

Detection of Unicolor ECG Electrode Reversals in Standard 12-lead ECG

I Jekova^{1*}, R Leber², V Krasteva¹, R Schmid²

¹Institute of Biophysics and Biomedical Engineering, Sofia, Bulgaria

²Schiller AG, Baar, Switzerland

Lead reversals, reported in 0.4-4% of all standard 12-lead ECGs, can lead to erroneous diagnosis and wrong therapy decisions due to simulated false or missed ECG abnormalities. Although the interchange between 12-lead ECG cables with matching colors is likely an occasionally occurring scenario, the effect of this problem has not been addressed in the literature so far. The aim of this study is to test the ability of a commercial lead quality monitoring library (LQMLib, Schiller AG) to detect reversals between limb and chest unicolor ECG electrodes and to propose methods for improvements, where necessary.

We performed a retrospective analysis of 1332 12-lead ECGs collected at the Emergency Department of the University Hospital, Basel via Schiller CS-200 Excellence device. We assumed correct electrode placement during ECG acquisition and simulated 7 unicolor electrode reversals, including:

- 3 single color reversals of red (RC1), yellow (LC2), green (FC3) electrodes.
- 3 twofold color reversals of red-yellow (RC1-LC2), red-green (RC1-FC3), yellow-green (LC2-FC3) electrodes.
- 1 threefold color reversal of red-yellow-green (RC1-LC2-FC3) electrodes.

LQMLib was applied on bandpass filtered (0.5-25 Hz) segments of 4s. LQMLib algorithm indicated the position of reversed chest and limb leads by detection of distortions in the normal ECG pattern cross-correlation progression within the matrices of only chest leads [V1,V2,V3,V4,V5,V6] and only limb leads [I,II,III,-I,-II,-III,-aVR,-aVL,-aVF] vs. V6. The LQMLib algorithm has not been trained to detect any interchanges between limb and chest electrodes, including unicolor ones.

LQMLib sensitivity (Table 1) for detection of all simulated unicolor reversals is found to be satisfactory (Se=97.3–100%), except RC1 (Se=29.1%). We propose a method for LQMLib algorithm amendment by scanning the cross-correlation progression within a composite matrix of limb and chest leads [VR,V1,V2,V3]. Se is improved to 92.6%. The specificity for the correct electrode placement is 92.2%.

Table 1. LQMLib sensitivity for detection of unicolor electrode reversals.

Reversal	RC1	LC2	FC3	RC1-LC2	RC1-FC3	LC2-FC3	RC1-LC2-FC3
Se (%)	29.1*	97.3	97.5	98.5	99.2	99.8	100

*: Improvement to 92.6% is provided by the proposed method.