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# Controversial and similar aspects of the Brugada and J wave patterns: The vectorcardiogram point of view

Carlos Alberto Pastore, MD, PhD, FESC,* Nelson Samesima, MD, PhD, Horácio G. Pereira Filho, MD, Bruna A. Madaloso, MD

*Clinical Unit of Electrocardiography–Heart Institute (InCor) from Hospital das Clínicas da Faculdade de Medicina, Universidade de São Paulo, São Paulo, Brazil*

**Abstract**

**Background:** The J-wave electrocardiographic patterns include early repolarization (ER) and Brugada syndrome; especially when ER is located in the anteroseptal leads (V1–V3), it can mimic the Brugada syndrome (BrS) ECG pattern and therefore mislead the diagnosis. We aimed to define the vectorcardiographic characteristics of BrS and ER using aspects of QRS complex loop, J-point and ST-segment.

**Methods/Results:** Vectorcardiographic loops in the transverse plane (TP) of 14 BrS patients and 26 individuals with ER were analyzed and defined, and then a third group of 17 patients with non-characteristic ECG patterns were analyzed and compared with them. All QRS loops showed end-conduction delay (ECD) located in the right posterior-to-anterior quadrant (BrS) or left posterior-to-anterior quadrant (ER). In 100% cases a "break" in the QRS loop end, resembling a "nose" identified BrS, and a "fish-hook" shape identified ER. Non-coincidental QRS complex onset-end defined J-point resulting vector. BrS showed a significantly longer end-conduction delay (100% right anterior quadrant), shorter J-point amplitude oriented to the right, and "nose-like" QRS end loop. Analysis of group 3 confirmed the accuracy of the qualitative aspects to distinguish this "atypical" population: "fish-hook" shape of ER in the transverse plane in 6 individuals (one with both patterns seen in the sagittal plane); and the "nose" shape of BrS in 14 patients (two of which were diagnosed with both patterns in the transverse plane).

**Conclusions:** Vectorcardiographic characteristics could clearly differentiate BrS from ER qualitatively and quantitatively even in atypical ECGs.


*Keywords:* Diagnostic method; Electrocardiography; Vectorcardiography; J-point; Brugada syndrome; Early repolarization; J-wave patterns

## Introduction

J point alterations (changes in the final portion of the QRS complex and beginning of the ST-segment) were thoroughly described for several pathologies [1,3]. However, the underlying mechanisms of such alterations can either have an autonomic origin, or be the result of dysfunctional ion channels, or even reflect disturbances in the electrical conduction of impulses [2]. Careful observation of electrocardiographic patterns and knowledge of the contributions from vectorcardiography can lead to a qualified and accurate distinction of the many reasons that result in a J point alteration. This distinction can be made by performing a regional analysis of vectorcardiographic loops alterations.

In the literature there is no agreement about what causes the J point elevation in J-wave syndromes [4,5]. Basically, there are two groups, one supporting a late depolarization mechanism [6], and the other in favor of an early repolarization hypothesis [7]. Although we acknowledge those two possible explanations, throughout the manuscript we will present our opinion supporting the early repolarization terminology. Generally speaking, many situations that present late depolarization abnormalities, such as isolated incomplete right bundle-branch block, and isolated complete right bundle-branch block, do not show J point displacement.

Those cellular alterations occurring in the epicardial region of the right ventricle in type I pattern of Brugada syndrome (BrS) are seen in leads V1, V2 and V3, while the ones caused by the ECG pattern of early repolarization (ER) are most commonly present in the anterior wall of the left ventricle, observed in leads V3 to V6.

The relationships between the Brugada syndrome and J-wave ECG patterns have been extensively discussed [8–11].

* Corresponding author at: Heart Institute (InCor)–HCFMUSP, Av. Dr. Enéas de Carvalho Aguiar, 44/AB—Cerqueira César, CEP 05403–000, São Paulo, Brazil.

*E-mail address:* ecg_pastore@incor.usp.br

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Both situations show J-point and ST-segment alterations which are critical for determining phenotype and prognosis.

In most cases, BrS and ER have clearly distinct ECGs, which can be easily identified by any medical intern. However, in a few cases the early repolarization pattern is also found in the anteroseptal region of the 12-lead ECG (V1–V3), with commonly misleading diagnosis, requiring other tools to differentiate them.

The vectorcardiogram is a classical tool to analyze, from a spatial point of view, the electrical phenomena occurring in the heart, in the frontal, transverse and sagittal planes. The spatial orientation of the cardiac resulting vectors allows a better heart centralization [12,13].

This study aims to define, both qualitatively and quantitatively, the vectorcardiographic patterns of the QRS loops, J-points and ST-segments in the classic Brugada syndrome and early repolarization ECG configurations. After that, we present controversial ECGs illustrating the usefulness of the vectorcardiogram in atypical case.

## Methods

### *Study subjects*

We retrospectively analyzed from our database the vectorcardiography and 12-lead electrocardiography tracings of all study subjects, who were divided into three groups according to their ECG characteristics.

- Group 1: 14 individuals with electrocardiographic type I Brugada pattern [14,15], defined as a coved type J-point elevation in $V_1$ and $V_2$, as described elsewhere by Bayés de Luna et al. [14]
- Group 2: 26 individuals with the electrocardiographic early repolarization pattern (ER), as described in the literature: presence of a notch or final slowing of conduction in the QRS complex, J-point elevation, either with or without ST-segment elevation, in inferior (II, III, aVF) and/or lateral (I, aVL, $V_4$ to $V_6$) leads [3,16].
- Group 3: After characterization of the vectorcardiographic loops in both groups, we tested those VCG patterns in ECGs of 17 individuals with J-point elevation in $V_1$ to $V_3$, in whom the 12-lead electrocardiogram did not allow a clear diagnosis of either the Brugada syndrome type II, or the early repolarization pattern, differently from the study by Haïssaguerre et al. [3]

The hypothesis of the study was to analyze the vectorcardiographic loops, evaluating the patterns that can distinguish these pathologies, irrespective of the J-point elevation being found in the anterior or the lateral region.

### *12-Lead electrocardiography and vectorcardiography*

Patients were evaluated at rest using a simultaneous 4 × 3 format 12-lead ECG Hewlett Packard Pagewriter Xli equipment (Hewlett Packard Co., USA) and DII rhythm strip, at a paper speed of 25 mm/s and 10 mV gain.

Vectorcardiographic examination was performed using a Fukuda Denshi HPM 7100 BPM equipment (Fukuda Denshi Inc., Tokyo, Japan).

Analysis was performed using the transverse plane, since both Brugada syndrome and early repolarization patterns are mostly found in leads V1 through V6.

The same observer performed the entire VCG analysis. The focus was on the QRS loop (clockwise/counterclockwise rotation; general aspect; length of terminal portion) and the J-point (position; vector [amplitude and angle]).

In the vectorcardiogram, all loops (P, QRS and T) tend to present the same point of their onset and off set. Every time this does not happen, a vector is created. When this phenomenon occurs with the QRS loop we have a J point displacement, either above or below the baseline. Its position depends exclusively on the J point vector projection on the plane we are looking at. It means that if the J point vector is on the positive side of the leads, we will see an ST elevation, and *vice-versa*. Thus, to determine the J point vector we analyze where the QRS ends, and its dimension, direction and angle can be established by a straight line from the point of beginning of the QRS to its end, in any plane (frontal, transverse or sagittal) we wish.

This study was approved by the Institutional Review Board of the Heart Institute (InCor)—HCFMUSP, which states that patients do not have to sign informed consent because this is a retrospective study.

### *Statistics*

Continuous variables were expressed as mean ± SD; categorical variables were expressed in percentages. Non-paired $t$-test, Fisher's exact test and the ROC curve analysis were used, with $p \leq 0.05$ significance level.

## Results

The population was predominantly male (80%), with a mean age of 37.3 ± 13.4 and a mean QRS duration of 98.3 ± 12.3 ms (Group 1: mean age 55.5 ± 11.5, 61% male, mean QRS duration 105.5 ± 9.1 ms; Group 2: mean age 36 ± 12.6, 88.5% male, mean QRS duration 94.3 ± 12.2 ms). Patients in Group 1 (BrS) presented with a wider QRS ($p = 0.005$) when compared to group 2 (ER). In the Brugada group, 75% were asymptomatic; palpitations were present in 25% and syncope in 6.3%. In the early repolarization group, 57.7% were asymptomatic; 19.2% had dyspnea, 15.4% had palpitations, 11.5% had chest pain, and 11.5% had syncope.

From the VCG point of view, for abnormalities of the J wave there is no standard guideline set so far. Based on previous experience, our group studied specific patterns of the J-wave abnormalities: Brugada syndrome and early repolarization. An important qualitative VCG analysis was performed in the whole study population, specifically the aspects of the region comprising the terminal portion of the QRS loop, the J point and the ST segment. In BrS we see a counterclockwise terminal rotation of the terminal segment of the QRS, J point and early ST segment around the midpoint resembling a "nose", and in ER a clockwise rotation of the same segments resembling a "fish hook".