A Slower Heart Rate and Therapeutic Hypothermia Unmasked Early Repolarization Syndrome in a Ventricular Fibrillation Survivor

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Summary

Patients presenting with aborted cardiac arrest who display early repolarization generally are diagnosed with early repolarization syndrome. Therapeutic hypothermia is a standard strategy to improve neurological outcome in comatose patients after cardiac arrest. We present here a patient in whom therapeutic hypothermia exacerbated the J-wave amplitude and morphology, which resulted in episodes of refractory ventricular fibrillation.

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For decades, an early repolarization (ER) pattern, defined as notches or slurs in the terminal portion of the QRS complex (J-wave), has been considered to be a benign ECG finding. However, in recent years, robust population-based studies have established an association between J-waves and ventricular fibrillation (VF), whether idiopathic in nature or secondary to ischemia.¹⁻³⁾ Also, in patients presenting with aborted cardiac arrest who display ER in the inferior and/or lateral leads, documented VF is generally diagnosed as ER syndrome (ERS).^{4,5)}

Therapeutic hypothermia is a standard strategy to improve neurological outcome in comatose patients after cardiac arrest.⁶⁾ J-waves are an established ECG manifestation of hypothermia,⁷⁻¹⁰⁾ however, data linking hypothermic J-waves and VF are sparse.

We present here a patient with ERS who survived from a VF episode. In this patient, on admission, no J-waves could be recognized due to the presence of sinus tachycardia and slowing of the patient's heart rate unmasked the J-waves. Therapeutic hypothermia exacerbated the J-wave amplitude and morphology, resulting in refractory VF episodes.

Case Report

A 42-year-old man with paroxysmal atrial fibrillation suffered an out-of-hospital cardiac arrest at a convenience store in the morning. Following immediate cardiopulmonary resuscitation and successful defibrillation of the VF using an automated external defibrillator, he was transferred to our hospital. On his arrival at our emergency room, his consciousness level was 5 points on the Glas-

gow Coma Scale (eye, verbal, and motor scores were 1, 1, and 3, respectively). He was taking disopyramide (300 mg per day) and a β -blocker (10 mg of carvedilol per day) for paroxysmal atrial fibrillation, but the disopyramide was halted two days before admission. He had no other past medical history or specific family history. The ECG on admission exhibited sinus tachycardia (120 beats/minutes [bpm]) with no J-waves (Figure 1). The plasma electrolyte levels were normal, and transthoracic echocardiography revealed a normal ventricular function without any significant abnormalities. Emergent coronary angiography revealed normal coronary arteries. Hypothermia therapy was performed in the intensive care unit. Approximately 5 hours later, at a body temperature (BT) of the patient of 33.5°C, VF occurred (Figure 2E). The VF was finally defibrillated by an eighth shock with a direct current of 270 J and converted to atrial fibrillation (Figure 2F). After the VF was defibrillated, we finally noticed the presence of J-waves during hypothermia and halted the hypothermia therapy.

The 12-lead ECGs and ECG monitor recordings before the VF episodes were retrospectively evaluated, and the changes in the J-wave amplitude and morphology after stopping the hypothermia therapy were prospectively observed. Fifteen minutes after beginning the hypothermia with a heart rate of 96 bpm and BT of 36.8°C, a slurred J-wave with an amplitude of 4 mm appeared on the ECG monitoring (Figure 2A). The J-wave amplitude gradually became augmented, and its morphology changed from a "slurred" type to a "notched" type parallel with a decrease in the BT (Figure 2B-D). Just before the VF occurrence, the notched J-wave amplitude was 12 mm (Figure 2E). Just after a successful VF defibrillation (Figure 2F), and

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Figure 1. The 12-lead electrocardiograms on admission, just after a successful shock for VF, the next day, and at discharge (1 month after VF). The numbers in the image indicate the height of the J waves (mm). The body temperature (BT), heart rate (HR), and corrected QT Interval (QTc) at each time point are presented at the bottom. bpm indicates beat per minutes.

on cessation of the hypothermia, BT was 33.1°C and heart rate was 55 bpm with high amplitude (8 mm) J-waves (Figure 2G). Therefore, during the rewarming phase, we started an isoproterenol infusion at 0.01 µg/min/kg. The heart rate gradually increased and the amplitude of the J-waves gradually attenuated with the morphology change from a “notched” type to a “slurred” type parallel with rewarming of the BT (Figure 2G-I). On the next morning, notched J-waves were present in the infero-lateral leads (Figure 1). The patient was extubated without any neurological deficits, and the isoproterenol infusion was halted.

The late potentials were negative on the signal-averaged ECG, and no late gadolinium enhancement was found by cardiac magnetic resonance imaging (MRI). No abnormal findings were detected on the fluoro-deoxyglucose positron emission tomography or ¹²³I-15-(p-iodophenyl)-3(R,S)-methylpentadecanoic acid scintigraphy. A genetic analysis of several genes previously implicated in repolarization disorders did not identify any putative disease causing the mutations. The patient underwent catheter ablation of atrial fibrillation, and received an implantable cardioverter defibrillator. One month later, the

Figure 2. The time-course of a bedside continuous single lead ECG monitoring during therapeutic hypothermia. A-E: Cooling phase; F: Direct current cardioversion [DCC] of VFs; G-I: Rewarming phase. The numbers in the image indicate the height of the J waves (mm). The time, body temperature, and heart rate are presented on the top of each tracing. AF indicates atrial fibrillation; HR, heart rate; and VF, ventricular fibrillation

patient was discharged without the use of any antiarrhythmic drugs, but “slurred” J-waves were still present in the infero-lateral leads on the 12-lead ECG (Figure 1). To date, the patient has done well with no VF episodes during a 17-month follow-up.

Discussion

In the present case, J-waves were absent with a heart rate of 120 beats per minutes on admission. However, shortly after starting therapeutic hypothermia with a slower heart rate, slurred J-waves appeared. With a decreasing BT, the J-wave amplitude became augmented with a change in the J-wave morphology from slurring to notching, and, finally, VF occurred. During the rewarming phase, both the amplitude and distribution of the J-waves in the infero-lateral leads became attenuated with an increasing BT. The J-waves were still present in the inferior leads upon discharge, but no VF occurred during his follow up.

Several studies have shown that a bradycardia-dependent augmentation of J-waves is often found in ERS patients with VF episodes.^{3,11} A recent study¹² showed that, at a higher rate, J-waves become attenuated in ERS patients whereas they are augmented in ER subjects with no VF episodes. Thus, an inverse relationship between the J-wave amplitude and heart rate is a characteristic of ERS. In the present case, J-waves were absent with a heart rate of 120 beats per minutes on admission, and we did not recognize that the present case had ERS. However, at the beginning of the therapeutic hypothermia and with a

slower heart rate, J-waves in the infero-lateral leads appeared. On emergency visits shortly after cardiopulmonary resuscitation, patients may often have tachycardias, as was the case in this research. In such a setting, and with no J-waves on the 12-lead ECGs, there is a fair possibility that physicians will not be able to recognize the presence of idiopathic VF. Careful and frequent recording and evaluation of the 12-lead ECGs are indispensable so as not to miss any underlying ERS.

To improve the neurological status, the guidelines⁶ advise performing induced hypothermia (32°C to 34°C) for a sub group of patients with out-of-hospital VF episodes after cardiac arrest and for most other comatose patients after a cardiac arrest.⁶ The precise duration and optimal temperature targets are unknown, but 12 to 24 hours duration at temperature of 32°C to 34°C are recommended based on the regimens studied in prior trials.⁶ Although hypothermia is known to result in J-wave augmentation,⁷⁻¹⁰ there seems to be less evidence that the temporal development and augmentation of J-waves during therapeutic hypothermia results in VF. A previous study prospectively examined the ECG changes during therapeutic hypothermia in 47 patients.⁹ Although J-waves appeared in 21.3% of these patients and the amplitude and duration of the J-waves correlated with the temperature, none of the patients experienced any life-threatening arrhythmias. In another study¹⁰ with 43 survivors of cardiac arrest, which includes patients with idiopathic VF and coronary artery disease-related VF, hypothermia increased both the prevalence and magnitude of the J-waves in these survivors. However, no patients exhibited any VF during

the therapeutic hypothermia either. Thus, there have been a few cases in which J-point augmentation during hypothermia has resulted in VF in patients with idiopathic VF, not Brugada syndrome.^{13,14)} In this case, sinus tachycardia masked the J-waves, and therapeutic hypothermia exaggerated the J-waves and triggered VF attacks. Continuous ECG monitoring disclosed that therapeutic hypothermia augmented the J-waves with changes in the J-waves morphology from slurring to notching, in addition to a decreased heart rate and prolonged QRS width, and that, finally, VF could occur. These ECG changes in addition to the lack of late potentials might support repolarization as the main mechanism of J-wave occurrence. If more careful attention had been paid to the ECG changes, we could have avoided the occurrences of VF. Although J-waves can be observed on ECG monitoring, bedside continuous single-lead ECG monitoring might be insufficient to recognize the appearance of J-waves in the inferolateral leads.

Several ERS cases who survived from an aborted death or VF have been reported.¹⁵⁾ However, to the best of our knowledge, there have been no reports in which the detailed and serial changes in the J-wave amplitude and morphology during therapeutic hypothermia and occurrences of VF were recorded. Therapeutic hypothermia can lead to VF due to an exacerbation of J-waves. This seems to be generally rare, but should be noted as an adverse event during the global use of therapeutic hypothermia in patients with cardiac arrest. During acute care in patients shortly after an aborted cardiac arrest or documented VF, careful and frequent recording and evaluation of the 12-lead ECGs and/or careful observation of the ECG monitor are indispensable, so as not to miss any underlying ERS.

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Disclosures

Conflicts of interest: None declared.

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