Electrocardiographic Axis Deviation in Navajo and Apache Indians

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It has been our clinical impression that the range of the mean frontal-plane electrocardiographic QRS axis was greater than might have been anticipated in healthy Navajo and Apache Indians. To determine whether this clinical impression was correct, electrocardiograms were obtained from 146 Navajo, 144 Apache, and 159 non-Navajo non-Apache schoolchildren with normal findings on cardiovascular examinations. A mean frontal-plane QRS axis between -1° and -90° was present in 19 percent of the Navajo, 12 percent of the Apache, and 2 percent of the control schoolchildren. A mean frontal-plane QRS axis between +91° and +180° was present in 18 percent of the Navajo, 19 percent of the Apache, and 5 percent of the control schoolchildren. There is a high incidence of electrocardiographic mean frontal-plane QRS axis deviation in healthy Navajo and Apache schoolchildren.

Materials and Methods

One hundred forty-nine Navajo Indian schoolchildren at Window Rock, Ariz., 146 Mescalero Apache Indian schoolchildren at Ruidoso, NM, and 161 non-Navajo non-Apache schoolchildren from Tucson, Ariz., were screened for cardiovascular abnormalities. A cardiovascular history was obtained, and a cardiovascular physical examination was performed on each child by a board-certified cardiologist. Any child who had hypertension or physical findings of valvular or congenital heart disease was excluded from this study. Three Navajo children were excluded; two had hypertension, and one had a murmur of mitral regurgitation. Two Apache children were excluded; one had a murmur of mitral regurgitation, and one had an unexplained wide fixed splitting of the second heart sound. Two of the children from the Tucson Public School were excluded because of auscultatory findings suggestive of mitral valvular prolapse. The remaining children had normal cardiovascular findings.

The group under study consisted of 146 normal Navajo Indian schoolchildren (51 percent boys) and 144 normal Mescalero Apache Indian schoolchildren (45 percent boys) who ranged in age from 12 to 14 years (median, 13 years). The control population was 159 children (58 percent boys) from a public school in Tucson, who ranged in age from 14 to 17 years (median, 15 years). The control schoolchildren had the following ancestral precedence: white, 40 percent; Mexican, 55 percent; black, 2 percent; Papago Indian, 2 percent; and Asian, 1 percent.

In each child the three standard electrocardiographic limb leads, the three augmented unipolar leads, and the V1 precordial lead were recorded with an electrocardiographic

Table 1—Distribution of Mean Frontal-Plane QRS Axis in Navajo, Apache, and Control Schoolchildren

<table>
<thead>
<tr>
<th>Data</th>
<th>Navajo</th>
<th>Apache</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total children</td>
<td>146</td>
<td>144</td>
<td>159</td>
</tr>
<tr>
<td>Left axis deviation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(-1° to -90°)</td>
<td>28 (19)</td>
<td>17 (12)</td>
<td>4 (2)</td>
</tr>
<tr>
<td>-1° to -29°</td>
<td>13 (9)</td>
<td>11 (8)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>-30° to -44°</td>
<td>9 (6)</td>
<td>3 (2)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>-45° to -90°</td>
<td>6 (4)</td>
<td>3 (2)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Normal QRS frontal-plane axis (0° to +90°)</td>
<td>85 (58)</td>
<td>94 (65)</td>
<td>147 (93)</td>
</tr>
<tr>
<td>Right axis deviation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(+91° to +180°)</td>
<td>26 (18)</td>
<td>27 (19)</td>
<td>7 (4)</td>
</tr>
<tr>
<td>+91° to +180°</td>
<td>18 (12)</td>
<td>10 (7)</td>
<td>3 (2)</td>
</tr>
<tr>
<td>+100° to +180°</td>
<td>8 (6)</td>
<td>17 (12)</td>
<td>4 (3)</td>
</tr>
<tr>
<td>Extreme axis deviation</td>
<td>+180°</td>
<td>3 (2)</td>
<td>2 (1)</td>
</tr>
<tr>
<td>Indeterminate axis</td>
<td>4 (3)</td>
<td>4 (3)</td>
<td>1 (1)</td>
</tr>
</tbody>
</table>

*Table values are numbers of patients; numbers within parentheses indicate percentage of group of schoolchildren.

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The distribution of the frontal-plane mean QRS axis in 146 Navajo Indian schoolchildren is shown in Table 1 and Figure 1. Examples of the electrocardiograms are shown in Figure 2. Twenty-eight Navajo children (19 percent) had left axis deviation. Six of the 28 children with left axis deviation had a frontal-plane mean QRS axis between $-45^\circ$ and $-90^\circ$. None of these six ECGs met Rosenbaum's criteria for left anterior hemiblock. None of the children had left bundle-branch block. Twenty-six children (18 percent) had right axis deviation. Eight of these 26 children had a QRS axis between $+100^\circ$ and $+180^\circ$. None of the children had right bundle-branch block. There was no statistical difference between the number of male and female children with axis deviation.

Apache Indian Schoolchildren

The distribution of the frontal-plane mean QRS axis in 144 Apache Indian schoolchildren is shown in Table 1 and Figure 3. Examples of the ECGs are shown in Figure 4. Seventeen children (12 percent) had left axis deviation. Three of the 17 children with left axis deviation had a frontal-plane mean QRS axis between $-45^\circ$ and $-90^\circ$, and none met the criteria for left anterior hemiblock. None of the children had left bundle-branch block. Twenty-seven children (19 percent) had right axis deviation. Seventeen of these 27 children had a QRS axis between $+100^\circ$ and $+180^\circ$. None of the children had right bundle-branch block. There was no statistical difference between the number of male and female children with axis deviation.

Control Schoolchildren

The distribution of the frontal-plane mean QRS axis in 146 Apache Indian schoolchildren is shown in Table 1 and Figure 1. Examples of the electrocardiograms are shown in Figure 2. Twenty-eight Navajo children (19 percent) had left axis deviation. Six of the 28 children with left axis deviation had a frontal-plane mean QRS axis between $-45^\circ$ and $-90^\circ$. None of these six ECGs met Rosenbaum's criteria for left anterior hemiblock. None of the children had left bundle-branch block. Twenty-six children (18 percent) had right axis deviation. Eight of these 26 children had a QRS axis between $+100^\circ$ and $+180^\circ$. None of the children had right bundle-branch block. There was no statistical difference between the number of male and female children with axis deviation.
axis in 159 control (non-Navajo non-Apache) schoolchildren is shown in Table 1 and Figure 5. Four children (2 percent) had left axis deviation. One of the four children with left axis deviation had a frontal-plane mean QRS axis between $-45^\circ$ and $-90^\circ$; however, the patient did not meet the criteria for left anterior hemiblock. None of the children had left bundle-branch block. Seven children had right axis deviation. Four of these seven children had a QRS axis between $+100^\circ$ and $+180^\circ$. None of the children had right bundle-branch block. There was no statistical difference between the number of male and female children with axis deviation.

Indeterminate Axis = 4

Figure 3. Distribution of mean frontal-plane QRS axis in 144 Apache Indian schoolchildren.

Indeterminate Axis = 1

Figure 5. Distribution of mean frontal-plane QRS axis in 159 control schoolchildren.

Discussion

Writing in his textbook of pediatric electrocardiography, Guntheroth states that "according to conventional definitions," normal electrical axis is $0^\circ$ to $+90^\circ$, right axis deviation is greater than $+90^\circ$, and left axis deviation is less than $0^\circ$. Marriott, a cardiologist with adult patients, also suggests that the range of normal axis is $0^\circ$ to $+90^\circ$. In this study, only 58 percent of the Navajo and 65 percent of the Apache children had electrocardiographic mean QRS axes that were in this normal range.

Authorities have defined leftward QRS axis devia-
The etiology of left axis deviation (less than 0°) among asymptomatic adult subjects is reported to be 0.3 to 4.3 percent. The present study demonstrates a high incidence of left axis deviation in Navajo and Apache schoolchildren, without evidence of cardiovascular disease. Compared to the control schoolchildren, the incidence of left axis deviation is increased ninefold in Navajo Indian schoolchildren and sixfold in Apache Indian schoolchildren. This incidence of left axis deviation in the Indian schoolchildren is also more than ten times the incidence reported in other populations of normal children of comparable age. Soffer found that 1 percent (53/5,163) of adults with no history of heart disease had a mean frontal-plane QRS axis between -30° and -60°. If left axis deviation had been defined in this study as a mean frontal-plane QRS axis between -30° and -90°, the incidence would have been 10 percent in the Navajo and 4 percent in Apache Indian schoolchildren, compared with 1 percent in the control group. The incidence of axis deviation less than -30° in Ziegler's study of normal children aged 8 to 12 years is less than 1 percent.

It is difficult to find a consensus on the definition of right axis deviation in children. Ziegler reported the mean electrical QRS axis to be +90° in 10 percent, +105° in 1.0 percent, and +120° in 1.0 percent of normal children aged 8 to 12 years. In the age range of 12 to 16 years, a vertical QRS axis of +90° occurred in 13 percent, an axis of +105° occurred in 5 percent, and no one had an axis of +120°. In the present study, we found an axis greater than +90° in 18 percent of the Navajo and 19 percent of the Apache Indian schoolchildren studied. An axis greater than +90° was found in only 4 percent of the control schoolchildren. An axis between +100° and +180° was present in 7 percent of the Navajo and 12 percent of the Apache schoolchildren, compared with 3 percent of control schoolchildren. Again, in Soffer's study of adults without a history of heart disease, 0.3 percent (14/5,163) had an axis between +110° and +133°.

The etiology of a mean QRS axis outside the expected range of normal has long been debated. Early theories postulated that axis deviation was due to altered anatomic and electrical positions of the heart, since obesity, ascites, and pregnancy can result in a leftward shift of the mean electrical axis. In patients without these conditions and without valvular or congenital heart disease, the cause of axis deviation appears to be delayed conduction through the fascicles of the left bundle branch.

A delay in conduction through the fascicles may occur secondary to ischemia, since several studies have demonstrated a high correlation between axis deviation and atherosclerotic heart disease; however, recent epidemiologic studies have suggested that left axis deviation may frequently occur as an isolated finding without the associated poor prognosis of coronary arterial disease. Chronic complete heart block in the elderly patient is commonly caused by fibrotic degeneration of bundle branches. Since bundle branch block and axis deviation are precursors of chronic complete heart block, it is assumed that axis deviation can be caused by fibrotic degeneration of the fascicles of the left bundle. Axis deviation has been shown to be associated with many conditions, such as left ventricular hypertrophy, scleroderma, chronic pulmonary emphysema, amyloidosis, Friedreich's ataxia, progressive muscular dystrophy, myotonia atrophica, endocardial cushion defects, idiopathic myocardial hypertrophy, tricuspid atresia, hemochromatosis, myocarditis, alcoholic cardiomyopathy, idiopathic cardiomyopathy, and hyperkalemia.

The etiology of the axis deviation in these two populations of Indians is unknown. The findings do not appear to be dependent on sex differences, since boys as well as girls were equally likely to have axis deviation in this study. Because of their young age, it is also unlikely that the axis deviation in these Indian children is due either to atherosclerotic heart disease or to fibrotic degeneration of the fascicles. The role of altitude on the rightward deviation of the mean QRS electrocardiographic axis should be considered. The altitude of Window Rock, Ariz, is 6,880 feet, and that of Ruidoso, NM, is 6,800 feet. Studies have demonstrated a delay in the evolutionary pattern of the normal left ventricular preponderance in children living at elevations greater than 5,280 feet. Although altitude could account for the increased incidence of rightward axis deviation in the Navajo and Apache schoolchildren, the leftward axis deviation remains unexplained.

It is possible that the axis deviation is a normal variation in the Navajo and Apache Indians and is hereditary. This assumption is supported by the finding of a similar incidence of axis deviation in two...
different Indian groups of common Athapascan ancestry, but with major differences in present-day activities, habits, and location; however, additional studies of family aggregates and parents would be required to prove a hereditary etiology. If axis deviation is found to be hereditary, the technique of mass screening for electrocardiographic axis deviation in schoolchildren might be useful in ancestral studies. It is also possible that the axis deviation in these Indians is due to a common environmental factor. One such factor to be considered would be neonatal malnutrition.

The finding of a high incidence of axis deviation in these otherwise healthy Navajo and Apache schoolchildren is clinically significant. In patients with atrial septal defects, the presence of left axis deviation is usually an indication that the defect is a primium-type rather than a secundum-type defect. We have encountered two Navajo Indians with atrial septal defects and left axis deviation who were found to have secundum-type atrial septal defects at operation. In older Indians the presence of left axis deviation may not indicate organic heart disease.

In summary, we have demonstrated that the mean electrocardiographic QRS axis is greater than might have been anticipated in healthy Navajo and Apache schoolchildren. The etiology of the axis deviation in these Indian populations is currently unknown; however, it is possible that axis deviation in Navajo and Apache schoolchildren is a normal variation and is hereditary.

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