LEADS, a research-oriented calipers program for computer-assisted vectorcardiography-based ECG analysis

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Original research in the field of electrocardiography is often done with conventional ECG variables, like QRS duration, QT interval, etc. From time to time new variables are proposed and evaluated, such as, *e.g.*, the Sclarovsky-Birnbaum ischemia grading system. Most computerized ECG analysis systems do not support the direct computation of such novel variables, however, neither do they support the computation of vectorcardiographic variables.

Vectorcardiography, after having nearly vanished in the form of a dedicated recording system with specific (e.g., Frank) electrode configuration, is now experiencing its comeback in research in the form of mathematically synthesized vectorcardiograms (VCGs) computed from standard 12-lead ECG recordings. Hence, there is a need for research-oriented VCG analysis tools, to facilitate studies that investigate and validate important VCG variables. The Leiden Ecg Analysis and Decomposition Software (LEADS) is meant to be such an instrument.

The initial part of this presentation is devoted to discuss the basic properties of the VCG: essentially a "corrected" ECG recording method with three leads, X-Y-Z, in the direction of the main axes of the body, and with equal lead strenghts. The standard 12-lead ECG, in contrast, has different lead strenghts in all leads, and no lead vector points in the direction of a main axis of the body. The VCG makes the time relationships between the leads explicit, and allows for the dynamic measurement of the heart vector (magnitude and direction as a function of time) throughout the cardiac cycle. From this, important VCG variables such as the maximal amplitudes of the QRS and the T wave, the spatial orientation of the QRS and T axes, the spatial integrals of the QRS and T waves, the spatial angle (SA) between the QRS and T axes, and the spatial ventricular gradient (VG) can be computed. These variables can be linked to specific electrophysiological properties of the heart and cannot be computed in the 12-lead ECG. Inherently, the VCG signal offers no more information than the 12-lead ECG signal, but the before mentioned VCG variables address information that remains unexplored in conventional 12-lead ECG analysis.

Any digital standard 12-lead ECG recording can be used as input for the LEADS system, this requires only a conversion program from the stranger format to the LEADS format (a simple ASCII comma-separated-values file). LEADS has been programmed in Matlab, and is normally used as a compiled program, that does not require the installation of Matlab on the computer of the LEADS analyst.

The second part of the presentation is meant to illustrate the sequence of LEADS signal processing steps. LEADS processing is computer-assisted, essentially interactive. In a simple and efficient review-and-edit procedure, the default performance of the LEADS analysis algorithms for beat detection, baseline removal, beat selection for averaging, localization of onset-QRS, J point, and end of the T-wave can be checked and, when needed, be corrected. Thus an optimal balance is reached between the reliability of the results, the reproducibility of the results, and the time spent to the analysis. Anyone with interest in ECG analysis and basic knowledge of the electrocardiogram can become a skilled LEADS analyst in a few working days.