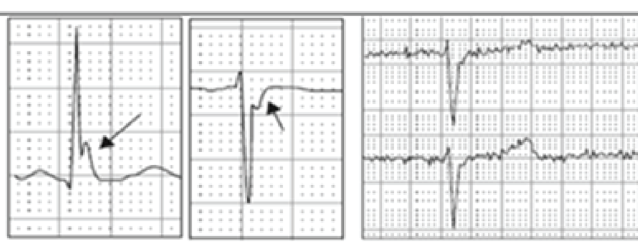


VT is seen limb leads. It can be noted that black notches are equal to or simple multiples of R-R intervals of native beats, the 'Notch sign'. Also lead I shows a sinus rhythm, arrows indicate P-waves followed by QRS complexes, the 'Sinus sign'. This suggests tremor induced pseudo-VT.

Fig 6 **Tremor induced Pseudo VT**

Remedy:

1. Proper and comfortable patient positioning to prevent movement as far as possible.
2. Skin preparation to ensure better electrode contact using razor, adhesive, tape, gel etc.
3. Moving the patient away from wall electric outlets prevents 60 Hz artifact.
4. Checking and replacing patient cables or lead wires periodically and when required.
5. Using fresh moist disposable electrodes that meet recommended standards,
6. Resorting to filtering techniques only if other measures fail[2].

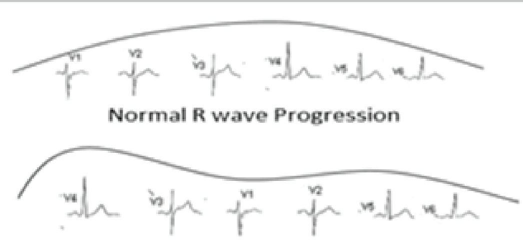


Osborne wave

Artifact

Bradycardia

Fig 7 **Triad of Hypothermia**



Chest electrode misplacement

Fig 8

Common filters available are Muscle filter, AC filter, wandering baseline filter etc.

Low frequency filter should be set no higher than 0.05 Hz to avoid ST segment distortion.

High frequency filters should be set no lower than 100 Hz.

II. ELECTRODE MISPLACEMENT:

In an ECG with proper lead placement[2], lead I has a positive P wave and a positive R wave. AVR has a negative P wave and a negative R wave. R waves progress in size across V1 to V4 and S wave decreases in size between V4 to V6.

Lead misplacement may cause false changes in ST segment, electrical axis, location of bundle branch blocks and infarct localization leading to misdiagnosis and delayed treatment and more seriously treatment initiation detrimental to the patient.

1. Chest electrode misplacement (Fig 8)

   Examples: V1 & V2 are frequently placed too high and other chest electrodes are frequently placed too low leading to false R wave progression which may get falsely attributed to LVH, RVH, COPD, ASMI or cardiomyopathy.

2. Limb electrode misplacement examples (Fig 9)

   The 4 electrodes attached to the limbs may be wrongly hooked in various combinations.

   Examples:

   RA & LA reversal: Most frequent reversal, presenting as a negative P - QRS complex in lead I.

   RA & LL reversal: Causes an inverted P-QRS complex in lead II that mimics an inferior myocardial infarction.

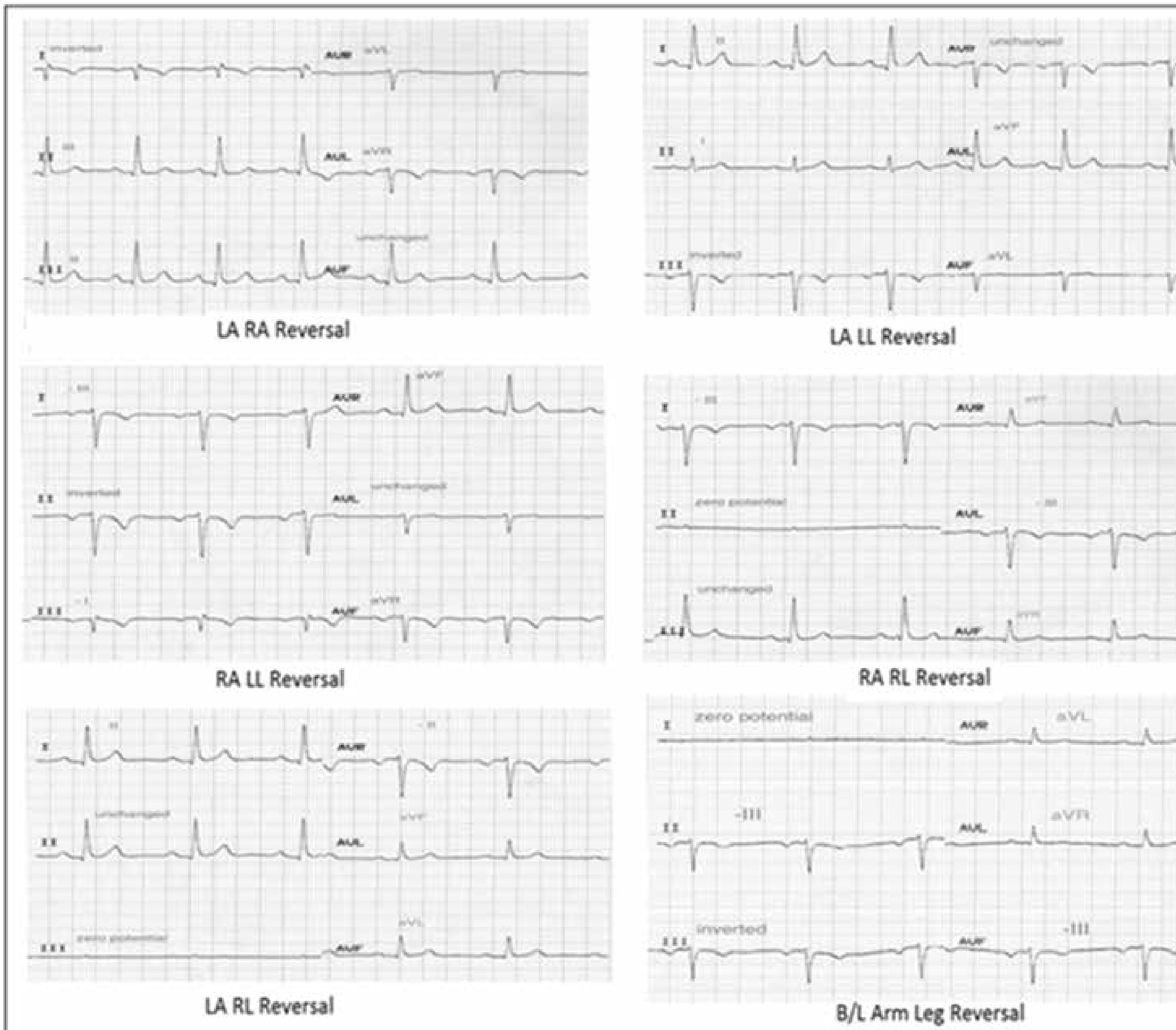


Fig 9 **Limb electrode reversal**

3. Differences in colour coding of electrodes (Fig 10)

   Facilities with multiple ECG machines from different manufacturers using different electrode colour coding may cause confusion among the staff. This can easily be rectified by standardizing each new machine with a preset local policy.

	AHA		IEC	
Location	Inscription	Colour	Inscription	Colour
Right Arm	RA	White	R	Red
Left Arm	LA	Black	L	Yellow
Right Leg	RL	Green	N	Black
Left Leg	LL	Red	F	Green
Chest	V1	Brown/Red	C1	White/Red
Chest	V2	Brown/Yellow	C2	White/Yellow
Chest	V3	Brown/Green	C3	White/Green
Chest	V4	Brown/Blue	C4	White/Brown
Chest	V5	Brown/Orange	C5	White/Black
Chest	V6	Brown/Purple	C6	White/Violet

Fig 10 Differences in electrode color coding

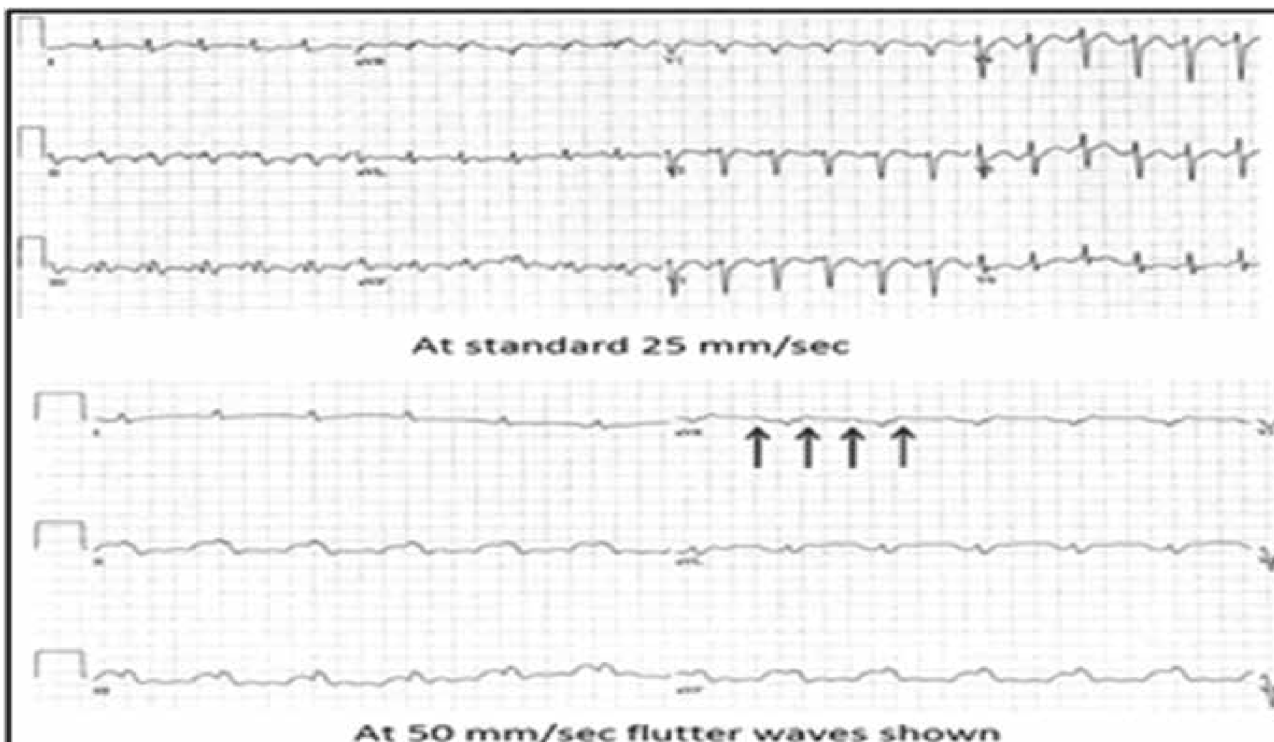


Fig 11 Changing the paper speed

Special issues:

In the absence of any electrode misplacement, an LA RA reversal pattern i.e. negative P wave in lead I along with poor R wave progression of chest leads may be the result of dextrocardia[2].

Remedy:

1. Routine ECG training, discussion and practice among team members regarding these operational mistakes is imperative.
2. Routinely excluding ECGs for a possibility of electrode misplacement.

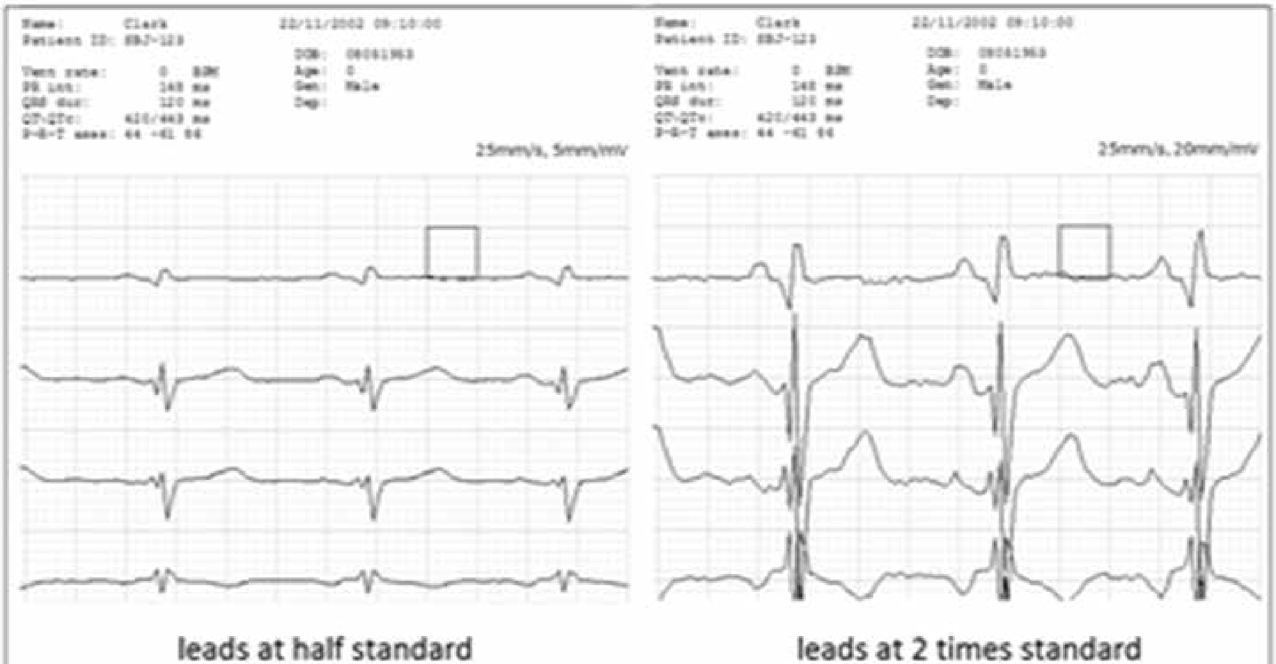


Fig 12 Adjusting the Gain setting

III. ECG STANDARDIZATION:

The ECG is normally recorded at a paper speed of 25 mm/sec and a gain setting of 10mm/mV. All interpretations by waveform measurements are based on these standards.

Distances between the QRS complexes may be widened by increasing the paper speed. This is particularly helpful to interpret ECGs where fast heart rates are encountered as in paediatric age group or to determine tachyarrhythmia types that are otherwise masked (Fig 11). At the same time ignoring the paper speed while interpreting ECGs may lead to fatal errors.

Complexes too tall may be reduced in size by adjusting the gain to 5mm/mV to facilitate counting. Modern machines print this on the electrocardiogram as 'All leads at half standard' (Fig 12) this should otherwise be mentioned by the operator to avoid any confusion. Interpretations for chamber hypertrophy, ST segment etc. would go wrong if the gain settings are not considered.

Conclusion:

Recording an ECG as per standard recommendations along with the knowledge of common operational mistakes is necessary not only for accurate diagnosis but also patient safety.

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