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Muhammad Mohsin Zafar

Department of Cardiology, Reading Hospital – Tower Health, West Reading, PA

Muhammad Asad Hanif

Department of Cardiology, Reading Hospital – Tower Health, West Reading, PA

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Which Endocrine Disorder Does This ECG Suggest?

Muhammad Mohsin Zafar¹, Muhammad Asad Hanif¹

¹ Department of Cardiology, Reading Hospital – Tower Health, West Reading, PA

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CASE PRESENTATION

A 45-year-old male with a history of Graves' disease who recently underwent total thyroidectomy presents on post-op day 3 with symptoms including fatigue, numbness around the lips, and tingling in both hands. The electrocardiogram (ECG) displayed findings similar to those shown in Figure 1.

Questions:

1. Describe the ECG?
2. Dysfunction of which endocrine organ should be suspected?

EKG INTERPRETATION

The ECG shows normal sinus rhythm with a heart rate of 80 beats per minute. The QT interval is markedly prolonged with a QTc of 500 milliseconds (*indicated by the red two-way arrow in Figure 2*). Notably, the T wave remains unchanged (not widened), suggesting that the QT prolongation is due to the lengthening of the ST segment, a characteristic feature of hypocalcemia. This helps differentiate it from hypokalemia, which also causes QT prolongation but is accompanied by T wave widening.

DISCUSSION

Calcium ions play a crucial role in both cardiac muscle contraction and relaxation, impacting the cardiovascular system broadly.^{1,2} The cardiac ac-

tion potential is created through voltage-gated ion channels that facilitate the movement of ions across the cell membrane. Disruptions in serum electrolyte levels can interfere with these ionic currents, affecting cardiac conduction and altering the electrocardiogram which may lead to arrhythmias or, in some instances, offer protection against them.³ Although potassium imbalances, particularly hyperkalemia, are more commonly linked to severe arrhythmias, imbalances in calcium and magnesium levels can also play a role.

In hypocalcemia, the primary ECG finding is the prolonged QTc interval, which results from the lengthening of the ST segment.⁴ This prolongation is directly related to the severity of hypocalcemia; in other words, the lower the serum calcium level, the more prolonged the QTc interval. Conversely, hypercalcemia tends to shorten the QTc interval.

Hypocalcemia extends the duration of phase two of the cardiac action potential (*as shown in Figure 3*) and influences calcium channel function and calcium influx during this phase.⁵ These changes contribute to the prolonged QT interval observed in hypocalcemia. Despite the lengthening of the QT interval, it rarely exceeds 140% of the normal duration.⁶

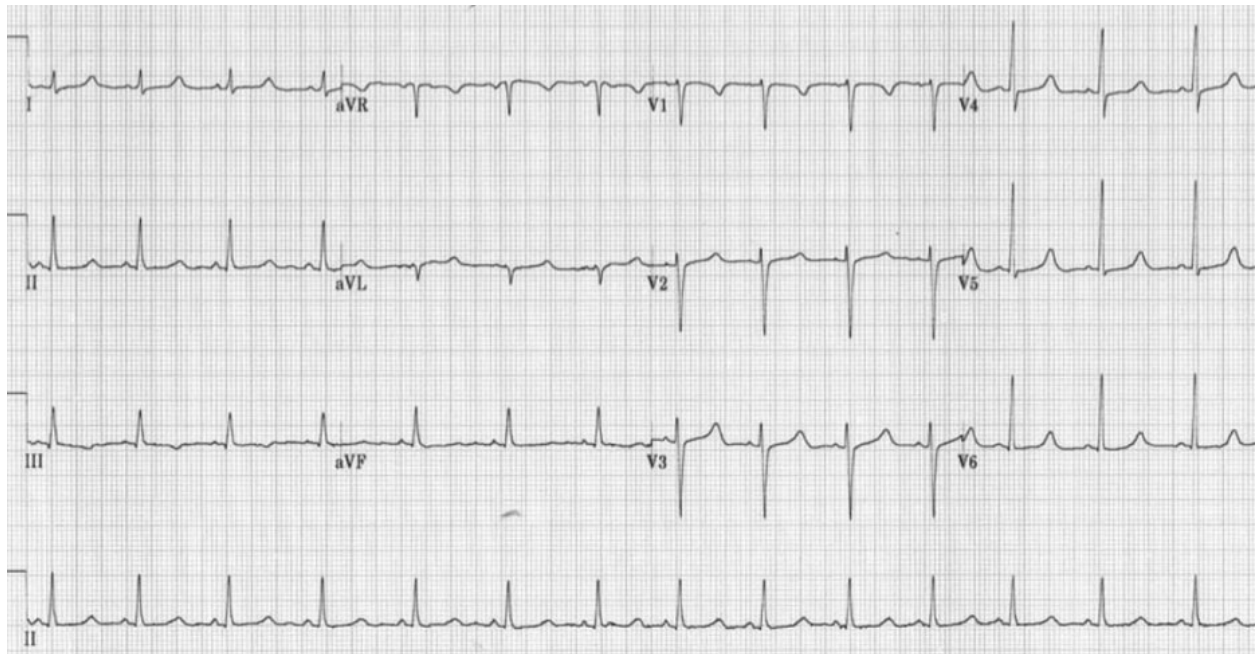
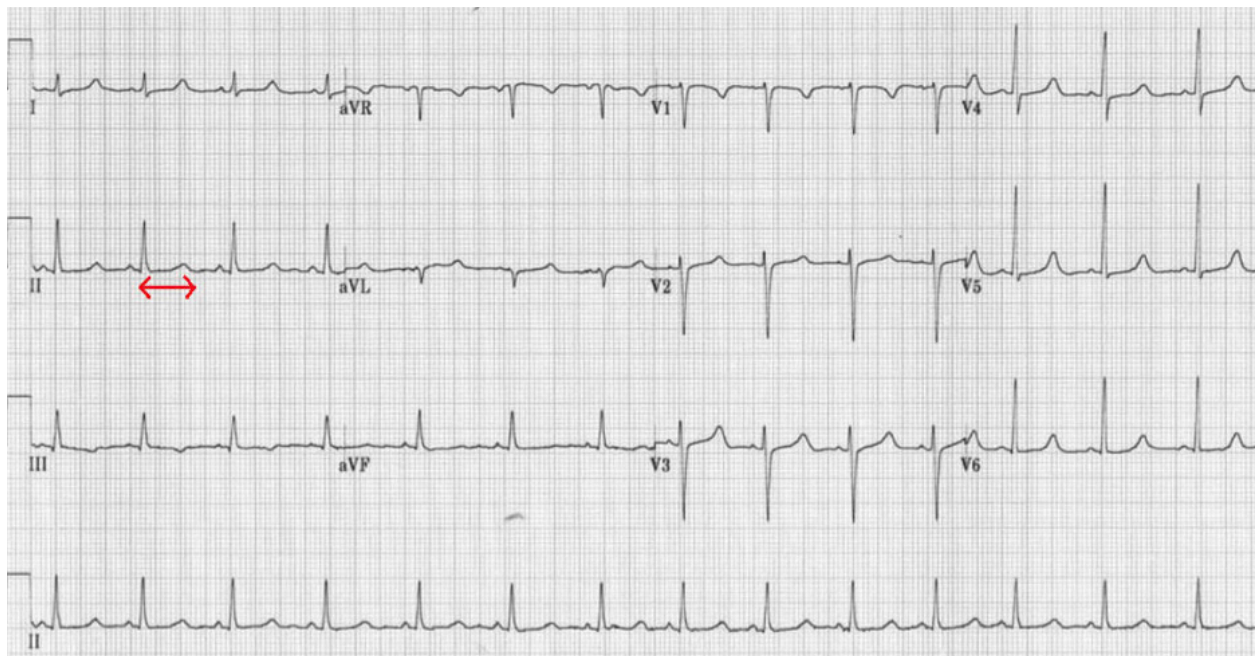
Hypocalcemia typically does not affect the T-wave on the ECG, as it does not alter phase three of the action potential. Consequently, T-waves usually remain normal in duration, amplitude, and morphology. However, in severe cases of hypocalcemia, there may be rare occurrences of decreased T-wave voltage, T wave flattening, terminal T-wave inversion, or deep T-wave inversion.⁷

It is important to consider that hypomagnesemia can exacerbate the ECG changes associated with hypocalcemia. While rare instances of torsades de pointes linked to hypocalcemia have been reported, these cases often involved additional factors that prolong the QT interval.⁸

A prolonged QT interval can also be associated with various other conditions, such as hypokalemia

Correspondence to Muhammad Moshin Zafar at muhammad.zafar@towerhealth.org

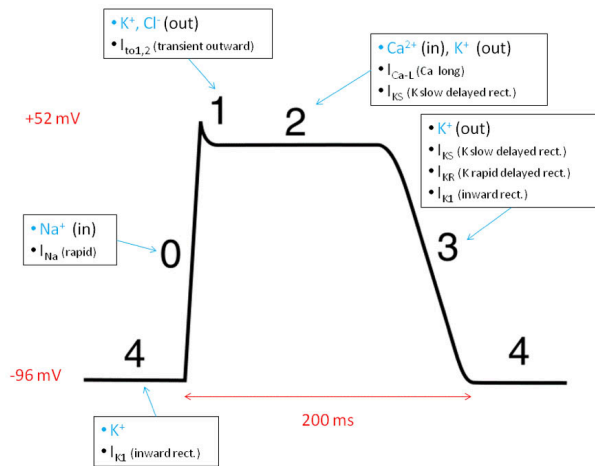
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FIGURE 1. 12-lead electrocardiogram**FIGURE 2.** Annotated 12-lead electrocardiogram

(characterized by broad T-waves and U-waves), hypoglycemia, diabetic ketoacidosis, alkalosis, beriberi, heart failure, cardiomegaly, heart block, bundle branch block, and the use of quinidine. Therefore, measuring both the QT interval and the corrected QT interval is essential to accurately assess the presence of hypocalcemia and rule out other potential causes of QT prolongation.

CLINICAL OUTCOME

In our patient, the hypocalcemia was confirmed through serum calcium levels (5.6 mg/dl). Treatment was initiated with calcium supplements and close monitoring of electrolyte levels. The patient's symptoms of fatigue and tingling improved with the normalization of calcium levels. Follow-up ECGs

FIGURE 3. Cardiac muscle action potential.⁹

showed resolution of QTc prolongation, confirming the correlation between his hypocalcemia and the ECG changes.

The patient was advised on the importance of monitoring calcium levels regularly, particularly in the post-operative period, and was instructed on recognizing symptoms of electrolyte imbalances. Continued follow-up was scheduled to ensure stable calcium levels and prevent the recurrence of similar issues.

TAKE HOME POINTS

1. A prolonged QTc interval with unchanged T waves often indicates hypocalcemia, helping distinguish it from other causes of QT prolongation.
2. Regular serum calcium checks are essential after surgeries like thyroidectomy to detect hypocalcemia early.

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