JOURNAL OF INSURANCE MEDICINE

*J Insur Med* 2017;47:125–129

**ECG CASE STUDY**

# A Notch Hiding in the R Wave

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A benign appearing ECG is found to contain subtle clues suggestive of underlying structural heart disease.

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**Received:** July 15, 2017

**Accepted:** August 5, 2017



## HYPOTHETICAL SCENARIO

A couple is applying for a large *Joint Last to Die* policy offered by your company. The husband, age 71, has been assessed as a mildly substandard risk.

Preliminary information gathered by the paramed company's questionnaire reveals that the wife is 68 years old and has been a lifetime non-smoker. Her past health includes recurrent step throats and a tonsillectomy as a child, four uneventful pregnancies and a wrist fracture sustained during a fall while hiking in Colorado. Except for minor illnesses, she has reported no ill health since that time. Both parents died in their 80s, and her 2 siblings and 4 children are all alive and well. The paramed exam revealed a normal build, a heart rate of 79 bpm and an average blood pressure of 139/85. The underwriter is waiting for an attending physician's statement from her personal physician.

Figure 1 represents the applicant's current electrocardiogram (ECG) obtained for age and amount by the paramed company. I did not have an original ECG of sufficient quality to be reproducible for publication. This similar ECG was reproduced with permission from the Harvard ECG Wave-Maven site: ECG Wave-Maven: Self-Assessment Program for Students and Clinicians.[1] (http://ecg.bidmc.harvard.edu).

## ECG FINDINGS

The ECG shows sinus rhythm with an average ventricular rate of 70 bpm. The PR interval is 0.19 second. The QRS axis is normal. The QRS duration is 0.11 second with an incomplete right bundle branch block pattern (rSR′ morphology in leads V1-2 and mild slurring of the S wave in leads I, AVL, V5 and V6). There is mild fragmentation of the QRS complex with notching of the R wave in leads III and AVF. Nonspecific ST-T abnormalities are present in leads V1-V4.

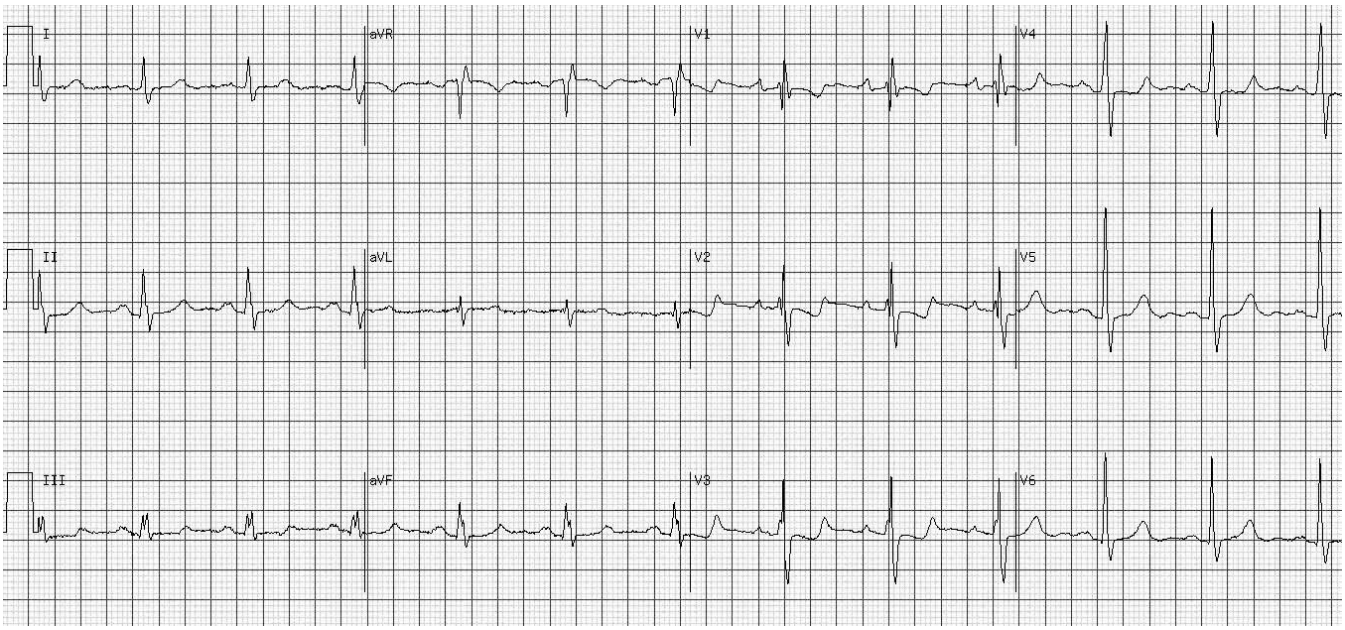


**Figure 1.** *Applicant's Electrocardiogram.*

## ECG INTERPRETATION

The diagnostic criteria for *incomplete* right bundle branch block (iRBBB) consist of a QRS duration of 0.10-0.11 second (in contrast to *complete* right bundle branch block where the QRS must measure 0.12 second or longer), an rsr′, rsR′, or rSR′ QRS pattern in V1 and/or V2 and an S wave in lead I, V5 and V6. If the QRS complex measures only 0.09 sec. or less and yet there is an rsR′ in V1 or V2, this is usually considered a normal variant and not an intraventricular conduction defect.[2, 3]

Assuming no technical error in recording the ECG such as higher placement of the right precordial leads V1 and V2, the interpretation of iRBBB as an isolated finding depends on the company it keeps. Normal individuals especially young individuals or athletes, or those with chest wall deformities such as pectus excavatum, may have this ECG pattern. In insurance medicine, if there is no history or sign of cardiac disease, iRBBB is usually accepted as producing no risk and is not given any weight in the underwriting process.[2–4]

iRBBB is seen also in congenital heart disease (especially atrial septal defects), myocarditis, infiltrative cardiomyopathies (although these usually produce complete RBBB), right ventricular enlargement (hypertrophy or dilatation) as seen in valvular disease, pulmonary emboli or arrhythmogenic right ventricular dysplasia/cardiomyopathy, ventricular preexcitation, type-2 Brugada pattern and iatrogenically after cardiac surgical or ablation procedures.[2,4,5] Therefore, it is important to look for additional subtle ECG signs that might provide clues to unsuspected structural heart disease.

The notches on the R wave in leads III and AVF of our applicant's ECG may provide such a clue (Figure 2). In the literature, these notches are further characterized as notching on the ascending branch or at the zenith of the R wave (within the first 80 msec of the QRS) in the inferior leads. This pattern is referred to as the *crochetage* sign, because the notch resembles the shape of a crochet needle.[6]

Crochet is a process of creating fabric by interlocking loops of yarn, thread, or strands of other materials using a crochet hook. The name is derived from the French term *crochet*, meaning "small hook." The salient difference between crochet and knitting, beyond the implements used for their

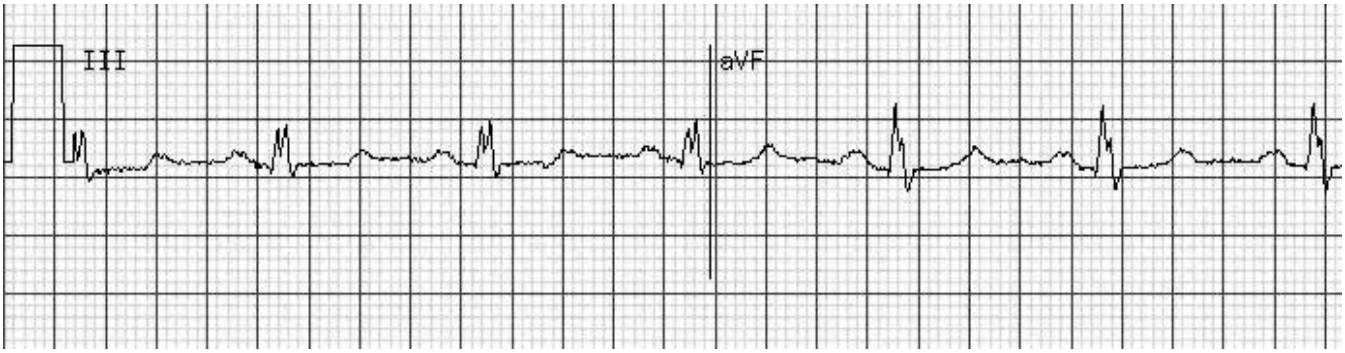


**Figure 2.** *Crochetage Pattern in leads III and AVF.*



production, is that each stitch in crochet is completed before proceeding with the next one, while knitting keeps a large number of stitches open at a time.[7]

This electrocardiographic pattern was first reported in a small group of patients with ostium secundum atrial septal defects in 1958.[6] A more detailed study of this pattern was reported by Heller et al in 1996.[8] In their study, the crochetage sign was observed in at least one inferior lead in the majority of patients with ostium secundum atrial septal defect but in only 7.4% of normal subjects, in fewer than one-third of patients with other congenital heart disease and one-tenth of patients with acquired heart disease. Subtypes of ASD, such as ostium primum and sinus venosus defects, were not included in this study.

The incidence of the crochetage sign increased with larger anatomical defects or greater left-to-right shunts even in the presence of pulmonary hypertension. Although crochetage has been correlated with shunt severity, the pattern has also been reported with a patent foramen ovale and has been suggested as an ECG marker of a patent foramen ovale associated with ischaemic embolic stroke.[8, 9]

The underlying pathophysiology remains unknown. In atrial septal defect, the crochetage pattern appears to be independent of the iRBBB with several examples reported in the absence of the latter. The crochetage pattern involves the initial 80 msec of the QRS, while the iRBBB involves the last part of the QRS. In the immediate atrial septal defect repair postoperative period, it frequently disappears while the right bundle branch block, which is attributed to chronic right ventricular volume overload, usually persists longer.[8, 10]

Are there any other clues in this ECG to suggest that our applicant might have underlying structural heart disease? The T wave pattern with its inverted proximal limb in leads V2 and V3 of our applicant's ECG might be an additional clue.

This pattern has been referred to as a *defective T wave (DTW)* pattern and has recently been described as a sensitive marker of atrial septal defect.[11] The main features of the defective T-wave pattern are:

1. A negative T wave phase in the proximal portion of the wave, including horizontal or inverted displacement;
2. A positive phase, typically steep, appearing in the distal portion of the T-wave; and
3. The peak of the positive phase in the right precordial leads typically lags behind that of the T wave in lead V6.

The first two criteria are clearly present in leads V2 and V3 of our applicant's ECG (Figure 3). The absence of simultaneous recording of leads V2 and V6 did not allow confirmation of the third criteria.

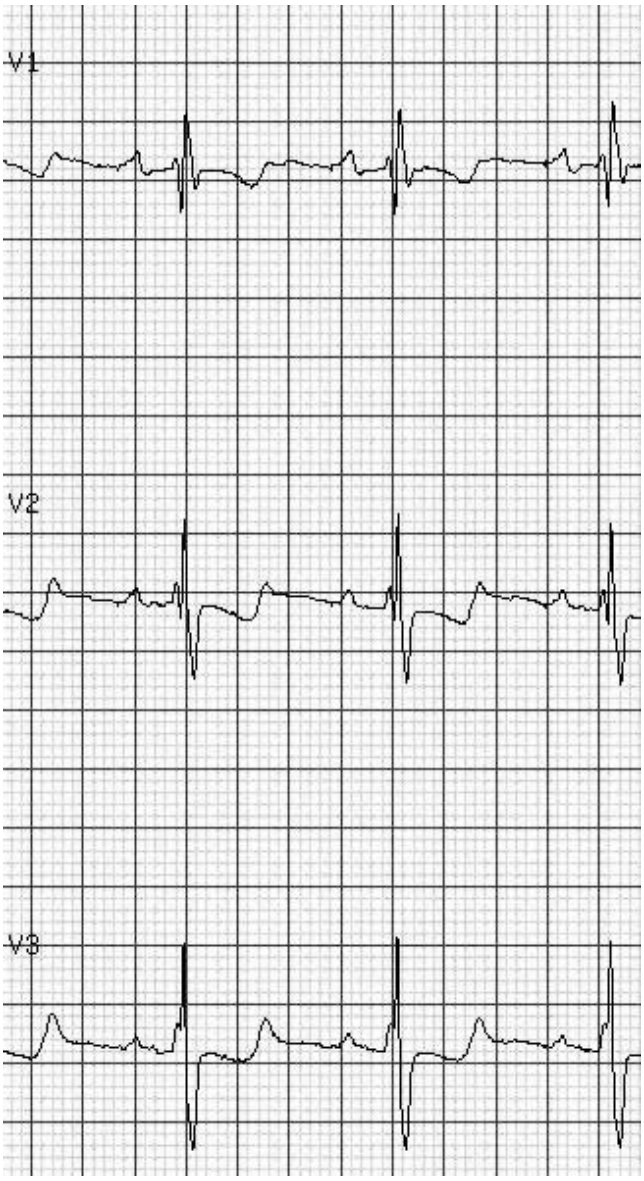


**Figure 3.** *Defective T wave pattern in leads V2 and V3 showing inverted proximal limb followed by steep positive phase.*

## DISCUSSION

Because of the ECG findings, further investigations were undertaken including a cardiology consultation, echocardiography and cardiac catheterization. These investigations confirmed a large secundum type atrial septal defect. There was predominant left-to-right shunting with a pulmonary to systemic flow ratio of about 2:1. She underwent surgical repair of the large atrial septal defect since closure with a percutaneously inserted device was not technically feasible.

The various types of atrial septal defects are classified according to their location and the nature of the embryologic defect. There are 3 major types of defects: ostium secundum, ostium primum and sinus venosus. Ostium secundum defects account for 70% to 75% of all ASDs. Ostium primum defects account for 15% to 20% of ASDs. Sinus venosus defects account for 5% to 10% of atrial communications. A patent foramen ovale, which can be detected in approximately 25% to 30% of normal adult hearts, is another form of interatrial communication associated with shunting of blood.[12]

As summarized by Webb and Gatzoulis in an overview of atrial septal defects, the ECG may be an important clue to diagnosis of an atrial septal defect: "the rhythm may be sinus, atrial fibrillation, or atrial flutter. Inverted P waves in the inferior leads may suggest an absent or deficient sinus node, as may be seen in a sinus venosus defect. Right atrial overload may be present. First-degree heart block may suggest a primum atrial septal defect but may be seen in older patients with a secundum. The QRS axis is typically rightward in secundum, markedly so if pulmonary hypertension is present. The QRS axis is leftward in ostium primum atrial septal defects. Voltage evidence of right ventricular hypertrophy may be seen in all atrial septal defects, often in the form of "incomplete" right bundle-branch block, with the more extreme forms usually found in patients with pulmonary hypertension. Patients with mitral valve insufficiency may have left ventricular hypertrophy or left atrial overload."[13]

Most young individuals with atrial septal defect have no symptoms, and, because of the nonspecific nature of the presenting symptoms and the relatively subtle signs, it is not unusual for atrial septal defects to be diagnosed first during early to middle adulthood or even older age as seen in our applicant. Similarly, the ECG manifestations of an atrial

septal defect, including the iRBBB pattern, may be subtle or also be seen in normal individuals. Additional clues such as the crochetage and defective T patterns may provide further hints of this form of structural heart disease.[8]

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