JOURNAL OF THE AMERICAN COLLEGE OF CARDIOLOGY
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PUBLISHED BY ELSEVIER INC.

VOL. 66, NO. 4, 2015
ISSN 0735-1097/$36.00
http://dx.doi.org/10.1016/j.jacc.2015.05.033

THE PRESENT AND FUTURE

REVIEW TOPIC OF THE WEEK

The Early Repolarization Pattern

A Consensus Paper

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ABSTRACT

The term *early repolarization* has been in use for more than 50 years. This electrocardiographic pattern was considered benign until 2008, when it was linked to sudden cardiac arrest due to idiopathic ventricular fibrillation. Much confusion over the definition of early repolarization followed. Thus, the objective of this paper was to prepare an agreed definition to facilitate future research in this area. The different definitions of the early repolarization pattern were reviewed to delineate the electrocardiographic measures to be used when defining this pattern. An agreed definition has been established, which requires the peak of an end-QRS notch and/or the onset of an end-QRS slur as a measure, denoted Jp, to be determined when an interpretation of early repolarization is being considered. One condition for early repolarization to be present is Jp ≥0.1 mV, while ST-segment elevation is not a required criterion. (J Am Coll Cardiol 2015;66:470–7)
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The electrocardiographic (ECG) pattern of early repolarization has historically been regarded as a benign ECG variant. However, during the past few years, this concept has been challenged on the basis of multiple reports linking the early repolarization pattern in the inferior and/or lateral leads of the standard 12-lead ECG with an increased risk for sudden cardiac death (1,2). Case-control studies have unanimously shown that patients resuscitated from cardiac arrest of unknown etiology have a higher prevalence of the ECG pattern of early repolarization in the inferior and/or lateral leads (i.e., the early repolarization syndrome) than matched control subjects. Epidemiological follow-up studies have also shown that the early repolarization pattern carries an increased risk for future arrhythmic death (3,4). Therefore, the recognition and correct diagnosis of the ECG pattern of early repolarization has importance for specialists, general cardiologists, and physicians.

The ECG term *early repolarization* has been in use by cardiologists for almost 40 years. Its exact definition has varied according to different investigators, so much so that a recent review (5) showed that the prevalence of early repolarization apparently varied between 2% and 31%. One definition of early repolarization, published in 1976 by Kambara and Phillips (6), which built on earlier work by Wasserburger and Alt (7), suggested that early repolarization was defined by: 1) end-QRS notching or slurring; 2) elevation of the ST-segment; and 3) an upward-sloping ST-segment followed by a tall, symmetrical

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Manuscript received February 5, 2015; revised manuscript received April 21, 2015, accepted May 18, 2015.

T-wave. However, many cardiologists have reported the presence of ST-segment elevation alone, most commonly in the inferior and lateral leads in younger persons, as being consistent with early repolarization. This view can be found in respected textbooks on ECG (8).

In the seminal study of Haissaguerre et al. (1), the investigators defined early repolarization as "an elevation of the QRS-ST-segment junction (J-point) in at least 2 leads" (within the same territory; e.g., inferior or lateral leads) as being a sign of early repolarization. The amplitude of the J-point elevation had to be at least 0.1 mV above the baseline level, as either QRS slurring or notching. The amplitude and slope of the ST-segment were not part of the definition.

In subsequent papers, Tikkanen et al. (3,4) followed this definition but also measured the degree of so-called J-point elevation, which was stratified at levels of 0.1 and 0.2 mV. These investigators also introduced the concept of the ST-segment slope having significance in the presence of early repolarization, showing that a horizontal or downward-sloping ST-segment is associated with greater arrhythmic risk (4).

Thus, there has been considerable variation in the definition of early repolarization, as well as some controversy regarding the term itself. Spodick (9), for example, regarded the term as a misnomer, while others believed that it was inappropriate and confusing (10), a view which was challenged (11).

The aim of this paper is essentially to present a unified definition of early repolarization to assist future studies in the field by recommending measurements that should be made to facilitate sharing of data, with the ultimate aim of having a greater understanding of the ECG pattern of early repolarization.

TERMINOLOGY

So that doubt can be avoided, an end-QRS notch is a notch that occurs on the final 50% of the downslope of an R-wave occurring as the final segment of the QRS complex; that is, it links with the ST-segment of the waveform (**Figure 1A**). It should be distinguished from a notch midway on the downslope of an R-wave (**Figure 1B**), because this may be due to fragmentation (12). Similarly, an end-QRS slur is an apparent slowing of the inscription of the waveform at the end of the QRS complex that merges with the ST-segment of the complex (**Figure 1A**). Likewise, in the context of this paper, a slur should occur in the final 50% of the R-wave downslope.

There is considerable variation in the use of the term *J point*. For many cardiologists, this is taken as the onset of the ST-segment (13), which may equate with the termination of an end-QRS notch, whereas others use the term for the peak (1-3) or the onset (C. Antzelevitch, personal communication, March 28, 2014) of an end-QRS notch. It is proposed that the following terminology be used: 1) *J onset* (Jo) should denote the onset of a notch; 2) *J peak* (Jp) should denote the peak of a notch or onset of a slur; and 3) *J termination* (Jt) should denote the end of a notch or slur.

ABBREVIATIONS AND ACRONYMS

ECG = electrocardiography
Jo = J onset
Jp = J peak
Jt = J termination

Figure 2A clarifies these points for an end-QRS notch. In the case of a slur (**Figure 2B**), Jo and Jp are electrocardiographically the same point. However, for consistency of measurement, it is proposed that the slur onset be regarded as Jp, rather than Jo, because this allows *Jp* to be used to denote both the peak notch and slur amplitude (**Figure 2B**). This means that in publications, such as those of Haissaguerre et al. (1), Rosso et al. (2), and Tikkanen et al. (3,4), the term *J amplitude* or *J-point elevation* equates with *Jp amplitude*, as confirmed by these investigators in contributing to this consensus paper. Antzelevitch has used *Jo* to denote the J point when describing early repolarization (personal communication, March 28, 2014). It also means that in publications such as the "Third Universal Definition of Myocardial Infarction" (14), *Jt* equates with *ST-segment amplitude* in relation to the definition of ST-segment elevation myocardial infarction. The new terminology should clarify what is being measured in future studies and is recommended for use henceforth.

MEASUREMENT RECOMMENDATIONS

A major aim of this paper is to set out recommendations with respect to measurements relating to the early repolarization pattern. To this end, the following definitions are presented.

NOTCHING AND SLURRING. To facilitate future studies, the following measurements should be made (**Figure 2**). All amplitude measurements are made with reference to QRS onset.

Notched QRS complex.

1. The amplitude Jo at the onset of the notch
2. The amplitude Jp at the peak of the notch
3. The amplitude Jt at the end of the notch
4. The duration D_1 from Jo to Jp
5. The duration D_2 from Jo to Jt

Slurred QRS complex.

1. The amplitude Jp at the onset of the slur
2. The amplitude Jt at end of the slur
3. The duration D_2 from Jp to Jt