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Review

Characteristics of "malignant" vs. "benign" electrocardiographic patterns of early repolarization

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Abstract The electrocardiographic (ECG) pattern of early repolarization (ER) has historically been regarded as a benign ECG variant, but during the past few years, this concept has been challenged based on multiple reports linking the ER pattern with an increased risk of sudden cardiac death. Although the mechanistic basis of ventricular arrhythmogenesis in patients with ER pattern is still incompletely understood, there is increasing information about the ECG and phenotype characteristics of "malignant" vs. "benign" patterns of ER. This review presents the current evidence of markers of "benign" and a more severe nature of ER.

Keywords: ECG; Early repolarization; Sudden Cardiac Death

Introduction

Electrocardiographic (ECG) patterns of early repolarization (ER) in the absence of symptoms have been considered as a normal state for over half a century. In fact, since this ECG pattern predominates among young and fit individuals with slow heart rates, it has been generally viewed as a marker of good health. Most recommendations for standardization and interpretation of the ECG include a statement that the term early repolarization is used to describe a normal QRS-T variant with ST segment elevation especially in the left precordial leads [1], and most clinicians have for years been considering early repolarization as nonspecific ST elevation. After some case-reports pointing to an arrhythmogenic potential of early repolarization, a series of case–control studies in 2008 unexpectedly described an apparent over-presentation of J waves, i.e. terminal QRS notching and/or slurring in infero-lateral leads with and without ST segment elevation, in patients with idiopathic ventricular fibrillation [2,3]. These findings challenged physicians to think again about the belief that this pattern was simply a normal variant, and lead to confusion among both professionals and patients. Thereafter, infero-lateral QRS notching and slurring, referred to as early repolarization ECG pattern, have also been demonstrated to possess an increased risk of sudden cardiac death (SCD) and mortality in general population [4–6]. With the current data, the absolute risk of SCD in those with J waves is estimated to be 70 per 100,000 [7]. This ECG pattern has recently also been reported to be a risk modulator in patients with pre-existing cardiac diseases, as it has been associated with malignant arrhythmias in patients with acute myocardial ischemia and also in heart failure patients [8–14]. The ECG pattern of ER itself is a prevalent finding in asymptomatic individuals, and thus the so called ER syndrome can be diagnosed only in patients with resuscitated cardiac arrest, documented VF or polymorphic ventricular tachycardia, or possibly in the relatives of the syndrome carriers in whom a genetic mutation can be documented [15,16].

There are conflicting data regarding the prognostic significance of ER in asymptomatic subjects, but as discussed elsewhere [17], there has been a major lack of consistence between the studies in the definitions of the ECG pattern of ER. There indeed seems to be variability in the magnitude of risk between different ECG patterns. Especially J wave distribution, J wave amplitude and dynamicity and morphology of the ST segment have been shown to modify the risk. This concise review summarizes the current evidence of arrhythmia risk associated with various J wave patterns, and intentionally elides any debate on the underlying pathophysiology and therapeutic interventions as these have been discussed in numerous preceding reviews.

Characteristics of a likely benign nature

Overall, not all manifestations of J wave patterns across the ECG leads seem to be equally proarrhythmic. In asymptomatic healthy individuals, J-point elevation with high takeoff

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ST-elevation is most prominently seen in mid-precordial leads, and terminal QRS notching accompanied by ST-elevation in left-precordial leads is likewise a common finding among young healthy individuals. These classical types of early repolarization have for long been demonstrated to possess a benign prognosis, also in the current era [18–23]. As mentioned, early repolarization is very commonly observed in the young, especially in fit and highly trained athletes, and therefore it is not surprising that our information of the ECG characteristics found in healthy individuals comes mainly from athlete populations, in which the prognosis of early repolarization has also been found to be benign [22–26]. Prevalence of J waves also in the inferior and lateral leads in athletes ranges up to 40%, but in >80% of cases the following ST segments are rapidly ascending [27,28]. J waves with rapidly ascending ST elevations have not predicted any risk of arrhythmic death in the general population [19,20,22,29,30] or in IVF patients [31]. Therefore, this ER pattern can generally be considered as a benign phenomenon similar to ER patterns in the precordial leads in asymptomatic subjects. In conclusion, the ECG characteristics of benign ER patterns include J wave distribution mainly in the anterior, but also inferolateral leads, tall R waves, and the hallmark of athlete ER: rapidly ascending ST elevations [22,26,31]. These patterns found especially in young and bradycardic athletic males, presumably with high testosterone levels [32] and high Sokolow-score are with the current knowledge most likely normal variants. Two examples of ECG patterns of J waves in young athletes are presented in Fig. 1.

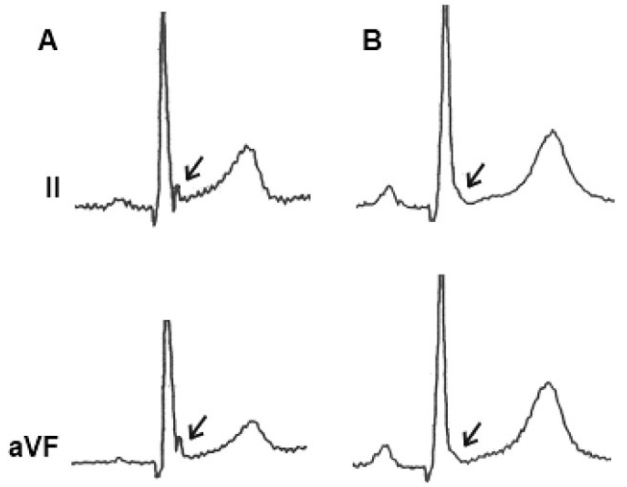

Fig. 1. Example J wave patterns in two young and healthy athletes illustrating terminal QRS notching and slurring with rapidly ascending ST segments. Paper speed 50 mm/s. Reprinted from ref # 22.

Characteristics of more severe phenotype and a potentially "malignant" nature

There are some clinical and ECG characteristics that are more often present in early repolarization patterns associated with an arrhythmic risk. These risk markers are presented in Fig. 2 in a simplified matter.

The distribution of J waves has been reported to influence the risk of sudden death in several studies, both in middle-aged unselected individuals as well as in those with ER syndrome. In general population samples, the inferior distribution of J waves has conferred an increased risk of arrhythmic death, but in contrast lateral manifestations have not predicted any risk [5,7,22]. There might actually be a significant difference in the pathophysiological mechanism of inferior and lateral J wave manifestations, as lateral J waves invariably normalized during beta-adrenergic stimulation, but precordial and inferior J waves persisted in a subset of patients [33]. However, in patients with

Fig. 2. A simplified illustration of the prevalence and risk associated with various electrocardiographic findings in early repolarization pattern. VF denotes ventricular fibrillation and sdr. denotes syndrome.