

Abnormal Electrocardiogram in a Woman with a Urinary Tract Infection

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A 52-year-old woman presented to the emergency department with atypical chest and back pain that began 24 hours earlier, dysuria, and frequency of urination. She had no known risk factors for coronary arterial disease. Her temperature was 100.6 ° F. Her white blood cell count was $16.8 \times 10^3/\mu\text{L}$ (normal, 4.5 – 11.0), and segmented neutrophils were $13.4 \times 10^3/\mu\text{L}$ (normal, 1.8 – 8.0). Her urine contained 500 mg/dL of protein, 150 red blood cells and 500 white blood cells per μL (confirmed microscopically by > 100 red blood cells and > 100 white blood cells per high power field), a few bacteria per high power field, and was positive for nitrites. Serum creatine kinase was 49 IU/L (normal < 190) with an MB fraction of 0.7 ng/mL (normal < 5.6), and serum troponin was 0.01ng/mL (normal < 0.09). Her urine drug screen was negative. An electrocardiogram was recorded (Figure).

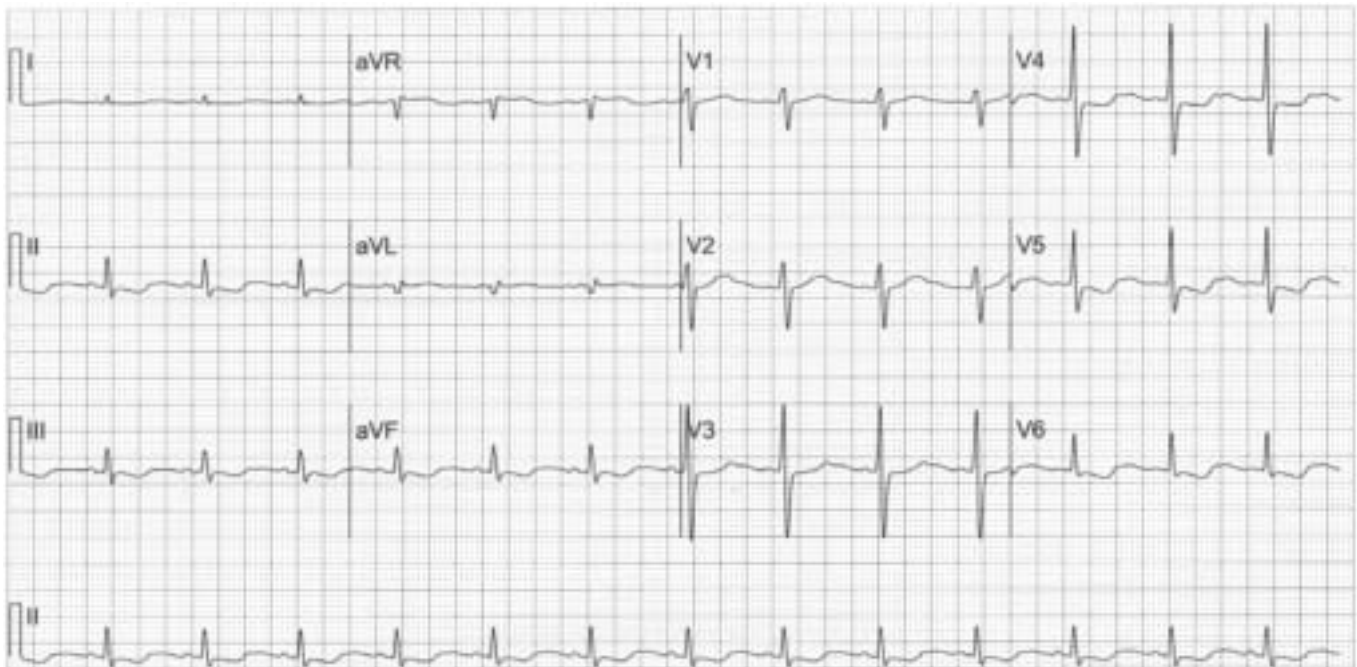


Figure. Electrocardiogram recorded in the emergency department.

What is your diagnosis?
Explication is on the following page.

ECG of the Month**Presentation is on the previous page.**

DIAGNOSIS: *Sinus rhythm, rate 82/minute. Sagging ST segments, low T waves, and prominent U waves suggest hypokalemia.*

Depressed ST segments with low or inverted T waves are common in myocardial ischemia or injury and are part of a "strain pattern" in some persons with left ventricular hypertrophy. What distinguishes this electrocardiogram from the electrocardiograms in those conditions are large U waves that in the lateral and inferior leads are as tall as or taller than the T waves. This pattern is typical of hypokalemia, and the patient's serum potassium at the time of the electrocardiogram was 2.8 mEQ/L (normal = 4.0 – 5.0).

Mild and even moderate degrees of hypokalemia often cause no electrocardiographic change.^{1,2} Hypokalemia's first manifestation on the electrocardiogram usually is an increase in the height of the U wave, which continues to have a polarity similar to that of the T wave. As the U waves get larger, the T waves get smaller, and soon the U waves are as tall as or taller than the T waves. At lower levels of serum potassium, the ST segment becomes depressed, and the full-blown pattern of hypokalemia is seen (Figure).¹⁻³ Surawicz et al found this typical pattern in only 10% of patients whose serum potassium level was between 3.0 and 3.5 mEQ/L, 35% of those with levels between 2.7 and 3.0, and 78% of those with potassium levels < 2.7.⁴ At even lower levels of serum potassium, the U waves are huge, and the T waves become notches on their upslopes or are no longer visible as separate waves. This huge U wave is sometimes mistaken for the T wave, which has led to the erroneous conclusion that the QT interval is long in hypokalemia.⁵

A low serum potassium causes more than a morphologic blemish on the electrocardiogram. Hypokalemia favors

early after depolarizations and enhanced automaticity. As a consequence, ventricular ectopy and supraventricular ectopy are common in hypokalemic patients, and when the hypokalemia is profound, ventricular tachycardia, torsade de pointes, and ventricular fibrillation may occur, even in patients without heart disease or digitalis therapy.² Severe hypokalemia also slows conduction and may rarely cause significant atrioventricular block, including complete heart block.¹ Increased automaticity together with disturbances in atrioventricular conduction may result in nonparoxysmal atrial tachycardia with block and several varieties of atrioventricular dissociation.² Non-cardiac manifestations of severe hypokalemia include anorexia, fatigue, nocturia, rapid shallow respirations, mental aberrations, and muscular weakness that at times proceeds to actual paralysis.¹

A paucity of potassium ions augments digitalis toxicity by allowing more digitalis molecules to bind to potassium sites on membrane sodium-potassium ATPase.³ Many of the hypokalemia-induced arrhythmias described above are identical to arrhythmias caused by digitalis toxicity. Hypokalemic patients with digitalis-induced tachyarrhythmias should be given potassium, but potassium may make digitalis-induced high-grade atrioventricular block worse and in this situation should be used with great caution.¹ In addition to its augmentation of digitalis-induced arrhythmias, hypokalemia increases the toxicity of drugs which prolong repolarization, such as quinidine, procainamide, and the phenothiazines.¹

Not all large U waves are due to hypokalemia. Left ventricular hypertrophy, bradycardia, and digitalis all increase the size of U waves, but rarely to the extent that marked hypokalemia does. Quinidine and other Vaughn Williams Class IA antiarrhythmic drugs also produce prominent U waves, and the combination of digitalis and a IA agent can cause ST-segment depression, low T waves, and prominent U waves indistinguishable from the hypokalemic changes seen in the Figure.^{1,5}

CME INFORMATION					
TARGET AUDIENCE	CREDIT				
The January/February ECG of the Month is intended for primary care physicians, general internists, general cardiologists, cardiac electrophysiologists, and cardiac nurses.	The LSMS Educational and Research Foundation designates this educational activity for a maximum of one-half (.5) <i>AMA PRA Category 1 Credit</i> TM . Physicians should only claim credit commensurate with the extent of their participation in the activity.				
EDUCATIONAL OBJECTIVES	DISCLOSURE				
After reading the article, the healthcare provider should recall the cardiac effects of a low serum potassium and be able to recognize the effects of such a deficit on the electrocardiogram.	Dr. Glancy discloses that he is the editor of this journal. Dr. Wang has nothing to disclose.				
Estimated time to complete this activity is one-half hour.	<table border="0"> <tr> <td style="text-align: center;">ORIGINAL RELEASE DATE</td> <td style="text-align: center;">EXPIRATION DATE</td> </tr> <tr> <td style="text-align: center;">1/31/2007</td> <td style="text-align: center;">1/31/2008</td> </tr> </table>	ORIGINAL RELEASE DATE	EXPIRATION DATE	1/31/2007	1/31/2008
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This **ECG of the Month** is presented by the Sections of Cardiology, Departments of Medicine, Louisiana State University School of Medicine, New Orleans, and Earl K. Long Medical Center, Baton Rouge. **Dr. Glancy** is a professor and **Dr. Wang** is a fellow in the Section of Cardiology, Department of Medicine, Louisiana State University Health Sciences Center, New Orleans.

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CME QUESTIONS

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Choose the one answer that is most correct for each question.

1. True or false:
Hypokalemia's first manifestation on the electrocardiogram usually is an increase in the height of the U wave.
2. Which of the following is not a cause of prominent U waves?
 - a. Hypokalemia
 - b. Sinus bradycardia
 - c. Hypercalcemia
 - d. Digitalis
 - e. Left ventricular hypertrophy
 - f. Class IA antiarrhythmic agents
3. Severe hypokalemia may produce which of the following disturbances in cardiac rhythm?
 - a. Ventricular ectopy
 - b. Supraventricular ectopy
 - c. Ventricular tachycardia
 - d. Nonparoxysmal atrial tachycardia with block
 - e. Complete heart block
 - f. All of the above.
 - g. All of the above except e.
4. True or false:
The full-blown electrocardiographic pattern of severe hypokalemia includes ST-segment depression, low T waves, and prominent U waves.