

CASE REPORT

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An interesting electrocardiogram caused by lead reversal

Changjun Li¹, Nan Wang², Qinghua Chang² and Dianzhu Pan^{3*}

Abstract

Background During normal sinus rhythm, atrial depolarization is conducted from right atrium to left atrium through Bachmann's bundle, and a normal P wave axis which is measured on the frontal plane is between 0° and +75°. The change of P wave polarity is helpful for the analysis of origin point.

Case presentation We report a patient with negative P wave in lead I. The characteristics of QRS complex in leads V₁ to V₆ are helpful to preliminarily differential diagnosis. The 12-lead electrocardiogram (ECG) with correct limb leads (right arm-left arm) placement shows sinus rhythm with complete right bundle branch block (RBBB).

Conclusions The change of P wave polarity as well as characteristics of QRS complex can help identify limb-lead reversals.

Keywords Limb-lead reversals, Electrocardiogram, Mirror-image dextrocardia, Acquired dextrocardia, Left atrial rhythm

Background

Limb-lead reversals on electrocardiogram (ECG) have an estimated frequency of 0.4% in the outpatient setting to as high as 4% in the intensive care unit [1]. Left arm and left leg lead reversals can lead to the misidentification of inferior wall ST-segment elevation myocardial infarction (STEMI) as lateral STEMI [2]. Promptly identifying lead reversal is important to avoid diagnostic and treatment delays of any clinical situation. We report a patient with

negative P wave in lead I as a result of right arm-left arm lead reversal.

Case presentation

A man in his 60s presented to our hospital with complaints of poor activity of the left limbs accompanying barylalia for the past 6 days. His medical history included hypertension for which he took amlodipine. He had no other medical history, including diabetes mellitus and coronary heart disease. On examination, his blood pressure was 157/80 mmHg, with a heart rate of 78/min and respiratory rate of 20/min. Transthoracic echocardiography showed discordant left ventricular myocardial motion and left atrial enlargement (40 mm). His initial ECG is shown in Fig. 1, which demonstrates a wide QRS complex (140 milliseconds) with rsR' pattern in lead V₁ and Rs pattern in lead V₅ (S wave of greater duration than 40 ms), indicating a complete right bundle branch block (RBBB). P wave morphology shows negative deflection in lead I, biphasic deflection in lead II and positive polarity

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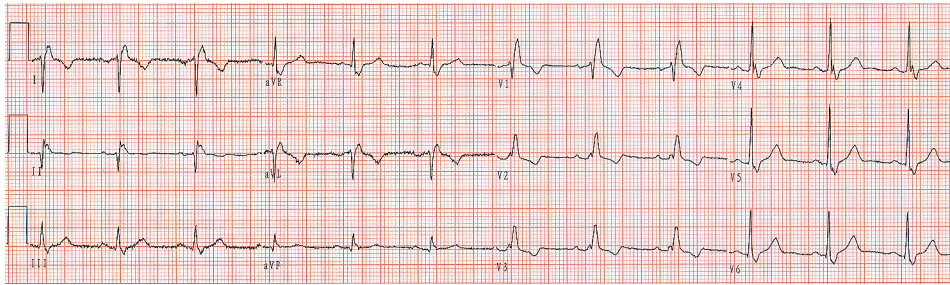


Fig. 1 Patient's initial 12-lead ECG

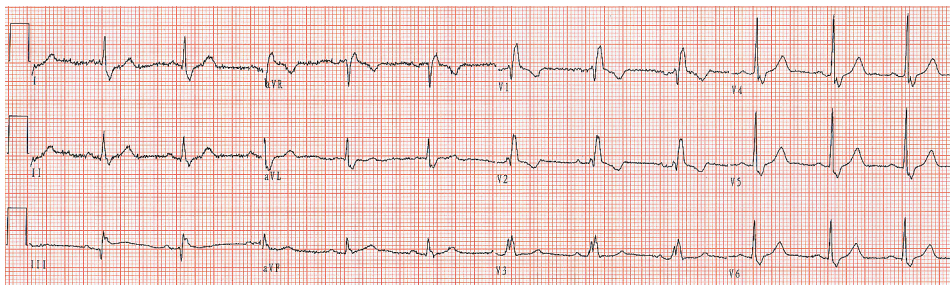


Fig. 2 The 12-lead ECG with correct limb leads placement shows sinus rhythm with complete right bundle branch block

in lead aVR. Besides, the P-QRS-T polarity in lead aVR is identical to that seen in leads V₅ and V₆. These features aforementioned should raise the suspicion of the presence of limb electrode reversal. The 12-lead ECG with correct limb leads (right arm-left arm) placement shows sinus rhythm with complete RBBB (Fig. 2).

Discussion and conclusion

The P wave on the ECG represents atrial tissue activation. During normal sinus rhythm, atrial depolarization is conducted from right atrium to left atrium through Bachmann's bundle, and a normal P wave axis which is measured on the frontal plane is between 0° and +75° [3]. Therefore, the atrial depolarization vector projection on the lead II and aVR results in positive polarity of lead II and negative polarity of lead aVR. Besides, P wave morphology shows positive deflection in lead I. When the limb and precordial leads are placed in their standard location, the aVR and V₅ or V₆ leads are in the same alignment but have deflections in the opposite polarity [4].

In our case, P wave morphology shows biphasic deflection (initially positive followed by negative deflections) in lead II and positive polarity in lead aVR, indicating that it isn't likely the result of normal sinus rhythm. P wave morphology shows negative deflection in lead I, indicating that it is likely the result of conduction from the left atrium to the right atrium. The 5 most likely causes of depolarization sequence are the mirror-image dextrocardia, acquired dextrocardia, left atrial rhythm, the right arm-left leg lead reversal and the right arm-left arm

lead reversal [5, 6]. The characteristics of QRS complex in leads V₁ to V₆ are helpful to preliminarily differential diagnosis. Figure 1 shows a RBBB morphology in chest leads. There is a progressive increase in R-wave amplitude from leads V₁ to V₆, which isn't favor of mirror-image dextrocardia. Transthoracic echocardiography also didn't show mirror-image dextrocardia. The causes of acquired dextrocardia (dextroposition) include lung, pleural, and diaphragm lesions, such as right pneumonectomy, left pneumothorax, and left lung hypoplasia, which can induce negative P wave in lead I. Recently, Tsai et al. [6] reported one patient with inverted P and T waves in lead I and aVL, and dominant R wave in lead V₁ in acquired dextrocardia. Our patient denied any above medical history and intra-abdominal or thoracic symptoms. The echocardiography showed left atrial enlargement, which can cause left atrial rhythm. If this was an example of a left atrial rhythm, QRS complex morphology is consistent with conduction to the ventricles through the normal His-Purkinje atrioventricular conduction system (normal QRS complex or BBB). The aVR and V₅ leads displayed identical polarity deflections, excluding left atrial rhythm [4]. At this time, we should suspect the presence of abnormal placement of limb leads. Besides, in a 2021 study, Littmann [7] proposed that lead V₁ can mimic aVR. The V₁ and aVR discordance also should raise the suspicion of the presence of electrode reversal. Right arm-left leg reversal leads is uncommon. Right arm-left leg reversal produces highly abnormal-looking limb leads, with leads I, II, III, and aVF being negative and aVR being upright, mimicking inferior myocardial infarction.

The aVL is unchangeable. In our case, P waves in leads III and aVF are positive and the QRS complex morphology in lead aVL is inconsistency with lead V₅, therefore it is highly unlikely to have a right arm-left leg reversal. Right arm-left arm reversal lead is common. In a patient with a right arm-left arm lead reversal, the P-QRS-T in lead I should be flipped, the pattern of lead aVR resembles a normal aVL, and lead II resembles a normal lead III [8]. The initial ECG (Fig. 1) corrected according to the aforementioned features was consistent with typical RBBB. The repeat ECG in Fig. 2 after correcting right arm-left arm lead connection shows sinus rhythm with RBBB, confirming right arm-left arm lead reversal on initial ECG.

The ECG is a simple and inexpensive tool which can be recorded by many different types of health personnel, including physician doctors, ECG technicians, nurses from a variety of hospital units. The value of the ECG depends upon the accuracy of how it is obtained. When right arm-left arm lead reversal is not complicated with arrhythmia, ECG features are typical and easy to diagnose. If combined with other abnormal ECG changes, such as the RBBB in this patient, electrocardiographic manifestations are diverse and atypical. Recognizing right arm-left arm lead reversal in patients with RBBB is an important and intellectually rewarding skill. Close evaluation of the lead characteristics of P-QRS-T changes such as lead I and chest leads may provide clues in diagnosing right arm-left arm lead reversal and its differential diagnosis. Besides, it is important to identify anatomic landmarks and to clear up any other misconceptions. Finally, a quality improvement program should monitor the incidence of common errors such as right arm-left arm lead wire reversal and provide retraining when indicated.

Abbreviations

ECG	Electrocardiogram
RBBB	Right bundle branch block
STEMI	ST-segment elevation myocardial infarction

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Author contributions

DZP conceived and designed the research. CJL, NW and QHC acquired the data. CJL, NW, QHC and DZP drafted the manuscript and made critical revision of the manuscript for key intellectual content. All authors read and approved the final version of the manuscript. All authors have agreed to authorship and order of authorship for this manuscript.

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Data availability

All relevant data supporting the conclusions of this article is included within the article.

Declarations

Competing interests

The authors declare no competing interests.

Ethics approval and consent to participate

The subject gave his informed consent. All the procedures performed in this study were in accordance with the ethical standards of the institutional and/or national research committee, and with the 1964 Helsinki declaration and its later amendments; or with comparable ethical standards. The study was approved by the Medical Research Ethics Committee of the First Affiliated Hospital of Jinzhou Medical University.

Consent for publication

Informed consent for publication of case report was obtained from patient in written form.

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