

## Frequency and Characteristics of Early Ventricular Repolarization Syndrome in Patients Diagnosed with Myocarditis

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### Abstract

**Introduction:** The syndrome of early ventricular repolarization (CPR) is an electrocardiographic phenomenon characterized by the presence of ST segment elevation (J point, notch or connection wave on the descending part of the R wave, sometimes resembling the r' wave), the rotation of the electrical axis of the heart counterclockwise along the longitudinal axis. The result of a number of studies has shown the prognostic value of CPR in patients with acute myocardial infarction (MI). Patel R. and co-authors, analyzing the ECG in patients with a history of MI and with an implanted cardioverter-defibrillator, found that CPR in this group is associated with the development of life-threatening rhythm disturbances regardless of the left ventricular ejection fraction.

**Objectives:** Objective: to study the frequency of early ventricular repolarization syndrome in patients diagnosed with myocarditis.

**Methods:** The 1st study group included 63 patients diagnosed with myocarditis, the 2nd study group included 108 patients undergoing medical examination in polyclinics who underwent ECG diagnostics.

**Results:** In group 1, CPR was detected in 14.28% of the examined (9 patients) (average age  $45.8 \pm 9.5$  years, 37 men, 26 women), in group 2, CPR was registered in 10.1% of patients (11 patients) (average age  $42.7 \pm 6.2$  years).. Statistical analysis revealed no difference between the incidence of CPR in patients with myocarditis and polyclinic patients ( $p > 0.05$ ).

**Conclusions:** In patients with myocarditis, CPR was more common in standard leads in the form of a notch.

**Keywords:** Syndrome of early ventricular repolarization, ECG, myocarditis, diagnosis

### 1. Introduction

The syndrome of early ventricular repolarization (CPR) is an electrocardiographic phenomenon characterized by the presence of ST segment elevation (J point, notch or connection wave on the descending part of the R wave, sometimes resembling the r' wave), the rotation of the electrical axis of the heart counterclockwise along the longitudinal axis. The rise of the ST segment during CPR can be combined with either high-amplitude positive or negative teeth, i.e. The listed characteristics of CPR can be recorded in isolation or in combination. Other features of the electrocardiogram (ECG) in the syndrome include: a double-humped P wave of normal duration and amplitude, shortening of the PR and QT intervals, a rapid and sharp increase in the amplitude of the R wave in the thoracic leads with a simultaneous decrease and disappearance of the S wave. The main criterion of the syndrome — wave j in the literature has different names: "camel hump sign", "Osborne wave", "late delta wave", "hat hook type connection", "hypothermic wave" or "hypothermic hump", "point-wave J", "wave K", "wave H" and "damage current". Previously, CPR was considered only as an ECG phenomenon without any clinical manifestations [1], [2].

In 2015, new CPR criteria were published, according to which CPR on an ECG should be considered: the presence of a notch or wave at the end of the QRS complex on the descending knee of the R wave above the contour. The peak J must be greater than or equal to 0.1 mV in two or more adjacent leads, except for leads with V1 -V3. It is important to note that the J-phenomenon can be evaluated only in complexes with a duration of less than 120 ms. Separately, it is recommended to evaluate changes in the ST segment. If it has a downward [1], [2].slope, the ECG phenomenon should be described as "early repolarization with an ascending ST segment". If the ST segment has horizontal or descending depression, the ECG phenomenon should be described as "early repolarization with horizontal or descending ST depression". If the rise of the ST segment is observed in at least two leads corresponding to the same blood supply zone, while there is also a horizontal or oblique depression in one lead, then this should be described as the rise of the ST. If the ST segment is horizontal in the lower leads and ascending in the lateral leads, the final interpretation will depend on where the early repolarization is most pronounced: more leads, the largest wave amplitude or notches. An isolated ST segment rise without a wave or notch should not be considered an early repolarization. Thus, for the diagnosis of CPR, it is necessary to have a wave or notch at the end of the QRS complex. At the same time, it does not matter whether changes in the ST segment (depression, elevation) are registered or not [3], [4].

In general, the prevalence of CPR in the general population is estimated from 2% to 31%. The result of a number of studies has shown the prognostic value of CPR in patients with acute myocardial infarction (MI). Patel R. and co-authors, analyzing the ECG in patients with a history of MI and with an implanted cardioverter-defibrillator, found that CPR in this group is associated with the development of life-threatening rhythm disturbances regardless of the left ventricular ejection fraction. Interesting data were obtained in 2015 by Korean scientists who revealed the relationship between CPR and the presence of hemodynamically significant asymptomatic coronary artery stenosis. [5], [6].

There are several possible causes of early ventricular repolarization syndrome:

1) Additional ways of conducting: many authors consider the functioning of additional ways of conducting to be the reason for SRR. It is believed that this phenomenon is a manifestation of an anomaly of atrioventricular conduction with the functioning of additional atrioventricular or paranodal pathways. The researchers believe that the notch on the descending knee of the QRS complex represents a delayed delta wave. As evidence of the presence of an additional pathway as a cause of CPR, data on the shortening of the P-Q interval are given. Electrophysiological examination of the heart in patients with CPR against the background of existing abnormalities of the cardiac conduction system revealed a higher rate of antegrade conduction along the atrioventricular junction and additional pathways compared with persons without this syndrome. At the same time, retrograde conducting additional atrioventricular connections were not detected in individuals with CPR. This confirms the opinion about the role of additional atrioventricular connections with a sufficiently large diameter and pronounced antegrade conduction of the pulse in the formation of the ECG picture of CPR. [7], [8].

2) Uneven flow of ventricular de- and repolarization processes, suggestions are made that CPR occurs as a result of excessive overlap of depolarization and repolarization processes due to their slowdown, but to varying degrees, or the predominance of one of them; There is also an opinion that CPR occurs as simultaneous excitation of a part of the ventricular myocardium from different directions according to the so-called ventricular depolarization pathways. Normally, the process of repolarization begins at the base, and ends in the region of the apex of the heart and occurs in the direction from the epicardium to the endocardium. The most late depolarizing part of the ventricular myocardium is the posterobasal region located around the interventricular septum. There are several points of view on the origin of the j wave and the rise of the ST segment at CPR. ST segment elevation in thoracic leads during CPR reflects an anteriorly directional displacement of the ST segment vector as a result of either delayed repolarization in the subendocardial zone or premature repolarization of the subepicardial zone. This latter point of view is recognized by most authors, fully justifying the term "early ventricular repolarization". In part, this hypothesis is confirmed by data on a decrease or disappearance of ST segment elevation under the influence of physical exertion and with the introduction of isoproterenol, which is regarded as a result of a decrease in the duration of the action potential in the

subepicardial areas of the ventricular myocardium. It was also found that the earliest ECG manifestation of CPR is a primary violation of the process of final depolarization of the ventricles in the form of a sharp slowdown in the decline of the positive potential on the descending knee of the R wave and the absence of the S wave on the ECG. Such a situation is possible only if there is a violation of the physiological asynchronism of depolarization in various parts of the heart muscle as a result of either earlier excitation of the posterobasal parts of the heart, or (more often) later depolarization of the myocardium of the anterior wall of the ventricles. In some patients, rapid, almost simultaneous excitation of the anterior and posterior walls of the heart is detected. In this regard, it is legitimate to interpret CPR as the result of superimposing the vector of delayed depolarization of individual sections of the myocardium on the initial repolarization phase of the ventricles. During isopotential mapping, it was found that the notch is on the descending knee. The R wave in the left precordial leads (V3- V6) is a manifestation of early repolarization, whereas the same changes in the right precordial leads (V1-V2) are caused by migration of the currents of the final activation of the ventricles. Perhaps this can explain the data obtained in the process of multipolar ECG mapping of the heart, when early positive repolarization currents that occur 5-30 ms before the end of the QRS complex were recorded with the same frequency in both patients with CPR and those without it. [8], [9].

3) Dysfunction of the autonomic nervous system: CPR may be associated with disorders in the vegetative sphere with a predominance of vagal influence, confirmed by the data of a physical exercise test, in which the signs of the syndrome disappear. In addition, a drug test with isoproterenol in patients with CPR also contributes to the normalization of ECG. With daily ECG monitoring in people with CPR at night, its signs increase, which may also indicate the significance of the vagus influence in the manifestation of this syndrome. There is an opinion that dysfunction of the autonomic nervous system only contributes to the manifestation of ECG signs of CPR, but does not determine their genesis. At the same time, there is evidence that an increased tone of the sympathetic component of the nervous system can also initiate CPR. Early repolarization of the anteroposterior region may be associated with increased activity of the right sympathetic nerve, which presumably passes in the interventricular septum and the anterior wall of the heart. [9], [10].

4) Electrolyte disturbances: Attempts have been made to link CPR with electrolyte disturbances. The hypercalcemic theory of the j-shaped wave was first postulated back in 1920-1922 by F. Kraus, who drew attention to the appearance of the j point during experimentally induced hypercalcemia. Similar j-shaped waves associated with elevated calcium levels were observed in CPR and other authors. The most important differences between the hypercalcemic j wave and the j wave in CPR are the absence of a domed configuration and the shortening of the Q-T interval. At the same time, no deviations from the norm of electrolyte content were found in patients with CPR. The experiment showed that with hyperkalemia, the duration of local repolarization decreases in many areas of the myocardium, but in the region of the apex of the heart and at the endocardial level, the shortening of the repolarization time is especially significant. The normal gradient of endocardial —epicardial repolarization time was increased at the base and decreased at the apex of the heart, i.e. a situation characteristic of CPR occurred. It is shown that during the potassium test, in 100% of cases, there is an increase in the signs of CPR. In general, the primary change in the electrolyte balance as the cause of CPR is considered by most authors to be an untenable hypothesis, since no deviations from the norm of electrolyte content in persons with "pure" CPR were found. Probably, electrolyte disturbances can explain the ECG dynamics of some signs of the syndrome, for example, a change in the polarity of the T wave, the duration of ECG intervals in various physiological and pathological conditions. [11], [12].

## **2. Objectives**

Investigation of the frequency of occurrence of early ventricular repolarization syndrome in patients diagnosed with myocarditis.

## **3. Methods**

From February to June 2023, 63 patients with a diagnosis of myocarditis were examined, who were included in 1 study group (average age  $45.8 \pm 9.5$  years, 37 men, 26 women). The second study group included 108 patients undergoing medical examination in polyclinics who underwent ECG diagnostics (average age  $42.7 \pm 6.2$  years). The study method was ECG, patients from the first study group also underwent Holter ECG monitoring.

#### 4. Results

In group 1, CPR was detected in 14.28% of the examined (9 patients), in group 2, CPR was registered in 10.1% of patients (11 patients). Statistical analysis revealed no difference between the incidence of CPR in patients with myocarditis and polyclinic patients ( $p>0.05$ ). In all patients from the first group (with myocarditis) CPR was registered as a notch on the descending segment of the QRS complex (Fig. 5). In group 2, 82.4% (89 patients) CPR was observed in the form of notches, in 17.6% (19 patients) — smoothness. In group 1, 76.2% (48 patients) had the J-pattern registered in standard leads (I, II, III, aVL, aVF), in 23.8% (48 patients) — in leads V1 -V4. In the 2nd group in standard leads (II, III, aVL, avR, aVF) CPR was detected in 89.8% (97 patients), in thoracic leads (V4 - V6) — in 10.2% (11 patients). Active myocarditis was detected in all patients with CPR from group 1 according to EMB data.

In group 1 (in patients with myocarditis), ventricular arrhythmias according to ECG (XM-ECG) were detected in 85.7% (54 patients), more than 400 ventricular extrasystoles per day — 38% (in 24 examined). 19.1% (12 surveyed) had unstable gastrointestinal paroxysms. Housing and communal services were registered in all patients with CPR, only 3.1% (2 patients) had less than 400 housing and communal services per day. Gastrointestinal paroxysms were registered in 1.5% (1 patient) with CPR. In group 2, Holter ECG monitoring was not performed.

#### 5. Discussion

Thus, CPR was registered in 14.28% of patients diagnosed with myocarditis (9 out of 63 examined). In patients with myocarditis, CPR was more common in standard leads in the form of a notch.

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