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Review

The classical versus the Cabrera presentation system for resting electrocardiography: Impact on recognition and understanding of clinically important electrocardiographic changes

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Abstract

The classical system for presentation of the 12-lead electrocardiogram (ECG) reflects the electrical activity of the heart as viewed in the transverse plane by 6 leads with a single anatomically ordered sequence, V_1–V_6; but in the frontal plane by 6 leads with dual sequences, I, II, and III, and aVR, aVL, and aVF. However, there is also a single anatomically ordered sequence of leads, called the Cabrera display that presents the six frontal plane leads in their anatomically ordered sequence of: aVL, I, −aVR, II, aVF, and III. Although it has been recognized that the Cabrera system has clinical diagnostic advantages compared to the classical display, it is currently only used in Sweden.

The primary explanation of why the Cabrera system has not been adopted internationally has been that analog ECG recorders had technical limitations. Currently, however, the classical system is most often seen as a historical remnant that prevails because of conservatism within the cardiology community.

Keywords: Cabrera system; Cardiac disease; Electrocardiography; Diagnostic criteria

Introduction

Since ECG leads have both positive (+) and negative (−) poles they may, of course, be viewed from either of these 180-degree distant spatial directions. The classical 12-lead electrocardiographic presentation system, most commonly used worldwide, presents the positive ECG leads in a single orderly sequence in the transverse plane: V_1, V_2, V_3, V_4, V_5 and V_6, but in two separate non-anatomical sequences in the frontal plane: I, II and III, and aVR, aVL, aVF (Fig. 1A) [1,2].

Lead +aVR "views" the heart from the right shoulder, while the other eleven leads "view" the heart from the left, from the front or from below. The directions of the ECG waveforms in lead +aVR, therefore, tend to be opposite their directions in the other leads. The interesting exception is lead $+V_1$. Since its view is both anterior and rightward, it also provides "+aVR-like" perspective of the waveforms. However, since lead $+V_1$ is displayed in the orderly sequence of the transverse plane, comparison with its neighboring lead is facilitated, in contrast to the situation for lead +aVR.

The consequence of the widespread use of the classical display is that ECG readers are typically unable to integrate consideration of lead +aVR into their overall ECG interpretation. This lead is, therefore, less used than other leads, but its potential clinical value could be facilitated if its waveforms were displayed in its inverted form as –aVR [1,3–8]. This lead then fills the 60°-gap between leads I and II, which results in an anatomically logical order for the frontal plane leads, termed the "Cabrera sequence": aVL, I, −aVR, II, aVF, III (Fig. 1B). The mathematical relationships among the frontal plane leads show that each augmented lead, +aVR, aVL and aVF, has the average electrical potentials (at any instant of time) of two of the leads I, II and III. The logical positions of leads aVR (in its inverted form, −aVR), aVL and aVF are therefore adjacent to leads I, II and III [1,4,9], as is the case with the Cabrera sequence.

Already in 1951, Graettinger et al. [10] published an article where they described that recording and displaying leads in the frontal plane in a logical sequence would enhance the ECG reader's visualization of the electrical activity of the heart. Not only did lead −aVR have an important role in their description, it constituted an essential part of the logical lead sequence.

No country other than Sweden has adopted the Cabrera system as national standard. The development in Sweden

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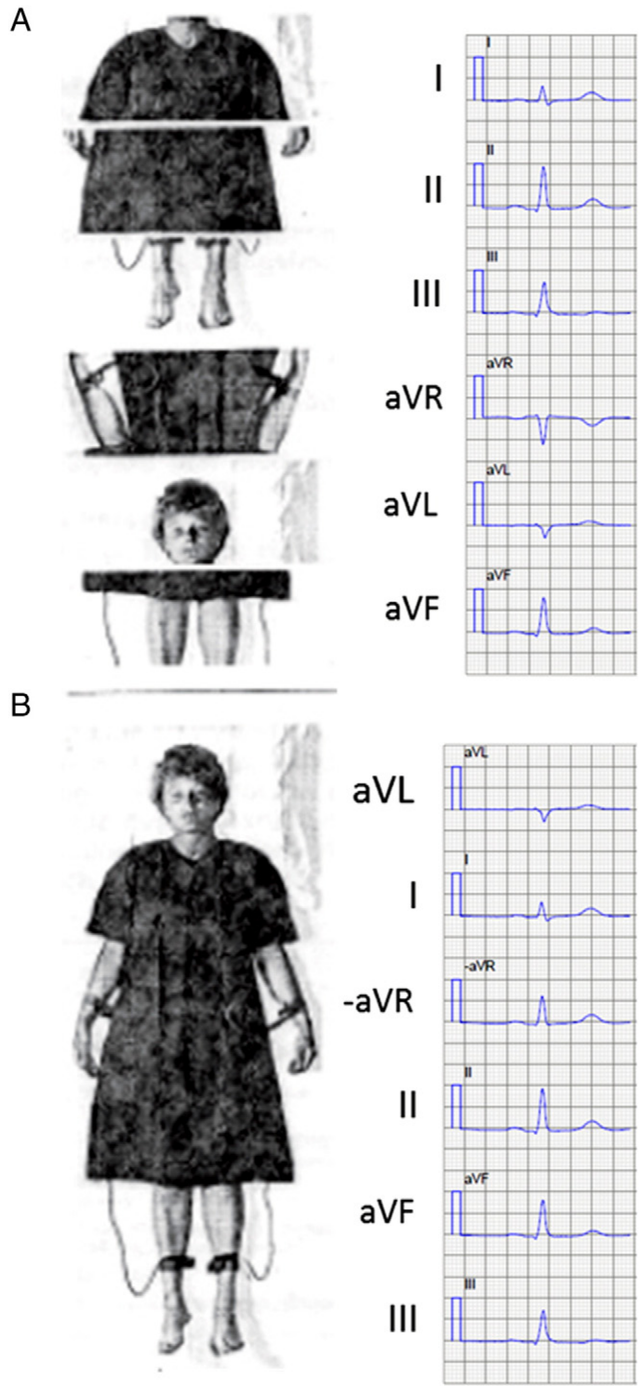

Fig. 1. When one takes a picture of a person one does not expect the various parts of the body to be shown in "jumbled" order (panel A), and even one of the sub-pictures shown upside down (panel A). This is akin to displaying the limb leads of the 12-lead ECG in the classical way. The Cabrera display (panel B) shows the limb leads in sequential, "anatomical" order.

goes back to a paper by White, which was published in the Journal of the Swedish Medical Association [2] and prompted trials of the Cabrera system in several Swedish hospitals. The evaluation of this system coincided with the standardization of the electrocardiographic leads, which facilitated a rapid decision process [11].

The purposes of this study are to analyze and to acknowledge the differences between the Cabrera system and the classical system.

Methods

This study is a review of articles with the PRISMA 2009 checklist-template [12] and it is based on three databases, PubMed, Web of Science and Embase. *"Lead aVR", "−aVR", "orderly presented ECG", "Cabrera system", "panoramic display", "orderly presented ECG" and "panoramic display"* were the terms that were used and there was no language restriction. The full texts of articles were read and decisions were made to include or not include the papers based on these inclusion criteria.

1) a distinct methods section present in the paper
2) the roles of the Cabrera system, lead +aVR or lead −aVR, are described
3) human studies

Historical development of the classical leads

Augustus Waller was the first to record electrical deflections linked to ventricular depolarization and repolarization in May 1887. The recording technique was improved by Willem Einthoven, and he recorded the first high-quality electrocardiogram in 1903. Einthoven was awarded the Nobel Prize in 1924 for his contribution to electrocardiography [13].

Einthoven introduced the "Einthoven triangle" which indicates the directions in the frontal plane of leads I, II and III, and this triangle is still used in teaching as well as in clinical practice. In 1934, the precordial leads (V_1–V_6) were established when Wilson connected a combination of three limb electrodes (this so-called Wilson's central terminal constituted the negative pole) and a body surface electrode (the positive pole), and measured the potential difference between these poles [13,14].

Later Wilson constructed leads VR, VL and VF. Lead VR measures the potential difference between the right arm and the central terminal. Leads VL and VF are measured similarly. Emanuel Goldberger constructed the "augmented limb leads" (labeled +aVR, aVL and aVF) with 50% higher amplitudes [15,16].

The Cabrera system

In the classical system, the limb leads are displayed with 60° intervals between lead I (0°), lead II (+60°) and lead III (+120°), and 120° intervals between lead +aVR (−150°), lead aVL (−30°) and lead aVF (90°) (Fig. 2A). Information may be missed if the electrocardiogram reader is not aware of the spatial orientation of the leads. The spatial orientation is much more easily appreciated in the Cabrera system, which gives an overview of the limb leads in a left-to-right sequence (aVL, I, −aVR, II, aVF, III) (Fig. 2B) [2,17].

In electrocardiograms recorded with the classical system the limb leads are typically presented as two groups of three leads, I, II, III and aVR, aVL, aVF (Fig. 3A). In the Cabrera system, the limb leads are often presented as one group of six leads, and leads V_1–V_6 as another group (Fig. 3B).

The progressions of ST-segment and Q, R and T waves which are highlighted by the anatomical presentation of the limb leads through the Cabrera system, are fundamental for