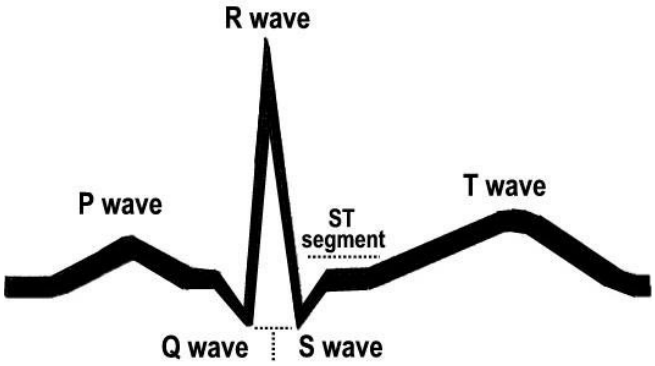
High-Frequency Electrocardiographic Wave Complex or Interval Electrocardiography

Todd T. Schlegel, Johnson Space Center
Brian Arenare, Johnson Space Center and Cardiosoft
Saeed Moradi, Cardiosoft
Walter B Kulecz, Wyle Laboratories

Clinical interpretation of the conventional electrocardiogram (ECG) with respect to myocardial ischemia as well as asymptomatic, underlying coronary artery disease relies on recognizing characteristic changes in the electrocardiographic wave complex or interval (QRS) complexes—representing electrical depolarization—and the electrocardiographic wave (ST) segments—representing the beginning of electrical repolarization—of the conventional ECG waveform.



Conventional ECG waveform consisting of P, QRS, and T waves and the ST segment.

The characteristics of this ECG waveform are readily measurable in the frequency range up to 100 Hz using conventional ECG devices. There are, however, clinically important signals present within the QRS complexes in a higher frequency range, 150 to 250 Hz, that can be used to more accurately screen asymptomatic individuals for underlying coronary disease and to better evaluate those individuals with acute heart conditions.

A team of NASA researchers, physicians, and software engineers has recently developed a novel medical technology that is capable of measuring, characterizing, and displaying, in real time and from beat-to-beat, these high-frequency QRS signals. This high-frequency QRS-ECG (HFQRS-ECG) technology uses sophisticated signal-processing algorithms to measure signal amplitude and morphology, as well as any real-time changes therein, during any given period of monitoring. We have found, in several recent clinical studies, that the HFQRS-ECG technology is more accurate than conventional ECG techniques for identifying myocardial ischemia, both in acute care settings and in screening of asymptomatic, resting individuals. The HFQRS-ECG is thus an innovative new tool with which doctors can assess heart disease in a variety of settings, significantly augmenting conventional ECG techniques. It also provides an improved means for continuous real-time monitoring of myocardial ischemia.

The NASA HFQRS-ECG technology has been licensed to CardioSoft (Houston), and a prototype device is now in development. The system uses medical-grade computer hardware and standard skin electrodes and lead positioning, allowing it to be used whenever and wherever conventional ECG is typically performed.

HFQRS-ECG prototype.

The HFQRS-ECG offers continuous monitoring and recording of real-time changes in high-frequency signals in each of the usual 12-leads, alongside the conventional ECG signals in the same leads. The software (Figure 3) identifies normal and abnormal high-frequency QRS signals in each lead by specific analysis criteria and incorporates a simple color-coded display. A quantitative

numerical score is also automatically calculated, which helps the user identify the presence or absence of overall pathology.

In addition to the diagnostic value now being demonstrated

12-lead HFQRS-ECG Display. The high-frequency QRS signal for each lead is shown below the respective conventional QRS signal.

in ground-based clinical studies, the HFQRS ECG could eventually have important in-flight operational roles during space missions whenever conventional ECG data are currently obtained. Since it uses the same lead configuration and electrode hardware as the conventional ECG, it is equally noninvasive and can be performed simultaneously. As with computerized conventional ECG, data from the HFQRS-ECG can be displayed in real time for monitoring purposes, or archived for later playback, analysis, and review.