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SCIENCE DIRECT
Journal of Electrocardiology 38 (2005) 119–127
JOURNAL OF Electrocardiology
www.elsevier.com/locate/jelectrocard

Where is the central terminal located? In search of understanding the use of the *Wilson central terminal* for production of 9 of the standard 12 electrocardiogram leads

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Abstract

The aim of this study was to evaluate the understanding of the term *central terminal* (CT) and to consider the consequences of this level of understanding. A total of 150 questionnaires was distributed during the 30th International Congress of Electrocardiology 2003, Helsinki, Finland; 42 (28%) of the anonymous questionnaires returned were considered adequate for the purpose of this study. The questionnaire addressed the following areas of interest: (1) the location of the CT; (2) the location of the negative poles of *unipolar leads*; (3) the naming of the electrocardiogram lead groups; (4) the relationship between the leads and cardiac electrical views; and (5) impact on accuracy of clinical diagnosis. The findings revealed diversity in understanding the basic term, a shift in understanding the term CT to abstract/theoretical understanding, and gaps in understanding the concept of CT and the more recent theories of the cardiac electric field.

Keywords: Central terminal; Unipolar leads; Clinical diagnostics

1. Introduction

The *central terminal* (CT) is a term introduced by Wilson for the reference electrode that he developed to create a practical technical basis for recording additional electrocardiographic leads [1-4]. The understanding and interpretation of the term CT have consequences on both theoretical reasoning and clinical interpretation of the standard 12-lead electrocardiogram (ECG).

The consideration by Frank Wilson that the use of the CT creates “unipolar leads” has led to the naming of these leads according to the position of the sites of the electrodes that record their positive poles. For example, leads V_1 through V_3 are considered *anterior leads* when they provide as much information from the posterior as from the anterior aspects of the left ventricle. Indeed, the Selvester QRS scoring system includes criteria for estimating the sizes of both anterior and posterior myocardial infarctions from these leads [5]. Thus, there are consequences on the clinical use of the ECG resulting from misconceptions regarding the Wilson CT. Failure to recognize this concept has led to extensive searches on the posterior aspect of the thorax for the *optimal positions* for diagnosis of posterior myocardial infarction. Indeed, it has been commonly recognized that viewing an ECG “upside down and backward” provides the capability of diagnosing posterior infarction in leads V_1 through V_3 (Fig. 1).

The aims of this study were to evaluate the understanding of the term CT, the conception of the 9 standard leads, which the use of the CT has provided, and the clinical ECG diagnoses based on waveform information provided by these leads. The study tested the following hypotheses: (1)

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doi:10.1016/j.jelectrocard.2005.01.002

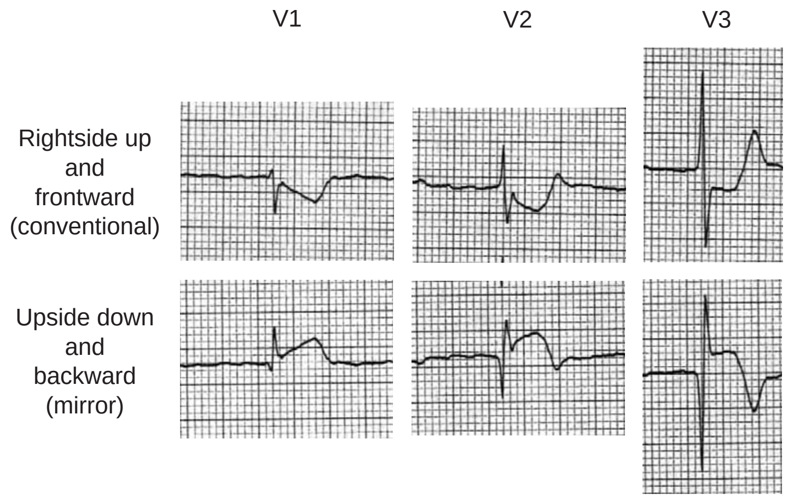

Fig. 1. Upside down and backward viewing of leads V_1 through V_3 providing the capability of diagnosing posterior infarction using leads V_1 through V_3. Upper panel, Right side up and frontward (conventional) viewing of leads V_1 through V_3. Lower panel, Upside down and backward (mirror) viewing of leads V_1 through V_3.

there is no common understanding of the term CT and (2) the use of the term *unipolar leads* based on the connection of the CT to an "exploring" electrode has created the incorrect assumption that these leads have only one pole (anterior, etc). This incorrect assumption can lead to routine incorrect clinical diagnoses and thereby potential selection of an inappropriate therapy.

2. Material and methods

2.1. Description of the interviewed sample of population

The questionnaires were distributed and collected during the 30th International Congress on Electrocardiology (Congress) in June 2003 in Helsinki, Finland.

Of 150 questionnaires distributed to the Congress participants, 42 (28%) of the anonymous questionnaires returned were considered adequate for the purpose of this study. The Congress participants were a group primarily interested in the interdisciplinary field of electrocardiology, which includes cardiology, medicine, biophysics and electrophysiology, biomathematics, and engineering sciences, among others. The survey sample was not a random sample and not necessarily representative of professional electrocardiographers, although the questionnaire was primarily distributed among the participants considered to be interested in the clinical or computer engineering aspects of electrocardiography. The main groups of the respondents appeared to be more senior electrocardiographers and junior investigators with a background in clinical or basic sciences or engineering sciences.

The questionnaire (Fig. 2) was designed as a multiple-choice type. The response alternatives provided a choice for "other" so that a correct answer not offered as an alternative in the opinion of the respondent could be included, and to solicit comments.

3. Results

3.1. The location of the CT

More than half (54%) of the respondents answered either that the CT is localized at the zero potential (33%) or that it is located at the electrical center of the heart (21%) (Fig. 3). These locations might be considered similar if one assumes that the value of the potential at the center of the cardiac electric field is indeed zero [2,3]. However, most (41%) either had no answer (10%) or attempted to define the CT rather than indicate its location (31%). Among those who addressed the CT location, 2 placed it within the electrocardiograph.

3.2. The location of the negative poles of unipolar leads

Fig. 4 presents the responses regarding the locations of the negative poles of 2 of the 9 leads of which a single electrode provides the positive pole, but an alternative to the specific placement of another electrode provides the negative pole: frontal plane lead aVR (2A) and transverse plane lead V_1 (2B). The most frequently designed site of the negative poles of both these leads (aVR, 29%; V_1, 58%) was "at the CT." Approximately one fourth (aVR, 26%; V_1, 19%) located the negative poles on the body surface directly opposite the locations of the electrodes that recorded the positive poles of these leads: on the left lower thorax for aVR and on the posterior thorax for V_1. One difference in the responses regarding these 2 leads is that most (58%) located the negative pole of lead V_1 at the CT, whereas one fourth provided a wide variety