CASE REPORT

Giant J Wave on 12-Lead Electrocardiogram in Hypothermia

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Findings on standard 12-lead electrocardiogram in patients with hypothermia include sinus bradycardia, prolonged QT and PR interval, wide QRS complex, supraventricular and ventricular arrhythmia, and the most striking electrocardiographic abnormality, the J wave. Although characteristic of hypothermia, J wave also occurs in other conditions. The electro-physiologic basis of J wave in hypothermia has been recently elucidated. We present a case of giant J wave due to accidental hypothermia and in addition discuss the features, mechanism, and significance of J wave in hypothermia.

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electrocardiogram, hypothermia, J wave, Osborn wave

The J wave is a positive deflection found on standard 12-lead electrocardiogram following the QRS complex. Also known as Osborn wave, J wave occurs in hypothermia, hypercalcemia,¹ Brugada's syndrome,² and after resuscitation in patients with cardiac arrest.³ J wave can persist even after re-warming from hypothermic to the normothermic state.⁴

ILLUSTRATIVE CASE

A 66-year-old man with history of chronic obstructive pulmonary disease, vocal cord paralysis, and permanent tracheotomy was admitted to the medical intensive care unit with accidental hypothermia after he was found in an unresponsive state.

A 12-lead electrocardiogram (ECG) obtained initially at a core temperature of 83 degrees Fahrenheit (°F) showed sinus bradycardia with giant J wave, a prolonged QT_c interval, and normal PR interval (Fig. 1). Two hours later, another 12-lead ECG done at a core temperature of 89°F demonstrated decrease in amplitude of J wave as well as shortening of the prolonged QT_c interval (Fig. 2). After

7 hours of re-warming, normal core temperature was established. On a subsequent ECG, J wave was absent and QT_c interval returned to normal (Fig. 3). All ECGs were done with a paper speed of 25 mm/s at 10 mV/mm voltage. Serum electrolyte levels were normal.

DISCUSSION

Although initially reported with hypercalcemia in 1920,⁵ Tomazewski was the first to describe J wave in association with hypothermia in 1938.⁶ Later, in the 1950s, Osborn studied the mechanism of the J wave phenomenon in hypothermia. Osborn, while experimenting with hypothermic dogs, described the prominent J wave and postulated that it was due to an injury current caused by acidosis.⁷

J wave is a positive deflection at least 1 mm in height in the terminal portion of the QRS complex near the QRS-ST segment junction. The J wave of hypothermia should be easily identified at the terminal part of at least two consecutive QRS complexes of any one left ventricular lead on the standard 12-lead ECG.⁸ The presence of J wave appears

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Figure 1. Zero hour: 12-lead ECG obtained while core temperature was 83°F. Giant J waves can be noted following the QRS complexes in all leads (represented by black arrows in lead V4 and II); QT_c interval: 640 ms.

Figure 2. Two hours later: 12-lead ECG obtained while core temperature was 89°F. Note that the size of the J wave has decreased during rewarming (represented by black arrows in lead V4 and II); QT_c interval: 560 ms.

Figure 3. Seven hours later: 12-lead ECG obtained when core temperature was normal. Here, J waves are absent; QT_c interval: 500 ms.

to be a function of temperature. Approximately 80% of patients with moderate hypothermia (core body temperature of $<95^{\circ}\text{F}$) manifest with J wave on standard 12-lead ECG.⁹ J wave is commonly found in the lateral or inferior precordial leads. The spatial orientation of the mean J wave vector is anterior, leftward, and inferior.¹⁰ However, in severe cases of hypothermia (core temperature $<86^{\circ}\text{F}$), J waves can occur in any electrocardiographic lead. J wave size is inversely proportional to core body temperature. Large J waves can occur in severe hypothermia. Moreover, J waves may persist even after core body temperature returns to normal.^{4,11}

Using physiologic ventricular cardiac cell models, the cellular action potentials causing the J wave deflection on the surface ECG has been studied. The J wave phenomenon occurs due to marked accentuation of the action potential notch of the epicardial cells. It has been demonstrated that the marked action potential notch created by the transient outward potassium current in the epicardial cells as compared to the endocardial cells results in a prominent voltage gradient between the epicardial and endocardial cells and manifests as the J wave on the standard 12-lead electrocardiogram.¹²

The prognostic value of J wave in hypothermia is unclear. Although cardiac arrhythmia has been reported in hypothermic patients with J wave,¹³ there is no conclusive evidence correlating the presence of J wave to cardiac arrhythmia in hypothermia. The electro-physiologic mechanism underlying the development of J wave predisposes to arrhythmogenicity in Brugada's syndrome. In this syndrome, the outward potassium current in the epicardial cells is significantly augmented causing heterogeneous repolarization within the ventricle.¹⁴ This conspicuous dispersion of repolarization potential causes reentry during cardiac muscle action potential phase-II resulting in ventricular reentrant arrhythmia.¹⁵

A wide range of other electrocardiographic changes occur in hypothermia (Table 1). In general, sinus rhythm predominates in mild hypothermia (core temperature more than 95°F). However, patients with moderate hypothermia (core temperature between 86°F and 95°F) develop supraventricular arrhythmia such as atrial fibrillation and junctional arrhythmia.¹⁶ When core temperature falls below 86°F , ventricular arrhythmia¹⁶ and asystole occur. The mechanism of ventricular arrhythmia in hypothermia is unclear. Manipulation of the patient, tissue hypoxia, acid-base disturbances,

Table 1. Summary of ECG Abnormalities in Hypothermia

Findings	Mild Hypothermia (>95°F)	Moderate Hypothermia (95–86°F)	Severe Hypothermia (<86°F)
P wave ¹⁶	Normal	Decreased size ^a	May be absent
PR interval ^{9,10,18}	Normal	Prolonged ^b	Prolonged ^b
QRS duration ¹⁷	Normal	Prolonged	Prolonged
J wave ⁴	Usually absent	Present in >80% of cases in the inferior and lateral leads	Present in all leads, sometimes large in size
T wave ⁸	Normal	Decreased height in the inferior leads	Decreased height in inferior leads
QT interval ¹⁷	Normal	Prolonged	Prolonged
Supraventricular arrhythmia ¹⁶	Absent	Frequent ^c	Frequent ^c
Ventricular arrhythmia ^{16,17}	Absent	Absent	Frequent

^aFine oscillations due to muscle tremor can mask P wave.

^bVarying degrees of AV block occurs with decreasing core temperature.

^cAtrial fibrillation and junctional rhythm occur.

autonomic dysfunction, vasopressor therapy, and iatrogenic factors such as insertion of central lines are suspected causative factors.¹⁷ Re-warming does not predispose to ventricular arrhythmia.¹⁸

CONCLUSION

J wave is a common electrocardiographic manifestation of hypothermia with core body temperature of less than 95°F. The size of J wave correlates with the degree of hypothermia. Heterogeneous dispersal of the action potential notch, prominent in epicardial cells as opposed to endocardial cells is a plausible mechanism of the J wave. The independent prognostic significance of J wave in hypothermia is unclear.

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