

LETTER TO THE EDITOR

Early Repolarization Redux: The Devil Is in the Methods

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The ability to reproduce results in other settings is a critical scientific concept in order to validate findings for wide spread application. While the recent ECG studies by Tikkanen et al.^{1,2} are seminal as the first prognostic studies of J waves and slurring on the downslope of the R wave, there are some important considerations when trying to reproduce their results by using their methods:

1. The ECGs were collected between 1966 and 1972, before multichannel recorders and digitization were available, and stored as paper recordings at twice paper speed without time coherent display of leads;
2. The isoelectric line they use for measuring waveform amplitudes is the T-P interval while most cardiologists and computer ECG programs use the PR interval;
3. Their amplitude criteria require two adjacent leads since paper recordings without filtering and averaging of the ECG signals have quality limitations;
4. QRS end for the Finnish researchers occurs in one arbitrary lead and early repolarization amplitude is measured at the point of a J wave or slur;
5. The actual ST segment level is not considered in their papers;
6. Their community-based population has a 10% prevalence of Minnesota codes consistent with coronary artery disease (i.e., Q waves, bundle branch block, ST depression, and T-wave inversion);
7. Their population has a 30-year follow-up completed in a small, scientifically advanced country with a unique health care system;
8. Laws in Finland mandate a very rigid protocol for assessing cause of death, enabling them to classify arrhythmic deaths.

Given the above clarification of their methods, it is apparent that the validation of their findings would be very difficult and require extensive resources. While the hazard ratio they report for the ECG phenomena in the inferior leads they describe (i.e., 2–3X) makes it of limited value as a screening tool, the theoretic basis for an association of cardiac death with the abnormalities on the downslope of the R wave is compelling.^{3,4}

Is there a solution to the quandary caused by their methods so that future studies of R-wave downslope can be accomplished? The considerable problem created by semantics and the lack of definition standardization has been addressed,⁵ so we will concentrate on the issue of validating the Finnish findings. Each of the above points will be addressed in order:

1. Rather than relying on obsolete, limited paper ECG recordings, we suggest that modern computer technology be used since it reduces artifact and respiratory variation, improves recording quality, and allows for time coherent display and analysis of leads;
2. The PR interval and T-P interval usually are quite similar except in the situations of pericarditis and tachycardia so we suggest that the more commonly accepted PR interval be applied;
3. By using computerized ECG recordings, amplitude criteria need only be met in one lead;
4. QRS end should be determined using digitally recorded data considering time coherent overlays of all 12 leads visually and/or by using available computer algorithms;
5. Because of the clinical concern with separating ST elevation from ischemia, damage, and pericarditis and that the computer program statement of "early repolarization" require ST

elevation, this finding should be included in future studies;

6. The prevalence and interaction of other ECG abnormalities must be carefully considered since fragmentation of the QRS complex is associated with ischemic heart disease and the standard abnormalities could be what is generating a risk particularly in the inferior leads;
7. Follow-up periods of less than 30 years are preferred and sufficient for prognostic assessment of tests;
8. Since death protocols are not routinely in place, arrhythmic deaths are a subset of cardiovascular deaths, and the Finnish group found the hazards similar using either arrhythmic or cardiovascular events as the outcome, we suggest that the more commonly available cardiovascular death end point be used.

Application of standardized terminology and computerized ECG technology to future studies of abnormalities on the downslope of the R wave would greatly facilitate the translation of laboratory data regarding "early repolarization" to clinical practice. The majority of studies have compared individuals with idiopathic VT/VF or families with arrhythmic disorders to athletes or controls.⁶⁻⁸ The only other population study comes from the MONICA group.⁹ While the Monica group used computerized measurements, they assessed J waves and slurs on paper tracings. Their findings are questionable though since they used a

case-cohort design with a subset of their community-based population "enriched by all those who died" resulting in a "limited challenge." Thus, if the hypothesis that abnormalities on the downslope of the R wave ("early repolarization") can predict cardiac events is to be validated, a proper population study is needed. Such a study would be facilitated by incorporating algorithms to recognize J waves or slurs on the R-wave downslope in current ECG programs.

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