A plea is made for not using in publications the terms *J-wave syndromes* and *early repolarization* until such terms are properly defined by appropriate task forces established by recognized authorities. The currently used electrographic terminology, including *J-point elevation*, meets our needs. (J Am Coll Cardiol 2011;57:1584–6)

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The term *J-wave syndromes* appeared first in a paper by Yan et al. (1) and is a title of a contemporary review by Antzelevitch and Yan (2). In Table 1 of the review (2), the authors list 4 inherited and 2 acquired types of J-wave syndromes. The inherited types are: early repolarization (ER) type 1, where the ER pattern is located in the lateral leads; type 2, where the ER pattern is in the inferior or inferolateral leads; type 3, where there is global ER; and type 4 is the Brugada syndrome. The 2 acquired types are associated with ventricular tachycardia (VT) or ventricular fibrillation (VF); 1 is ischemia mediated, and the other hypothermia mediated.

**What Does “J” Stand for in Cardiac Electrophysiology?**

**J-wave.** The J-wave or Osborne wave (3) frequently appears in the electrocardiogram (ECG) during deep hypothermia (4). It is a low-frequency deflection at the end of the QRS complex, morphologically similar to the P-wave, and is usually present in all 12 ECG leads. It is not clear whether it represents ventricular depolarization or early repolarization. A similar deflection may be present in patients with hypercalcemia, Brugada syndrome, and in several other conditions (4).

**J-point elevation.** The J (junction) point marks the end of the QRS complex, and is often situated above the baseline, particularly in healthy young males. It may also be elevated as a result of injury currents during acute myocardial ischemia and pericarditis, as well as in various other patterns of both normal and abnormal ECGs.

Defining normal limits of J-point elevation in millivolts above the baseline requires consideration of several variables, such as the lead, heart rate, age, sex, race, and overall amplitude of the QRS complex (see the following text). The absence of such data makes it difficult to evaluate the significance of increased J-point elevation found in survivors of primary ventricular fibrillation (5).

**End of QRS complex.** One of the problems in measurement of the QRS duration is defining the J-point when the transition of the QRS complex into the ST segment is not sharp but gradual because of an overlap of ventricular depolarization and repolarization at the end of the QRS complex. In a method proposed by Lepeschkin and Surawicz (6) to define the J-point when the QRS-ST junction is not sharply demarcated, but curved (wide QRS-ST junction), the discrepancy of repeated measurements of the QRS interval reached 40 ms.

In current clinical practice, the measurement of the QRS interval is performed by automated methods of analyzing all 12 leads simultaneously recorded in digital form. The automated technique appears to decrease the error of measurement. However, the International Electrotechnical Commission tolerance limits in measurement of QRS duration in biological (real) as opposed to calibration and analytical ECGs are ±10 ms (7).

**Elevation of J-Point and ST Segment Above the Baseline in Normal ECGs: Age, Sex, and Race Differences**

Differences between ventricular repolarization in the ECGs of males and females have been known for a long time (8). Bidoggia et al. (9) found that the amplitude of the J-point and the angle between the ST segment and the baseline (ST...
angle) were the best discriminators between the ECGs of males and females.

Surawicz and Parikh (10) examined the previously mentioned 2 variables in normal ECGs of 529 males and 544 females, age 5 to 96 years. They inspected only the 4 precordial leads: V₁ through V₄. The pattern was considered as female when the J-point amplitude above baseline was <0.1 mV in each of the 4 leads, and as male when the J-point was >0.1 mV and the ST angle was >20° in at least 1 of the 4 leads.

In females of all ages, the male pattern was present in <20% subjects, whereas in males, it was present in 60% at the age 5 to 7 years, increased at puberty, reaching 91% in the age group of 17 to 24 years, and gradually declined to the same level as in females after the age of about 60 years.

Macfarlane (11) published age- and sex-based normal limits of J-point (STJ) amplitude. In a more recent publication in collaboration with Katibi and others (12), he pointed out that STJ is more elevated in African males living in Nigeria than in Caucasian males.

We provide this information to explain the importance of lead, sex, age, and race in the evaluation of the significance of J-point elevation and the angle of ST segment takeoff during early repolarization.

The Tale of 2 Js

It is curious that the letter J in cardiac electrophysiology defines 2 unrelated and totally different events. One is a rarely encountered, several millimeter long, slow deflection of uncertain origin at the end of the QRS complex, originally identified in hypothermia. The second is a point in time, marking the end of QRS and the onset of the ST segment that is present in all ECGs. The differentiation between the meanings of the 2 Js is so great that confusion is unlikely.

What Is Early Repolarization?

The repolarization in ventricular myocardial cells may or may not begin with a notch attributed to transient outward current (Iₒ), and is followed by a plateau (phase 2) and rapid phase 3 (13). To our knowledge, the course of repolarization has not been separated into an early and late phase by a dividing line. The widely used term early repolarization has been generated by electrocardiographers to describe, in most cases, a normal variant of ST-segment elevation. The American College of Cardiology (ACC)/American Heart Association (AHA)/Heart Rhythm Society (HRS) recommendations for the standardization and interpretation of the electrocardiogram (14) include a statement that the term early repolarization is used frequently to characterize a normal QRS-T variant with J-point elevation. In the textbook Chou’s Electrocardiography in Clinical Practice, the term early repolarization is featured as a normal variant that lacks precise definition (4). This is because it is an early portion of the ST segment of undetermined duration.

Moreover, the normal limits of amplitude depend on the lead, total QRS amplitude, age, sex, and race.

Other Interpretations of the Term Early Repolarization

Antzelevitch and Yan (2) referred to a 1961 paper by Wasserburger and Alt (15), who defined ER as an elevated takeoff of the ST segment varying from 1 to 4 mm from the isoelectric line, accompanied by downward concavity of the ST segment and symmetrical T-wave.

Kimbaris and Phillips used the term early repolarization in the title of their 1976 paper (16), but concluded that it was a normal variant. However, Gussak and Antzelevitch (17) pointed out that ER has a potential for arrhythmogenicity.

Haissaguerre et al. (18) reported that ER is present in 31% of 206 subjects who were resuscitated from cardiac arrest caused by idiopathic ventricular fibrillation, versus 5% in control subjects (p < 0.001). Early repolarization in this study was defined as an elevation of the QRS-ST junction of at least 0.1 mV from baseline in the inferior or lateral leads manifested as QRS slurring or notching. Similarly assessed was the risk of ER in other studies. Tikkanen et al. (19) found that among 630 middle-aged subjects with ER in the inferior leads, ST-segment elevation exceeded 0.2 mV in 36 subjects (0.3%). This finding was associated with an increased risk of cardiac death (p < 0.001).

Watanabe et al. (20) found ER in 63% of 37 patients with short QT and associated sudden death (SQT syndrome). Ghosh et al. (21) reported that in 2 patients with aborted sudden death, ER was associated with large local dispersion of repolarization. In a recent prospective study of 2,063 subjects between 35 and 74 years of age, prevalence of ER was 18.5%, and ER was associated with increased cardiovascular mortality (22).

Morphology of ER

In publications in which the ER pattern (mostly in leads III, aVF, and V₄ to V₆) is identified by an arrow (19,20,22), the 12-lead ECGs were recorded at the speed of 25 mm/s. When the figures were magnified, it was possible to see that the arrows pointed either at a slow descent of the R-wave toward baseline (reminiscent of poor frequency response of the recorder), or at notches before or after the approach of R descent to the baseline. In 1 case, the terminal deflection resembled that of an incomplete right bundle branch block.

Unfortunately, the deflections marked as ER in the aforementioned studies were not synchronized in several leads, not recorded at higher paper speeds, and not examined by body surface mapping or vectorcardiography. Thus,
it is not possible to know whether the alleged ER is indeed an abnormality of repolarization.

Wellens in his editorial comment (23) on the study of Haïssaguerre et al. (18) questioned “...whether the described abnormality at the end of QRS complex is indeed early repolarization, or rather delayed activation of the inferolateral wall.” The origin of the terminal QRS portion was debated in subjects with the Brugada syndrome (24).

Concluding Remarks

The electrocardiographic terminology stemming from the end of the 19th and the beginning of the 20th century has undergone few modifications when scrutinized by a succession of task forces appointed by the ACC or the AHA from 1978 (25) onward. The terminology, including ST-segment elevation, was recommended by the most recent task force of the AHA/ACC/HRS, published in 2009 (14).

In our opinion, the established ECG terminology is sufficient to define clearly and accurately all normal and abnormal ECG patterns, and therefore terms other than the existing electrocardiographic nomenclature, such as J-wave syndrome and early repolarization are superfluous and confusing.

The J-wave was described originally in the setting of deep hypothermia, where it was often a precursor of ventricular fibrillation. The J-wave is very seldom encountered under other circumstances.

The J-point exists in all ECGs but does not need to be singled out in the ECG reports describing ST-segment deviations because it is a component of the ST segment.

The terms early and late repolarization are synonymous with phases 2 and 3 of the transmembrane action potential. In the ECG, they correspond to ST segment and T-wave. Unlike ER, the duration and the amplitude of the ST segment are measurable in millimeters and millivolts, respectively. This means the term ER is not needed in clinical electrocardiography. The terminal QRS abnormalities can be adequately described as fragmentation, slurring, or notching.

We have refrained from discussing the suggestions that terminal QRS abnormalities in the quoted references 18 to 22 mark substrates for ventricular arrhythmia, but acknowledge the need to investigate such correlations. This will probably not change the existing ECG terminology.

**References**


