The Natural History of Right Bundle Branch Block and Frontal Plane QRS Axis in Apparently Healthy Men*

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We examined the characteristics, long-term follow-up, and prognosis of right bundle branch block (RBBB) detected on a routine ECG in men with no apparent heart disease. During the 29-year period, 59 cases of RBBB were observed in men with a mean age of 44.4 ± 1.9 years. Because marked right or left axis deviation may identify cases with concomitant involvement of the left bundle branch system, subsets of frontal plane QRS (Å QRS) were examined. Comparisons were made with groups of similar ages who were free of RBBB. Cases with RBBB were observed for 936 person-years (mean 15.9 ± 1.6 years per case), showing no excess ischemic heart disease incidence, no cases of progression to advanced AV block (second- or third-degree), or sudden death. Right bundle branch block was associated with a greater proportion of both right axis (≥ +90°) and marked left axis (−45° to −90°) deviation compared with those of the same age without this conduction disturbance. In apparently healthy men, RBBB had no adverse long-term prognosis regardless of frontal plane QRS axis.

The natural history of right bundle branch block (RBBB) has been studied primarily from the perspective of its prognostic importance in patients with organic heart disease. The limited number of studies that included primarily persons without heart disease1–4 were mainly conducted before attention was focused on the potential importance of deviations in the mean frontal plane QRS vector (Å QRS) as a possible indicator of impaired conduction in the left bundle branch system.7 Marked left axis deviation may be due to impaired conduction in the anterosuperior part of the left bundle branch, and marked right axis deviation to impaired conduction in the posteroinferior part of the left bundle branch system.7 These deviations in Å QRS in conjunction with complete RBBB suggest impaired conduction in both the right and left bundle branch system.

Such ECG abnormalities have been considered forerunners of complete heart block or sudden death.8–10 Prospective studies6,11,12 are currently determining the incidence of these events. Some of these investigations, however, are based primarily on patients with cardiac disease. Prognosis derived from clinical studies may not be applicable or applicable to persons with no evidence of heart disease but with the same ECG findings recorded at the time of a routine examination. In addition, most of these studies have difficulty in obtaining an appropriate comparison group.

The Manitoba cohort consisted of 3,983 North American men who were healthy, predominantly between 25 to 34 years of age at entry, and under observation with repeated examinations including ECGs since 1948. The purpose of this study is to examine the characteristics, long-term follow-up, and prognosis of RBBB with different Å QRS detected on a routine ECG in men without evidence of heart disease and compare them with other members of the cohort without this conduction defect.

Methods

The details of this study have been reported previously.13,14 In summary, the cohort consisted of 3,983 men, who during World War II were pilots, pilots in training in the Royal Canadian Air Force, or pilots licensed by the Department of Transport, and all had had a routine ECG in addition to the regular medical examination. After release from the service, some continued to fly, but the majority found different occupations and are in all strata of society. For each subject, the examination closest to June 30, 1948 (date that the population was defined), was selected as the entry examination. The mean age of the cohort at that examination was 30.8 years. The age distribution was as follows: 318 men were aged 15 to 24 years; 1,479 aged 25 to 29 years; 1,258 aged 30 to 34 years; 539 aged 35 to 39 years;
Definitions and Case Selection

The criteria for the diagnosis of RBBB were outlined by the New York Heart Association\(^1\) and the Minnesota Code.\(^1\) The criteria include QRS duration of \(> 0.12\) sec with rSR, qR, or a tall R wave in \(V_1\). The mean frontal plane QRS vector was determined for each ECG from the limb leads, using the hex-axial reference. It was calculated to the nearest 15° because this is a reasonable limit of precision of the method for standard ECG leads. In the presence of RBBB, the frontal plane QRS vector was determined from the initial 0.06-sec QRS, hereafter referred to as \(\hat{A}\) QRS, because the initial forces are unchanged while the terminal forces are deformed by RBBB.\(^1\)

Cases of RBBB included in the analysis satisfied the following criteria: (1) detection of this conduction defect at a routine examination, and (2) no clinical evidence of ischemic or valvular heart disease on that examination or on previous ones. Cases of RBBB occurring after, for example, myocardial infarction, angina pectoris, or coronary insufficiency were excluded. The diagnostic criteria for each of these manifestations of ischemic heart disease have been reported previously.\(^1\)

During the observation period, 59 cases fulfilled these criteria. The age distribution at detection of RBBB shows that the majority of cases were between 40 to 59 years of age, but almost one fourth of them were younger than 30 years of age. The mean age was 44.4 ± 1.9 (SEM) years. Forty-two cases acquired the conduction disturbance after entry, while in 17 cases it was found at entry.

Distribution of A QRS

A QRS at detection of RBBB is shown in Figure 1. Over all ages, the \(\hat{A}\) QRS distribution reveals that 31 percent (18/59) were from \(+90°\) to \(+180°\), 25 percent (15/59) from \(+15°\) to \(75°\), 20 percent (12) from \(0°\) to \(-30°\), 15 percent (9) from \(-45°\) to \(-90°\), and the remainder (8 percent) were indeterminant.

Data Analysis

\(\hat{A}\) QRS is an angular measurement. The use of conventional means and SDs to describe these data lead to inaccuracies.\(^1\) Thus, we chose to present \(\hat{A}\) QRS distributionally, classify it within specific ranges, and apply \(\chi^2\) tests of association for categorical data. Student's \(t\) test was used to test hypotheses for nonangular data.

To adjust for varying lengths of follow-up after RBBB occurrence, the person-year exposure method was used to calculate ischemic heart disease incidence rates. Hypothesis testing for the person-year method used the \(\chi^2\) approach.

RESULTS

The RBBB group has been under observation for 936 person-years, an average of 15.9 ± 1.6 (SEM) years per case. During this time the following were noted: one case of myocardial infarction at age 68 years, 20 years after RBBB; one case of angina pectoris at age 46 years, one year after RBBB; and no ischemic heart disease deaths. To determine the expected number of ischemic heart disease cases in this group, the ischemic heart disease incidence rate was calculated for age groups at five-year intervals consisting of those free of RBBB and ischemic heart disease. Based on the age distribution and length of follow-up of the RBBB group, 6.77 ischemic heart disease cases were expected. The observed number, two, is less than but not significantly \((\chi^2 = 2.7, df = 1)\) different from expected, although the small number of cases observed and expected is a concern for statistical testing.

During the observation period for the entire group, there was no occurrence of advanced degrees of heart block (second- or third-degree AV block). Also, no sudden deaths were noted.

The length of follow-up and status of cases with marked left (-45° to -90°) and right axis (+120° to +180°) deviation of frontal plane QRS vector are illustrated in Figure 2. Seven cases in which marked left axis deviation developed after RBBB are also considered. Almost all are still living. The majority have been followed-up for more than ten years, and some as long as 30 years. Only one case of ischemic heart disease (myocardial infarction) occurred, 21 years after onset of RBBB in a man with marked left axis deviation who later died of a noncardiac cause.

\(\hat{A}\) QRS at Detection of RBBB

Age at detection of RBBB, not unexpectedly, was
A significant determinant of A QRS. Classifying A QRS into three categories, +90° to +180°, +15° to +75°, and 0° to -90°, revealed that men younger than 40 years of age had a significantly different (P < 0.05) A QRS distribution than men 40 years of age and older (χ² = 9.04, df = 2). Two-thirds of those with A QRS > +90° were younger than 40 years. Eighty-two percent of those older than 40 years had an A QRS less than +90°. One group is noteworthy. A small number of young men, all less than 40 years of age, had at entry RBBB with an A QRS less than -30°.

The A QRS for the three major groups, namely, +90° to ±180° from +15° to +75° and between 0° to -90°, was compared in those with and without RBBB within four age groups—less than 30 years, 30 to 39 years, 40 to 49 years, and 50 years and older. In each age group the distribution of A QRS in the RBBB group is consistently different from the rest of the cohort free of RBBB. This is illustrated in Figure 3, where the A QRS of 0° to -90° is further subdivided to show the subset of -45° to -90°. An increased proportion of cases with A QRS +90° and -45° to -90° was observed in the RBBB group compared with those without this conduction defect in all age groups, except those 30 to 39 years old with an A QRS -45° or less.

To examine factors other than age that might influence A QRS of RBBB, we tested the hypothesis that persons with right axis deviation are more likely to be tall and slender. Heights and weights were examined in the age group with the greatest prevalence of right axis deviation (+90° to ±180°)—those younger than 40 years. To adjust for the usual increase in weight with increasing height, body mass index (weight divided by height squared) was the weight index used.14 There was no significant difference (P > 0.10) in either height (175.7 ± 1.4 cm vs 176.1 ± 1.1 cm) or body mass index (23.5 ± 0.9 vs 23.0 ± 0.9 kg/m²) between RBBB cases with A QRS > +90° compared with those with A QRS < +90° at this age.

**Long-term Changes in A QRS**

The five- and ten-year changes in A QRS were compared in those with and without RBBB and divided according to initial A QRS and age. Because of the relationship of these variables, sufficient numbers of cases were available only for ages 18 to 39 years with A QRS +90° and 40 to 59 years with A QRS -90° to +90°. The subgroup with right axis deviation and RBBB showed less change in A QRS than the rest of the cohort (Fig 4). In the subgroup with marked left axis deviation

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**Figure 2.** Length of follow-up and status (A-alive, D-dead) of cases with marked left (upper panel) and marked right axis deviation (lower panel). Age at marked axis deviation is displayed along with A QRS. One case with prolonged PR interval is indicated by pr. Gastrointestinal (GI) cause of death is noted.

**Figure 3.** QRS axis for RBBB detected at 18 to 29 years (upper left) and 30 to 39 years (upper right), at age 40 to 49 years (lower left) and 50 to 59 years (lower right) compared with control group at midpoint of age group without RBBB.
AQRS and age

**Figure 4.** Change in A QRS for those 18 to 39 years at RBBB compared with control group at about midpoint of age group (30 years) without RBBB. Subgroups according to A QRS shown for \( \geq +120^\circ \) (upper panel) and +105\(^\circ\) and +90\(^\circ\) (lower panel).

**Figure 5.** Change in A QRS for those 40 to 59 years at RBBB compared with control group at midpoint of age group (50 years) without RBBB. Subgroups according to A QRS shown for 15\(^\circ\) to +75\(^\circ\) (upper panel), 0\(^\circ\) to -30\(^\circ\) (middle panel), and -45\(^\circ\) to -90\(^\circ\) (lower panel).

**Figure 6.** Another case manifests left axis deviation at entry at age 33 (upper left), marked left axis deviation at age 61 years just before (upper middle) and at (upper right) development of RBBB at age 62 years. Case with marked right axis deviation at entry at age 29 years (lower left) again on a routine ECG, at age 54 years (lower middle) and three years later at development of RBBB (lower right).

there is little change in A QRS both in those with and without RBBB (Fig 5). The relatively small changes in A QRS for these extremes of A QRS is illustrated over a 25-year period before RBBB occurrence (Fig 6).

**Prevalence of Hypertension**

The prevalence of hypertension was determined by examining the blood pressure distribution, using the examination at detection of RBBB and for comparison the blood pressure at the midpoint of the age group in men without RBBB. Using criteria for hypertension of systolic of 165 mm Hg or greater or diastolic of 95 mm Hg or greater, the prevalence was 15.4 percent (2/13) for ages 40 to 49 years and 17.6 percent (3/17) for ages 50 to 59 years. Neither rate was significantly different from the rate for men without RBBB of 6.6/100 (\( \chi^2 = 1.6, P > .1 \)) and 13.3/100 (\( \chi^2 < 1, P > 0.1 \)), respectively, for these age groups. The prevalence was zero percent for other age groups. Using the criterion of systolic blood pressure of 150 mm Hg or greater, the prevalence was 29 percent (5/17) for those ages 50 to 59 years with RBBB that was not significantly dif-
different from those without right RBBB of 17.5/100 ($\chi^2 = 1.68, P > 0.10$). The prevalence rate was zero percent for other age groups. The results were similar using diastolic blood pressure of 90 mm Hg or greater as the level for defining hypertension.

**DISCUSSION**

This study presents longitudinal data on RBBB in a highly selected cohort of North American men. Thus, caution should be exercised when extrapolating these data to the general population. However, the relatively young age at entry of the majority of this cohort permits more accurate estimation both of the age at onset of RBBB and freedom from preexisting disease than is possible in studies commencing with older age groups. It also provides longitudinal data on this conduction disturbance from a young age. Other cautions include the problem of measuring A QRS in the right bundle. The exact time during the QRS that activation of the right ventricle occurs is not always apparent or predictable for each individual case. Although much of the interest is centered on extremes of axis deviation, the small number of cases in some subgroups of A QRS is also a concern. Another precaution in the extrapolation of these results is the different lengths of follow-up within each age group. Those 30 years of age and younger at detection of RBBB have been under observation for almost 30 years, but the length of follow-up is decreased in older age groups.

The present study demonstrated that the ominous prognosis attributed to RBBB and marked right or left axis deviation in patients with heart disease should not be applied to persons without heart disease who have the same ECG finding recorded on a routine examination.

The prognosis of RBBB with marked axis deviation varies widely in different studies. Excluding the clinical setting following myocardial infarction, total mortality for RBBB and marked left axis deviation has been reported to be zero percent in ten years,\(^5\) 1 percent per year,\(^6\) 7 percent per year,\(^8\) or more than 10 percent per year.\(^1,10,20\) The incidence of sudden death for the same conduction disturbance has varied from zero percent in two years\(^19\) or ten years\(^8\) to 1 percent per year\(^8\) to about 4 percent per year.\(^21\) The rate of progression to high degree of AV block has been reported to be zero percent,\(^5,21\) 1 percent per year,\(^8\) 2 percent per year,\(^9,20,21\) and more than 5 percent per year.\(^12\) For RBBB and marked right axis deviation, reported total mortality has been zero percent in ten years,\(^5\) 2 percent per year,\(^23\) and 8 percent per year.\(^11\) Sudden death incidence in this group has varied from zero percent,\(^5\) 2 percent per year,\(^22\) and 5 percent per year.\(^11\) The rate of progression to second- and third-degree AV block in this group is 0.6 percent per year,\(^5\) 2 percent per year,\(^8\) 5 percent per year,\(^23\) or higher.\(^7\)

These differences in mortality and progression of conduction disturbances may be due in part to differences in age as well as to the prevalence of hypertension. The lower incidence rates were usually in studies with a low proportion of heart disease, and the higher incidence rates were in those with a high proportion of heart disease that was often severe. Some investigators concluded that the prognosis of RBBB and extreme axis deviation appeared to be more dependent on the presence\(^6\) or severity of the myocardial disease\(^8,9\) than on the conductive disease. Our data are consistent with this thesis in that in persons without heart disease, RBBB, and marked left or right axis deviation have a good prognosis. Differences between the results of the present study and those of Framingham, which found an increased incidence of coronary heart disease plus heart failure (the data were not analyzed separately for each endpoint) may be due to their greater prevalence of hypertension (\(>105/95\) mm Hg). The absence of a relationship between RBBB and hypertension in our study is consistent with the findings in two other cohort studies.\(^25,26\)

The A QRS in RBBB was different from the A QRS in the absence of this conduction defect in that RBBB was associated with a significant excess proportion of axis deviation, +90° or greater and -45° to -90°. Because the development of RBBB alters only the terminal proportion of A QRS,\(^7\) a case with axis deviation at entry should have had it before development of RBBB. Since many of the cases of RBBB at entry were in their 20s, one can speculate that in adolescence axis deviation, either absolute or relative for age, is predictive of RBBB occurrence. This can be supported by the observation that marked left axis deviation (-45° to -90°) in men 40 to 69 years of age without apparent heart disease is associated with a small but significantly increased probability of RBBB occurrence.\(^7\)

It is unlikely that a single confounding variable or a technical error of measurement was responsible for the association of RBBB and axis deviation, because it should have induced a consistent alteration producing either right or left axis deviation, but not both. Explanations for this association would include the possibilities that RBBB and axis deviation represents a distinct kind of bundle branch block. It might result from a single lesion in the proximal part of the right bundle branch or the bundle of
His.\textsuperscript{17,28} Alternatively, one factor such as fibrosis could involve the right bundle branch and the anterior and posterior radiations of the left conducting system.\textsuperscript{9}

Regardless of the etiology, the A QRS in persons with RBBB and marked axis deviation is not influenced to the same extent by the force-inducing leftward movement of the A QRS with increasing age or the passage of time. This observation may relate to the nature of the lesion in the conduction system or the possibility that the extremes of A QRS represent the outermost limit of the A QRS so that movement decreases once these limits are reached.

Thus, right and left axis deviation occurs more commonly in cases of RBBB than in those without this conduction disturbance, but for the age groups in this study, in the absence of heart disease, this conduction disturbance carries no adverse prognosis.

ACKNOWLEDGMENT: We sincerely thank the 3,983 members of the study group whose outstanding cooperation has made the collection of these data possible. The success of the follow-up program is due to the efforts of Mrs. A. R. Scott and the support staff. We also thank Dr. A. J. Harrop, Mrs. E. Thomas, Miss S. Prosick, Miss G. Shilson, and Miss J. Neufeld.

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