The Electrocardiographic Response to Maximal Treadmill Exercise of Asymptomatic Men with Right Bundle Branch Block

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This study presents the results of maximal treadmill testing and cardiac catheterization in 40 asymptomatic and apparently healthy men with acquired right bundle-branch block. Eight of the men had significant angiographic coronary artery disease, and six of the eight only had single-vessel disease. The 40 men had normal maximal oxygen consumptions, normal maximal heart rates, and normal maximal blood pressure responses; none of the men had abnormal ST-segment changes in response to maximal treadmill testing. Thus, the sensitivity of exercise testing for coronary artery disease in men with right bundle branch block is uncertain. However, the apparently high specificity of exercise testing demonstrated by this study necessitates further evaluation for coronary artery disease in men with right bundle branch block who develop abnormal ST-segment depression in response to exercise testing.

Exercise electrocardiography has been demonstrated to be a valuable tool for screening asymptomatic men. An abnormal response identifies a group at high risk for developing coronary atherosclerotic heart disease when the resting electrocardiogram is normal or shows mild abnormalities of repolarization; however, the value of exercise testing in individuals with bundle branch block is uncertain. A recent study at the United States Air Force School of Aerospace Medicine demonstrated that ST-segment changes induced by exercise testing in aircrewmen with left bundle branch block did not discriminate between men with and men without coronary artery disease.

In a follow-up study of asymptomatic USAF flying personnel with acquired left and right bundle branch block, prognosis was dependent on associated cardiovascular disease. Also, cardiac catheterization studies of apparently healthy men who serially developed right bundle-branch block on annual ECGs have shown a low prevalence of angiographic coronary artery disease. Some clinical studies have related acquired right bundle branch block to coronary artery disease and a poor prognosis, but this was probably because symptomatic patients were involved. In contrast, asymptomatic men who develop right bundle branch block without evidence of cardiovascular disease have not demonstrated an increased risk for sudden incapacitation and have an excellent prognosis. Therefore, aircrewmen with right bundle branch block but with normal findings on medical evaluations, normal results on noninvasive studies, and normal findings on cardiac catheterizations have been maintained on flying status. Their flying status has been contingent upon successfully completing annual noninvasive reexaminations at the School of Aerospace Medicine. Because of the large investment in aircrew training and the personal interest of aircrewmen in pursuing a flying career, it is desirable to maintain aircrewmen on flying status whenever possible.

Since the significance of the ST-segment response to exercise in individuals with right bundle branch block is uncertain, patients with right bundle branch block represent a unique group in regard to their electrocardiographic exercise tests. After a careful search of the medical literature, only two demonstrated cases of patients with right bundle-branch block and exercise-induced ST-segment depression could be found. Both of these patients had angina pectoris. Only reports by Ellestad and by Feil and Brofman mention any sizable experience with exercise testing of individuals with

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right bundle branch block. Unfortunately, these studies have not demonstrated the prevalence or diagnostic significance of exercise-induced ST segment depression in patients with right bundle branch block. Although there is the general impression that exercise-induced ST-segment depression has the same diagnostic value for coronary artery disease in patients with right bundle branch block as it does in those with normal QRS patterns, there are no data to substantiate this. Our study attempts to clarify this by presenting the experience at the USAF School of Aerospace Medicine with maximal treadmill testing and cardiac catheterization of asymptomatic men with acquired right bundle branch block.

**Materials and Methods**

This study deals with 40 asymptomatic aircrewmen with acquired right bundle branch block who were evaluated at the School of Aerospace Medicine since 1971. The patients were all referred for evaluation of right bundle branch block found as a serial change on annual ECGs. Standard criteria were used for diagnosing right bundle branch block. Prior ECGs were reviewed and indeed were unremarkable. All patients were asymptomatic and considered themselves to be in excellent health. All 40 had cardiac catheterizations performed as an elective procedure to rule out coronary artery disease as a possible cause for the right bundle branch block and to enable them to continue on flying status.

During the evaluation the following studies were performed in a standardized manner: medical history, physical examination, chest x-ray film, pulmonary function testing, blood chemistry profile, resting ECG, vectorcardiogram, continuous electrocardiographic monitoring (Holter), maximal treadmill testing, and cardiac catheterization. Maximal treadmill testing was performed using a constant speed of 3.3 mph and increasing the incline by 1.0 percent each minute or 5.0 percent each three minutes. The monitoring leads consisted of V5, CC5 (X), an inferior-superior bipolar lead (Y), and an anterior-posterior bipolar lead (Z). Silver-plated fluid-column adhesive electrodes were placed at the left and right anterior axillary lines at the level of the fifth intercostal space, on the forehead and left lower rib cage, and on the sternum and the spine at the level of the fourth intercostal space to form a nonorthogonal three-dimensional lead system. Comparison studies have shown lead CC5 to give measurements of ST-segment amplitude and slope comparable to lead V5. Lead Y is similar to leads 2 and aVF, and lead Z is similar to lead V2. Meticulous preparation of the skin kept impedance levels to 5,000 ohms or less, as checked by an alternating-current impedance meter. Electrocardiographic data were recorded before exercise with the patient supine, during 30 seconds of hyperventilation, standing, and then were recorded continuously during and for eight minutes after exercise. All electrocardiographic signals were recorded on electrocardiographic paper and stored on analog magnetic tape. Indirect cuff measurements of blood pressure were obtained throughout the procedure. The patients were encouraged to perform a maximal effort, and measurements of oxygen consumption were made as previously described.

The cardiac catheterization procedures were performed at the School of Aerospace Medicine. Left ventricular end-diastolic pressure was measured, and then a left ventricular angiogram was obtained in the right anterior oblique position. Selective coronary angiographic studies were performed using the Sones technique. Multiple injections of both right and left coronary arteries were done in multiple views and recorded on 35-mm cinefilm. Nitroglycerin was given before coronary injections, and coronary spasm was not encountered. Significant angiographic coronary artery disease was defined as the presence of an atherosclerotic lesion comprising 50 percent or more of the luminal diameter in any major branch of the three main coronary arterial systems.

The original electrocardiographic treadmill exercise tracings were available on most patients; however, in several instances the treadmill tracings were obtained from the magnetic tape recordings. All of the electrocardiographic tracings were reviewed together by two investigators (J.E.W. and V.F.F.). All four leads were reviewed for the amount of ST-segment depression, and samples of the three-dimensional lead recordings at the following time intervals were mounted: supine in the period before exercise, at early exercise, at midexercise, at late exercise, at immediate recovery, and at two and five minutes of recovery.

Most of the patients have undergone multiple annual

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**Table 1—Eight Asymptomatic Men with Acquired Right Bundle Branch Block Who Were Found to Have Significant Angiographic Coronary Artery Disease**

<table>
<thead>
<tr>
<th>Case</th>
<th>Involved Coronary Arteries*</th>
<th>Percent Obstruction</th>
<th>Additional Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Large marginal branch</td>
<td>50</td>
<td>Left circumflex and right coronary arteries, &lt;50 percent</td>
</tr>
<tr>
<td>2</td>
<td>Left anterior descending</td>
<td>50</td>
<td>Right coronary artery, minimal disease</td>
</tr>
<tr>
<td>3</td>
<td>Right coronary artery</td>
<td>50</td>
<td>Marginal branch, nearly 50 percent</td>
</tr>
<tr>
<td>4</td>
<td>Right coronary artery</td>
<td>&gt;50</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Right coronary artery</td>
<td>90</td>
<td>Left anterior descending and circumflex arteries, &lt;50 percent</td>
</tr>
<tr>
<td>6</td>
<td>Diagonal branch</td>
<td>&gt;50</td>
<td>Right coronary artery, &lt;50 percent</td>
</tr>
<tr>
<td>7</td>
<td>Right coronary artery</td>
<td>90</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Right coronary artery</td>
<td>90</td>
<td></td>
</tr>
</tbody>
</table>

*Involvement with lesions obstructing 50 percent or more of the vessel's luminal diameter.
Table 2—Physiologic Measurements of 40 Asymptomatic Subjects with Right Bundle Branch Block*

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Coronary Artery Disease</th>
<th>Normal Subjects</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of subjects</td>
<td>8</td>
<td>32</td>
</tr>
<tr>
<td>Age, yr</td>
<td>45 ± 7</td>
<td>39 ± 7</td>
</tr>
<tr>
<td>Height, in</td>
<td>69 ± 2</td>
<td>70 ± 3</td>
</tr>
<tr>
<td>Cholesterol level, mg/100 ml</td>
<td>234 ± 35</td>
<td>223 ± 41</td>
</tr>
<tr>
<td>Triglyceride level, mg/100 ml</td>
<td>102 ± 40</td>
<td>131 ± 44</td>
</tr>
<tr>
<td>Blood pressure, mm Hg</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting</td>
<td>119 (±10)/76 (±10)</td>
<td>122 (±12)/80 (±8)</td>
</tr>
<tr>
<td>Maximal systolic</td>
<td>184 ± 20</td>
<td>199 ± 21</td>
</tr>
<tr>
<td>VO2, ml/kg-min</td>
<td>38 ± 6</td>
<td>36 ± 5</td>
</tr>
<tr>
<td>Maximal heart rate, beats per minute</td>
<td>183 ± 5</td>
<td>186 ± 12</td>
</tr>
<tr>
<td>Double product**</td>
<td>33.6 ± 3.8</td>
<td>37.0 ± 4.9</td>
</tr>
</tbody>
</table>

*Table values are means ± SD.
**Double product = maximal systolic blood pressure x maximal heart rate/104.

medical evaluations at the School of Aerospace Medicine since the initial discovery of right bundle-branch block and have remained unchanged with respect to their electrocardiographic findings and other noninvasive studies.

RESULTS

The 40 asymptomatic men were divided according to their coronary angiographic findings. The eight men listed in Table 1 were found to have significant angiographic coronary artery disease. None of the other 32 men was found to have angiographic coronary artery disease and none of the 40 had evidence of left ventricular dysfunction.

The physiologic measurements obtained during evaluation of the 40 men are presented in Table 2. Using Student's unpaired t-tests, no significant differences were found between the eight men with significant angiographic coronary arterial disease and the 32 men with normal studies. The values for maximal oxygen consumption (VO2) and double product of the two groups were well within the normal ranges found in previous studies of our apparently healthy air-crew population.20,22,23

Four of the eight men with coronary artery disease and four of the 32 men with normal angiographic findings had left anterior hemiblock. The duration of the QRS complex in all men was approximately 0.12 second. Twenty percent (eight) of the men had intermittent right bundle branch block when the block was first noted, but subsequently all developed persistent right bundle branch block.

Figures 1 and 2 show the actual recorded ECGs from the three bipolar nonorthogonal leads at rest and in response to maximal treadmill exercise. The eight men with significant angiographic coronary artery disease are shown in Figure 1, while a representative sample of eight men without angiographic coronary artery disease is presented in Figure 2. None of the 40 men had abnormal ST-segment depression in leads V5, CCs, or the inferior-superior (Y) bipolar lead.

DISCUSSION

Previous studies have suggested that asymptomatic men with right bundle branch block are not in danger of sudden incapacitation as long as they do not have any manifestations of cardiovascular disease;5,14,24 however, there has been some concern that acquired right bundle branch block, when not due to chest trauma,25,26 could be an indication of coronary artery disease.27 Therefore, asymptomatic USAF air crewmen with acquired right bundle branch block and normal findings on cardiovascular evaluations have had coronary angiographic studies prior to having a decision made regarding their flying status.7,8 Annual noninvasive evaluations at the Consultation Service of the School of Aerospace Medicine have been required for the aircrewmen to remain on flying status. Their cardiovascular examinations have included maximal treadmill testing. Subjects with right bundle branch block have had a functional capacity, heart rate, and blood pressure response to maximal treadmill exercise comparable to our findings in apparently healthy aircrewmen.20,22,23

The main purpose of this report was to present the School of Aerospace Medicine's experience with the ST-segment response to maximal treadmill testing of asymptomatic and apparently healthy men with acquired right bundle branch block. This is especially pertinent, since it has been assumed that patients with right bundle branch block have ST-segment responses to exercise testing of comparable
Figure 1. Actual electrocardiographic tracings of three bipolar leads before and in response to maximal treadmill exercise in the eight asymptomatic men with right bundle branch block and significant angiographic coronary artery disease.

Significance to men with normal ECGs. Our report deals with 40 asymptomatic and apparently healthy men with acquired idiopathic right bundle branch block, all of whom had coronary angiographic studies and thorough cardiovascular evaluations. Eight of them had significant angiographic coronary artery disease that possibly could explain their right bundle branch block, although they were asymptomatic; however, most of these eight men had single-vessel right coronary artery involvement, and the right bundle is dependent upon the left coronary artery.

Surprisingly, none of the 40 men with right bundle-branch block had abnormal ST-segment responses to maximal treadmill testing. This is in contrast to the marked amount of ST-segment depression found in asymptomatic men with left bundle branch block. The sensitivity (percentage of individuals with disease who will have abnormal tests) of the treadmill test for detecting coronary artery disease was disappointing. We have no explanation for the low sensitivity of the test other than the fact that the eight men had coronary artery disease with six of the eight men having only single coronary arterial involvement, and five of these only had right coronary artery involvement. However, it was reassuring to find the specificity (percentage of individuals tested without disease that have normal tests) to be excellent in our patients with right bundle branch block; in fact, no false-positives were found. This is in contrast to the finding of approximately 7 percent false-positives in comparable populations of men with normal resting ECGs. Since others have reported ST-segment depression in response to exercise testing in patients with right bundle branch block and with
EKG RESPONSE TO TREADMILL EXERCISE IN ASYMPTOMATIC MEN WITH RBBB

Patients with right bundle branch block for coronary artery disease have exercise-induced ST-segment depression. This study has demonstrated that ST-segment depression in response to maximal treadmill testing is unusual in asymptomatic men with right bundle branch block and exercise-induced ST-segment depression in a manner similar to those with normal coronary arteriograms and abnormal exercise tests. Our sample size was not large enough and our patients coronary arteriogram was not severe enough to state categorically that the sensitivity of exercise testing is inadequate in men with right bundle branch block.

Figure 2. Representative sample of eight men without angiographic coronary artery disease showing normal treadmill exercise leads at rest and in response to exercise.
block. The sensitivity of exercise testing in men with single-vessel right coronary arterial disease and normal conduction is also limited, however, most screening studies have demonstrated 5 to 10 percent abnormal exercise tests in men with normal ECGs of a similar age to the asymptomatic men in this study. Further studies, especially in men with more severe coronary artery disease than those in our study, are necessary to evaluate the sensitivity of exercise testing for coronary artery disease in men with right bundle branch block. We conclude that apparently healthy asymptomatic men with acquired right bundle branch block rarely have ST-segment depression in response to maximal treadmill testing and that those with ST-segment depression should be evaluated further for coronary artery disease.

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