Case Report

Journal of INTERNATIONAL MEDICAL RESEARCH

Journal of International Medical Research
48(2) 1–8

DOI: 10.1177/0300060520903608
journals.sagepub.com/home/imr
SAGE

The phenomenon of concealed conduction in a case of His bundle pacing (HBP)

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Abstract

The phenomenon of concealed conduction in His bundle pacing (HBP) has rarely been reported. We report here a patient who had 2: 1 atrioventricular block and complete left bundle branch block was used because of HBP. The patient developed continuous right bundle branch block after the operation. After excluding mechanical damage, we speculate that the mechanism of right bundle branch block in this case was due to concealed conduction.

Keywords

His bundle pacing, concealed conduction, right bundle branch block, atrioventricular block, QRS complex, ventricular function

Date received: 7 June 2019; accepted: 8 January 2020

Introduction

His-Purkinje system pacing is divided into His bundle pacing (HBP) and left bundle branch area pacing (LBBaP).[1,2] Pacing in the left bundle branch area can produce a right bundle branch block (RBBB) pattern. When atrioventricular (AV) delay of the pacemaker is prolonged, fusion waveforms appear between right bundle branch descending excitation and left bundle area pacing. This situation creates a QRS wave

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that resembles that of a normal electrocardiogram (ECG). We present a case with a distinct bundle branch block pattern. Our patient showed a continuous RBBB pattern during HBP after an operation. When we prolonged the AV delay to the maximum value after the operation, the patient still showed RBBB, which may be due to a concealed conduction mechanism.

Case report

A 75-year-old male patient was hospitalized on 7 May 2018 because of a slow heart rate lasting for 2 days. The patient's history showed a slow heart rate for 2 days before admission and a self-measured pulse rate of approximately 40 times/minute, without dizziness or amaurosis. Thereafter, a dynamic ECG at the local hospital showed 2: 1 atrioventricular block (AVB) with complete left bundle branch block (CLBBB). A physical examination after admission showed that the pulse rate was 42 times/minutes and blood pressure was 150/70 mmHg. Routine blood tests did not show any major abnormalities in blood biochemistry. A chest X-ray showed increased lung texture, but normal heart shadow size and shape.

An ECG showed 2: 1 AVB and CLBBB (Figure 1). An ultrasonic cardiogram indicated that aortic valve degeneration was accompanied by a small amount of regurgitation and tricuspid valve regurgitation, the left ventricular ejection fraction (LVEF) was 45%, and left ventricular end-stage diameter (diastolic/systolic) was 51 mm/39 mm. A negative troponin test excluded the possibility of AVB caused by acute myocardial infarction. We considered using HBP or LBBaP to correct AVB and CLBBB because these can partially correct CLBBB. If correction of CLBBB failed

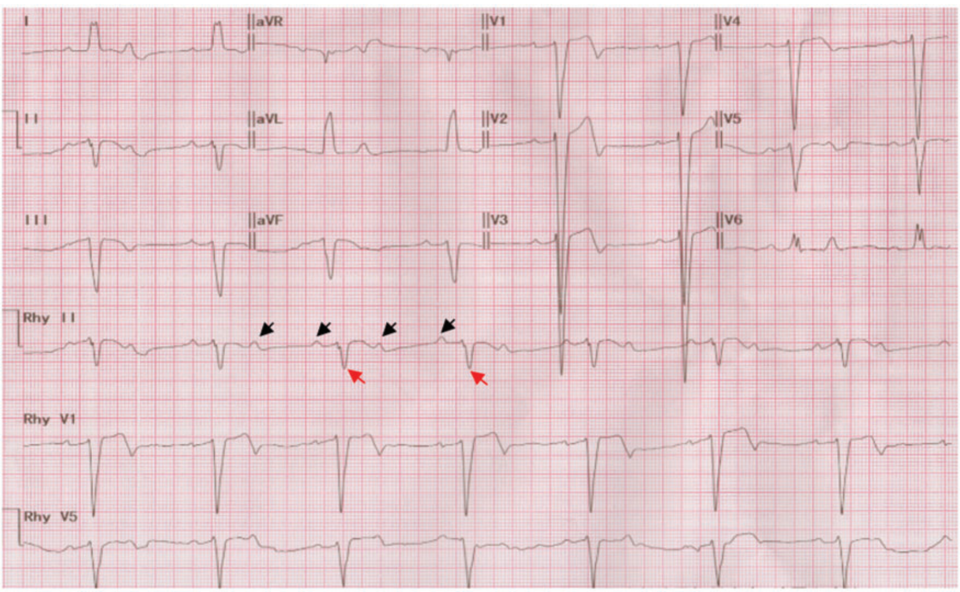

Figure 1. Preoperative electrocardiogram shows 2: 1 atrioventricular block and complete left bundle branch block. The black arrows show P waves and the red arrows show QRS waves. Atrioventricular conduction is 2: 1. The QRS morphology of V1 is rS and that of V6 is RsR', which represent left bundle branch block.

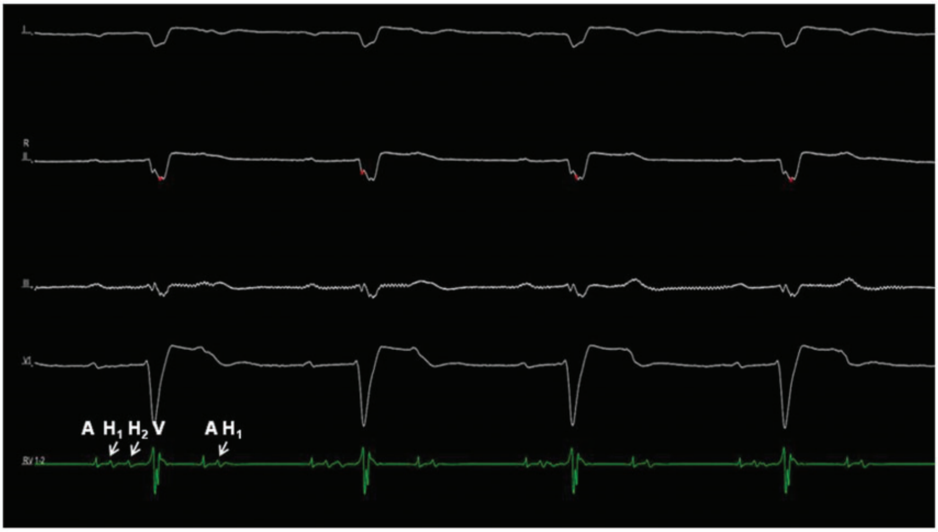

Figure 2. Intraoperative intraluminal view shows the His bundle separation potential (white arrow). When atrioventricular block occurred, the conduction block was in the His bundle.

during the operation, we would have considered upgrading to cardiac resynchronization therapy.

A Medtronic 3830-69 cm pacing electrode with the assistance of a Medtronic C315 His sheath (Medtronic, Minneapolis, MN, USA) was used to map the His bundle potential (unipolar) during the operation. The Carto-3 three-dimensional mapping system (Johnson & Johnson Company, New Brunswick, NJ, USA) was used to record His bundle potential. A Medtronic 2290 programmable controller was used to test sensing, pacing, and impedance parameters, and to record current of injury. The split His bundle potential was recorded during the operation (Figure 2). Dropped beats correlated with the missing H2 component, which indicated intrahisian block. During a threshold test, the QRS complex became narrower and the V1 lead rS wave became an rSR' wave and showed a pattern of continuous RBBB. CLBBB was corrected at a threshold of 1.4 V at 0.5 ms (Figure 3). When the output was adjusted to 5 V at 1.0 ms and 10 V at 1.0 ms, it remained in the RBBB mode. Because of the patient's restlessness during the operation and a lack of dependence on pacing during cessation of pacing, no ventricular backup lead was implanted (Figures 4 and 5). The pacemaker was temporarily programmed with a long AV delay. However, the paced QRS complexes continued to have RBBB morphology (Figure 6).

The patient was followed up for 6 months after the operation. The patient was in good condition and the pacing threshold was stable. The threshold was 1.5 V/0.5 ms and the LVEF increased from 45% to 71%. The left ventricular end-stage diameter (diastolic/systolic) was 45 mm/27 mm.

The study protocol was approved by the ethics committee of Shanxi Provincial People's Hospital. The patient provided written consent for publication.

Discussion

A meta-analysis showed that the HBP threshold was 1.76 V in the acute phase (<3 months) and 1.79 V in the

Figure 3. During His bundle pacing, the rS wave of V1 leads became an rSR' wave, and showed a pattern of continuous right bundle branch block and correction of complete left bundle branch block.

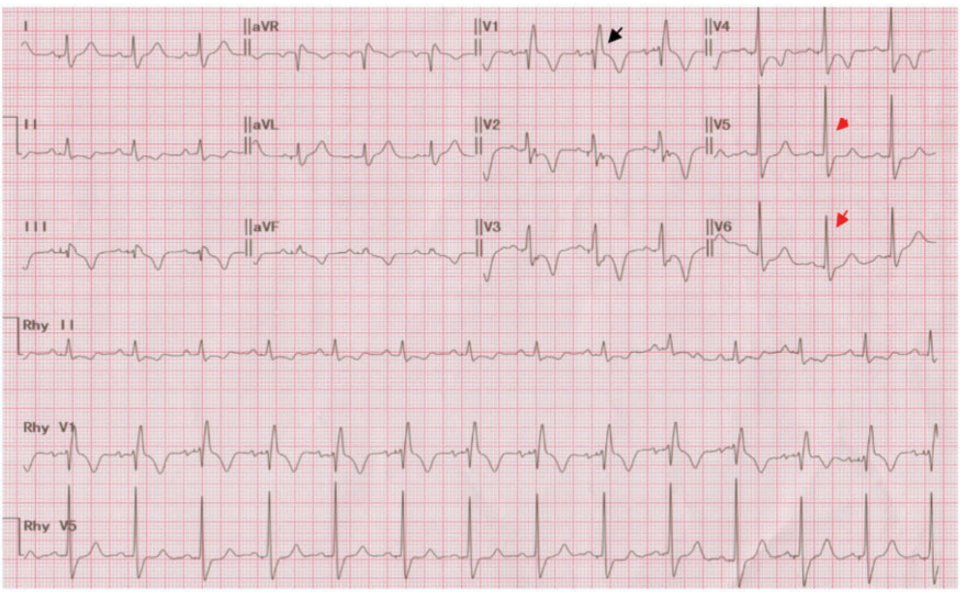

Figure 4. Postoperative pacing electrocardiogram suggests correction of complete left bundle branch block. With His bundle pacing, the QRS wave in V1 leads is M-shaped (black arrow) and that in V5 and V6 leads is Rs (red arrow), which represent right bundle branch block along with disappearance of left bundle branch block.

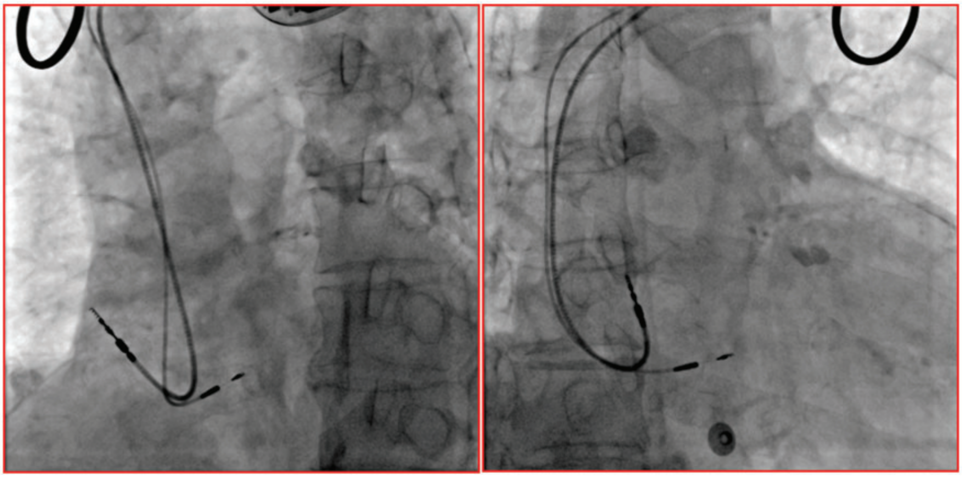

Figure 5. Fluoroscopic projection images. The left image was taken at the 45° left anterior oblique view and the right image was taken at the 30° right anterior oblique view.

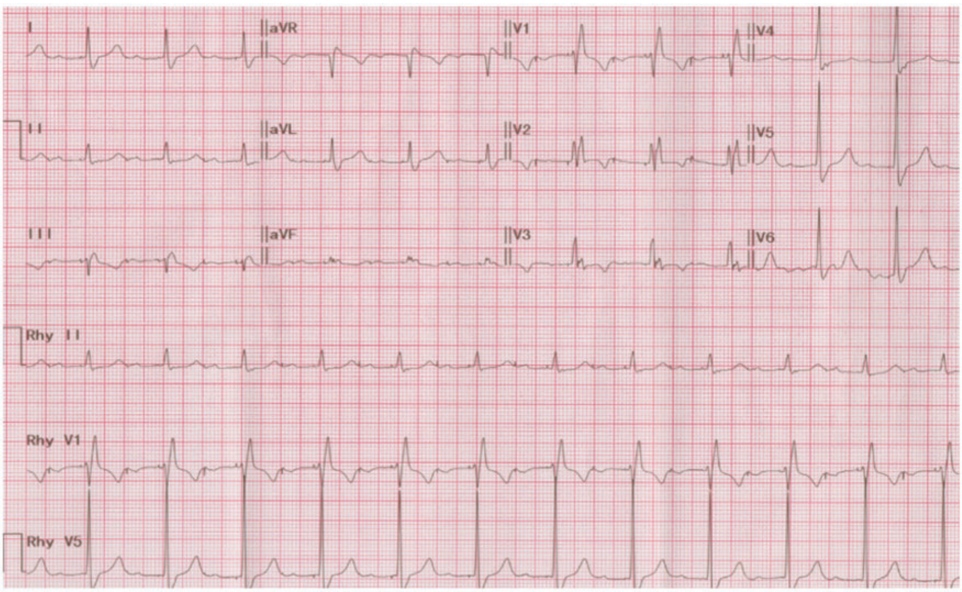

Figure 6. When the AV delay was prolonged, the pattern of right bundle branch block remained.

chronic phase.[3] The authors of this meta-analysis also conducted safety assessment of 18 studies and showed that the leads were revised in 26 of 966 patients because of dislodgement and 20 had an increased pacing threshold. In 2017, the international consensus of experts on permanent HBP stated that the His bundle capture threshold should be <2.5 V at 1.0 ms.[4] Therefore, a CLBBB correction threshold of 1.4 V at 0.5 ms was acceptable in our patient.

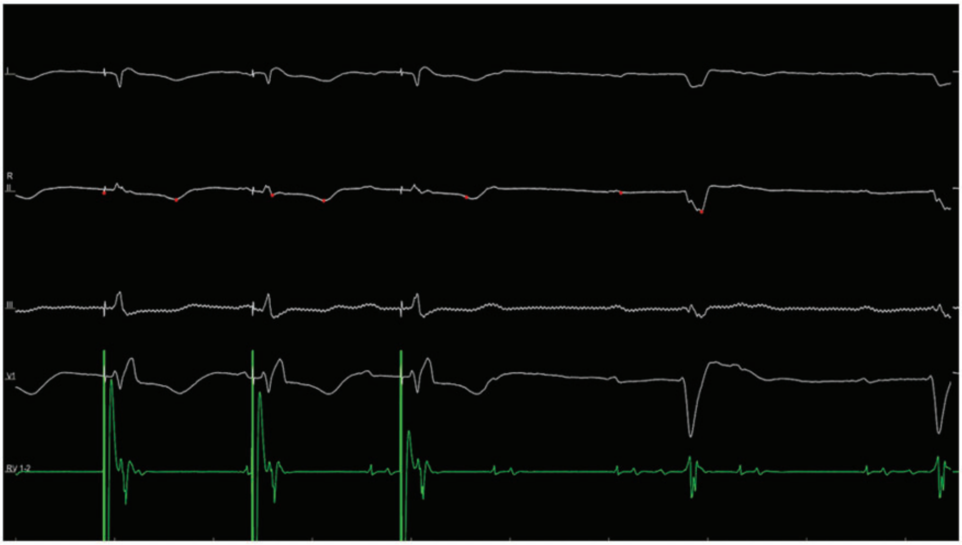

Figure 7. When pacing was stopped, 2: 1 atrioventricular block with complete left bundle branch block occurred again.

His bundle fibers are arranged longitudinally and separated by connective tissue. Because of a lack of side to side intercellular low resistance junctions, His bundle transmission is dissociated longitudinally. Therefore, the branches of the left and right bundles are separated within the His bundle.[5–7] The His bundle itself can be divided into the unbranched part and bifurcated part. The unbranched part is part of the atrioventricular junction, while the bifurcated part forms the beginning of the left and right bundle branches. Because of the histological and anatomical characteristics of the longitudinal separation, bundle branch block may occur in the His bundle and HBP can correct bundle branch block, similar to our case. In our case, the patient showed a continuous RBBB pattern during HBP after the operation rather than permanent damage to the right bundle branch during implantation of the 3830 electrode. When pacing was temporarily stopped during the operation, the original 2: 1 AVB with CLBBB pattern was restored (Figure 7). Huang et al.[8] reported the first case of LBBaP in 2017. When AV delay was gradually prolonged, a fusion waveform appeared between right bundle branch descending excitation and LBBaP, which created a QRS wave that was close to normal. In our case, the patient had 2: 1 AVB before the operation, and CLBBB was corrected after the operation, which produced a RBBB morphology. We speculate that prolonging the AV delay could encourage self-excitation to be transmitted downward through the right bundle branch and intermittent 2: 1 excitation conducted through the right bundle branch might also appear. This situation could result in one RBBB and one normal QRS waveform. However, this did not occur in our patient. When the AV delay was prolonged to the maximum value after operation, the patient still showed RBBB (Figure 6). This finding may be due to a concealed conduction mechanism. In 1948, Langendorf[9] first proposed the phenomenon of concealed conduction. Concealed conduction refers to

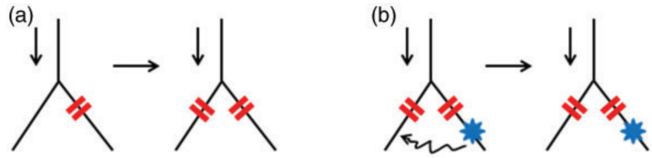

Figure 8. Schematic diagram. (a) Previous excitation generated a long refractory period through the right bundle branch, preventing the next excitation from being transmitted. (b) His bundle pacing induced left bundle branch excitation that could continue to produce concealed excitation of the right bundle branch. This prevented continuous transmission of upper excitation through the right bundle branch.

when excitation reaches a certain area, which is transitioning between absolute and relative refractory periods, and the excitability of that area is low. During this time, the 0-phase rise of the action potential in that area is low and excitation cannot spread to the surrounding area, preventing normal depolarization. However, because this area has been excited, continuous excitation prevents completion of the refractory period and the next excitement cannot be transmitted normally. Therefore, concealed conduction is not really "concealed", but is an "incomplete penetrating excitement". In our case, the patient had 2: 1 AVB with CLBBB before the operation, and therefore, supraventricular excitation was transmitted downward through the right bundle branch at 2: 1. The combination of incomplete conduction block in the right bundle branch and a long refractory period formed by the previous excitation results in the next excitation conduction block. In our case, excitation of the left bundle branch due to continuous HBP could have caused concealed excitation of the right bundle branch. This would then have affected transmission of excitation through the right bundle branch and resulted in the pattern of continuous RBBB in HBP (Figure 8).

RBBB can occur at all ages and can be found in a selection of otherwise normal people in addition to a variety of organic heart diseases. Right ventricular electrical activity is achieved by slow conduction through the interventricular septum after left ventricular excitation. Some previous studies have reported that RBBB may also cause delayed left ventricular activation. The majority of evidence suggests that RBBB can cause delayed right ventricular electrical excitation and decreased right ventricular diastolic function.[10] Furthermore, this has little effect on left ventricular electrical excitation and left ventricular diastolic function. Therefore, the effect of RBBB on left ventricular function is still controversial. At present, the guidelines do not include patients with RBBB and a left ventricular ejection fraction >35% as indications for cardiac resynchronization therapy. Although our patient showed RBBB after the operation, follow-up several months later showed that left ventricular function was improved.

HBP is a type of physiological pacing. Study of the anatomy and electrophysiological mechanism of the His system is beneficial in supporting the development of pacing electrophysiology. This study examined whether prolonging AV delay by LBBaP could generate a fusion waveform of pacing via the right bundle branch and left bundle branch. In our case, concealed conduction of the left bundle branch to the right bundle branch after capture of the left bundle branch was observed after HBP, resulting in continuous RBBB.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

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