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INTERPRETATION OF ECG RECORDINGS: PART 2

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ABSTRACT

Background: The analysis of irregularities in an electrocardiogram (ECG) recording is one of the basic skills of every doctor. That is why becoming familiar with the principles of appropriate ECG interpretation is critical during training and should be mastered at the initial stages of education. An accurate and timely ECG analysis constitutes one of the key factors that determine the prognosis for a patient. At the first stage of test evaluation, irregularities in the components of an ECG must be analyzed, including the waves and segments on the printout. During evaluation, it must be considered that, under certain conditions, particular irregularities may not be apparent. For example, with atrial fibrillation, P wave deviations in the recording are sometimes not visible. The data contained in the ECG recording provides information about heart defects, conduction disorders in the heart muscle, hypothermia, and acute (e.g., myocardial infarction) or chronic conditions (e.g., atrial fibrillation, stable ischemic heart disease). It is important to interpret ECG results in conjunction with the patient's condition and medical history.

KEYWORDS: electrocardiogram, interpretation, lead, complex, wave, irregularities in the ECG recording

Background

In the previous part of the article, we outlined how to perform the ECG test with the aid of an electrocardiograph, and reviewed the regularities occurring among waves and segments. However, to accurately interpret an ECG recording, it is also necessary to become familiar with the irregularities occurring among the individual deviations. Irregularities in the waves and segments are outlined below and are discussed in the order of occurrence on the printout [1].

Irregularities among the components of an electrocardiograph recording

P Wave

The P wave is the first deviation on the isoelectric line which, under normal conditions, takes on a positive value in leads V_2–V_6, I, II, and aVF. Irregularities in the P wave can include a negative or two-phase deviation. The occurrence of this phenomenon in the I and II limb leads indicates that the electrical impulse was created in the pacemaker cells and not in the sinoatrial node. This is a sign that distinguishes patients with a left atrial rhythm or those where the heart is located on the right side of the chest (dextrocardia) [2,3,4].

The occurrence a P wave amplitude above the rated value (>3 mm) is also treated as an irregularity. This observation is characteristic of patients with heart disorders or chronic pulmonary heart disease, and indicates an overgrowth of the right atrium. In addition, an increased P wave amplitude points to irregularities in the thyroid (hyperthyroidism), coronary artery disease, or to a dominance of the sympathetic system over the parasympathetic system. On the other hand, a decrease in P wave amplitude can depend on the inhibitory effect of the vagus nerve (X) on the sinoatrial node in the cardiac conduction sys-

tem. This phenomenon may be tied to a shift in the pacemaker towards the lower part of the node, which is conditioned by stimulation of the vagus nerve during treatment with digitalis, or by pressure on the carotid sinus [2,3,4,5].

A peaked, notched, or two-phase deviation in the P wave is also treated as irregular. The presence of a notch in one or both of the arms of the deviation indicates issues with conduction of the electrical impulse inside the atria, and points to disorders in the area of the atrial muscle [1,2,3,5].

An extended duration time (>0.11 s), indicated by a broad and sometimes split P wave, suggests left ventricle failure or disorders which lead to overgrowth of the left atrium (e.g., arterial hypertension, left-sided ventricular outflow tract obstruction, or incomplete closure of the mitral valve) [1,2,4,5].

In some cases, P wave deviations are not visible in the electrocardiograph. Such a phenomenon occurs in atrial fibrillation, where P waves are changed to slight deviations from the isoelectric line, of various frequencies, which are visible in the precordial leads V_1–V_2. Apart from this, invisible P waves are characteristic of a lack of electrical activity of the atria. There are also P deviations hidden inside the QRS complex or in T waves. The former occurs when there is an impulse running from the atrioventricular pathway, and the latter during paroxysmal tachycardia or an atrioventricular block [4,6].

PQ Interval and Segment

When the duration of the P wave and the PQ segment is higher than its maximum value (0.20 s) or lower than 0.11 s, we are dealing with yet another irregularity [2,5].

An increase in the duration of the PQ segment is known as an extended PQ segment. This occurs when the electrical impulse stimulating the atria of the heart is transferred to the ventricles, but its conduction time is extended (atrioventricular block I°) [7]. Patients with this abnormality in their ECG recording are typically treated with atropine. However, if atropine administration does not shorten the interval, it is likely that the extension is due to inborn heart defects, atherosclerosis in the arterial vessel area, inflammation of the heart muscle, or infectious diseases (e.g., diphtheria or sexually-transmitted diseases, including syphilis) [1,3].

An excessive shortening of the PQ interval typically appears in patients with an inborn defect of the cardiac conduction system. This irregularity is caused by the existence of an additional muscle bundle, which generates an alternative electrical impulse between the atrium and the ventricle. This phenomenon is known as pre-excitation, and is most commonly seen in Wolff-Parkinson-White (WPW) syndrome [8]. Apart from this, shortening of the PQ interval also occurs when the electrical impulse comes from the area around the atrioventricular pathway. In this case, we are dealing with a negative P wave in limb leads II and III, which appears in the form of a deviation near the QRS complex [3,5,6].

QRS Complex

A total of three separate deviations (Q, R and S) comprise the QRS complex. When analyzing irregularities here, the individual waves should be examined separately, as irregularities in a particular deviation can indicate distinct medical conditions, including those not associated with the circulatory system [2,5,4].

Special attention should be paid to the height and duration of the Q deviation, which is the first component of the QRS complex. This deviation may indicate a transmural myocardial infarction. In addition, a low amplitude and short duration time (≤0.03 s) in the second precordial lead can indicate the presence of ischemic heart disease [4,5,6,9, 10].

Attention must also be paid to an increase in the height of the R or S deviations. The presence of such a phenomenon in the left ventricular precordial leads (V_3, V_5, V_6) and the limb leads (aVL) indicates an overgrowth of the muscle of the left ventricle. In the case of an overgrowth of the right ventricle, an increase in the amplitude of the aforementioned waves is usually observed in the right ventricle precordial leads (V_1) and aVR [11]. In addition, a more in-depth analysis of the QRS complex may show an extended duration time (≥0.12 s) and the presence of a notched, wide R, as well as the absence of a "large" R, or its complete absence among the components of the complex. The occurrence of these latter variations is associated with a block of the left branch of the bundle of His [12], which is a consequence of a deceleration of the conduction or damage in the left branch area [2,4,5,6,9].

J Point

For the J point (found immediately after the QRS complex), a deviation of more than 2 mm from the isoelectric line is always treated as an irregularity. In order to determine the diagnostic value of this irregu-

larity, the ST segment must also be analyzed [4,5,13]. However, movement of the J point upward in leads I, II, and III always has clinical diagnostic value, regardless of the position of the ST segment. This phenomenon is indicative of a pericardial syndrome associated with the accumulation of fluid in the pericardial sac [14]. A high J deviation is also associated with a decrease in body temperature to 35°C, thus indicating hypothermia [4,5,6,13,15].

ST Segment

The ST segment in electrocardiography may take on various shapes, and its appearance depends on the physiological characteristics and the medical condition of the patient [5,6].

One example of an irregularity in the ST segment is seen in patients with the genetic disorder Brugada syndrome. Three types of irregularities may be observed with this condition. One is a deviation in the isoelectric line of 0.2 mV in one or more of the unipolar precordial leads V_1 or V_2 (known as a type 1 pattern). Other irregularities of the ST segment in these patients include a deviation of 1 mV that is saddle-shaped (type 2), and an elevation of the ST segment above the isoelectric line by < 0.1 mV (type 3) [16]. In addition, the occurrence of Pardee's wave (an elevation of an upwards-turned convex ST segment), also known as an injury current, is indicative of acute cardiac ischemia or fresh myocardial infarction. A similar shaped elevation of the injury current may also be an indicator of pericarditis [4,5,6,13,17,18,19,20].

Irregularities in the ST segment are not only limited to elevations above the isoelectric line. For example, a lowering of the ST segment not exceeding 2 mm can indicate cardiac ischemia. In addition, a lack of symmetricity in the ST segment may be an indication of coronary heart disease or an overburdening of the heart ventricles. An important clinical factor to consider when examining the ST segment is treatment with digitalis, as this medication can produce a bowl-shaped ST segment in the ECG image [5,13,19,20,21].

It should be noted that the appearance of the ST segment, to a significant degree, is a correlation between the appearance of the J point and the T wave [4,5].

T wave

With various pathological conditions, different shapes of the T wave can be observed. During a potassium disturbance (hyperkalemia) [22], acute cardiac ischemia, or coronary heart disease, the T wave exhibits a high amplitude with a pointed and symmetrical shape. Deviations with a negative potential in the precordial leads V_2 to V_4 [23] can indicate myocardial infarction, hypertrophic cardiomyopathy, or a stroke. In addition, waves that are flat in character are associated with damage to the heart muscle, disturbances in the water-electrolyte balance, or the presence of various medications. Another irregularity in the appearance of the T wave is a two-phase character that presents with a block of a branch of the bundle of His or with WPW syndrome [4,5,11,13,18,19,21].

QT Interval

Irregularities in the QT interval can be divided into two groups. The first shows a shortened duration of the interval. This can be related to an excess of potassium (hyperkaliemia) and calcium (hypercalcemia) in the serum, hypothermia, or to Short QT Syndrome (SQTS), where the QT interval is ≤0.34 s or < 0.36 s, and ≥1 s for SQTS. The second group includes extensions of the duration of the QT interval (in women ≥0.46 s and in men ≥0.45 s). Among the conditions contributing to QT interval extensions, we can distinguish Long QT Syndrome (LQTS), which increases the risk of an abnormal heart rhythm known as *torsade de pointes (TdP)* [11,13,18,19,24].

U Wave

The U wave is an inconsistent phenomenon on the ECG. Its origin remains unknown and irregularities in this area generally occur along with defects in the T wave. Irregularities in the U wave are characterized by a highly positive or negative amplitude. These large deviations are associated with LQTS, stroke, pheochromocytoma, and hyperkalemia. An exception to this is the atrioventricular block (hypervagotonia) [25], where high amplitude U waves are not connected with irregularities among T waves. Negative amplitude deviations are not common among U waves. Their presence may be an indication of an overgrowth of the left ventricle, fresh myocardial infarction, or cardiac ischemia [4,5,11, 13,18,19,20].

Interpretation of ECG results

Irregular recording in an electrocardiograph printout

Case 1.
Patient's age: 64 years old
Sex: M

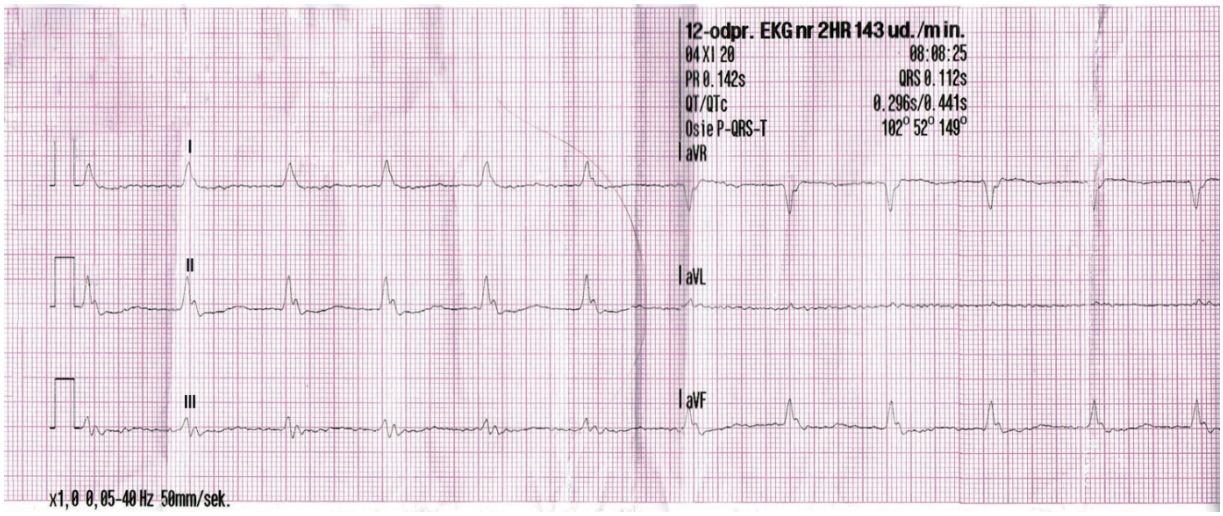

Figure 1. The first part of the abnormal ECG, tachycardia

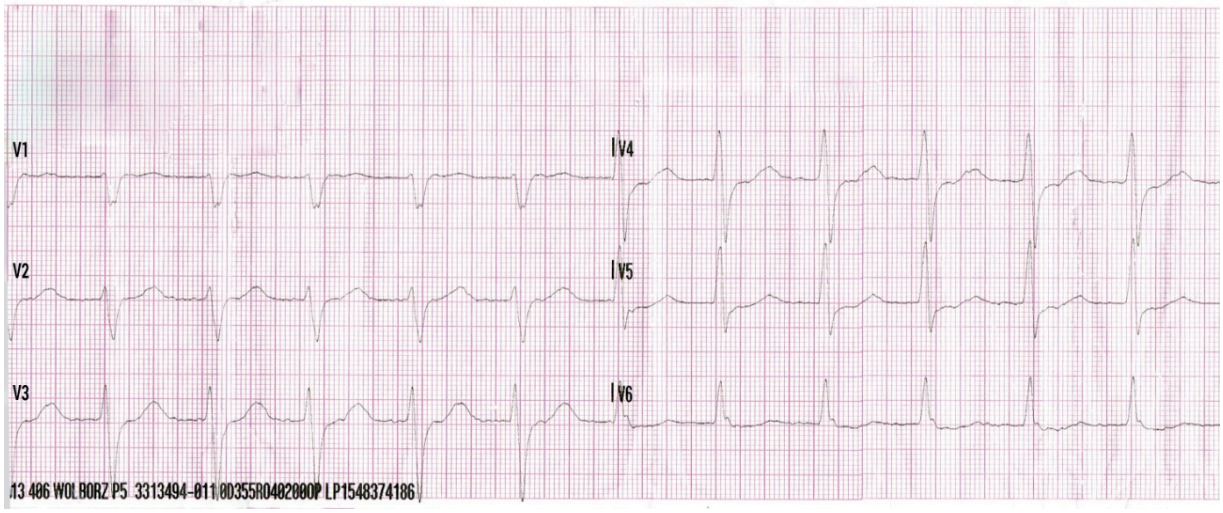

Figure 2. The second part of the abnormal ECG, tachycardia

Description:

a) 50 mm/s 10 mm/mV
b) Rapid regular rhythm with characteristics of supraventricular tachycardia (140 beats/min)
c) normal electrical axis of the heart
f-h) increased QRS deviation in precordial leads V_3, V4, and V_5, which may be an indicator of an overgrowth of the left ventricle
i) elevation of the ST segment in leads II, aVF, V_6,which may be an indicator of cardiac ischemia in the lateral and inferior walls

Case 2.
Patient's age: 56 years old
Sex: F

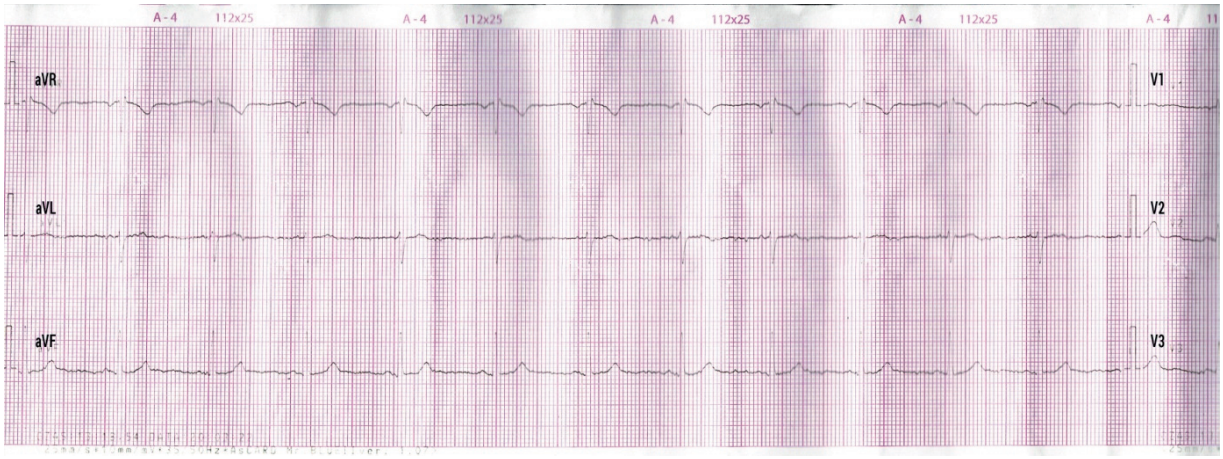

Figure 3. The first part of abnormal ECG, fresh ventricular septal rupture

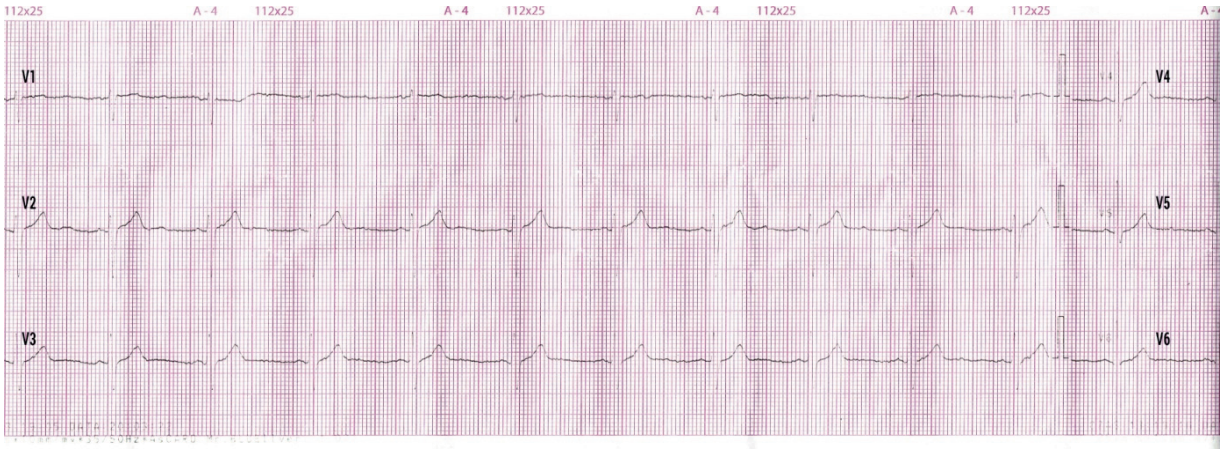

Figure 4. The second part of abnormal ECG, fresh ventricular septal rupture

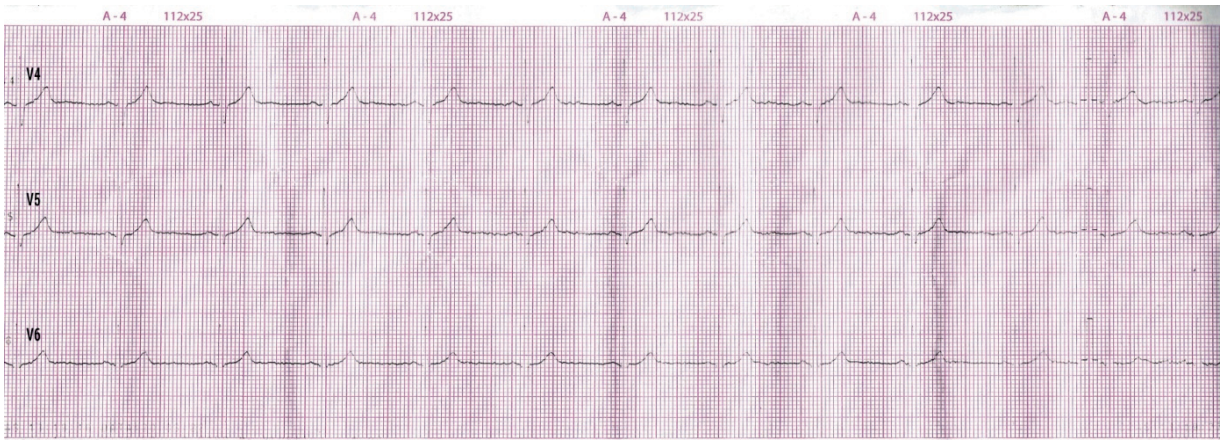

Figure 5. The third part of abnormal ECG, fresh ventricular septal rupture

DESCRIPTION:

a) 25 mm/s 10 mm/mV
b) regular sinus rhythm of 80 beats/min
c) normal electrical axis of the heart
d) visible elevation of the ST segment in precordial leads V_3 and V_4, which may be an indicator of a fresh ventricular septal rupture [26,27,28]

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