Correlations of Electrocardiographic Features with Airway Obstruction in Chronic Bronchitis*

M. K. Tandon, M.D.**

One hundred fifty-four patients with chronic bronchitis with or without emphysema were studied by electrocardiograms and pulmonary function tests. The incidence of the following electrocardiographic features: P waves greater than 2.0 mm in height, presence of Ta waves, P axes over +75°, S waves greater than 5 mm in V5-V6 and QRS axes over +75°, showed significant negative correlations with FEV1/VC ratio. The arterial oxygen tension had significant negative correlations with P and QRS axes while the arterial carbon dioxide tension had significant positive correlation with P axes only.

Though chronic obstructive airway disease is by far the most common cause of right ventricular hypertrophy reports of correlations between ventilatory functions and electrocardiographic features are not unanimous. Caird and Wilcken failed to find any relationship between P wave axis or direction of P waves in aVL and the volume expired in the first second of forced expiration (FEV1.0). Chappell reported significant correlations of (a) rightward deviation of P axis, (b) P pulmonale, (c) right ventricular hypertrophy, and (d) left axis deviation with severe breathlessness, peak expiratory flow rate of less than 200 liters per minute and FEV1.0 less than 1,200 ml.

This investigation was carried out to find correlations of airway obstruction as measured by the ratio of FEV1.0 to vital capacity (FEV1.0/VC percent) and arterial blood gas tensions with various electrocardiographic features suggestive of pulmonary heart disease in chronic bronchitis and emphysema.

MATERIAL AND METHODS

Subjects

One hundred fifty-four patients with chronic bronchitis, with or without radiologic evidence of emphysema, were selected for the study. As defined by Ciba Guest Symposium all had chronic bronchitis, namely a history of cough productive of sputum for over three months of the year for the last two years. All patients diagnosed as having systemic hypertension (diastolic blood pressure over 100 mm Hg), ischemic heart disease, rheumatic heart disease and cor pulmonale were excluded from the study. All were men aged 38 to 73 years and were studied in an optimum phase of their condition.

Pulmonary Function Tests

Spirometry was performed on all patients with the use of a water-filled, bell type, 10 liter spirometer. FEV1.0 and VC were measured. Best of the three attempts at these procedures were taken as the final readings and from these FEV1.0/VC percent was calculated.

Blood Cases

In 89 cases arterial blood samples which were taken with the patients at rest breathing room air were available for analysis. Partial pressures of oxygen and carbon-dioxide tensions were measured through use of Beckman electrodes.

Roentgenograms

Posteroanterior and right lateral roentgenograms of 141 patients taken in full inspiration were examined without any knowledge of results of electrocardiograms. Presence of definite radiologic evidence of emphysema was assessed according to criteria laid down by Simon.

Electrocardiograms

Standard 12 lead electrocardiograms were recorded with Cardiotrace direct writers employing conventional standardization (1 cm = 1 mv).

The following features were studied:

(1) P waves greater than 2.0 mm in height in any of the leads.

(2) Mean frontal P wave axes of over +75° (normal range +15° to +75°).

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ECG FEATURES AND AIRWAY OBLITERATION IN CHRONIC BRONCHITIS

Table 1—Distribution of Cases According to FEV\textsubscript{1}/VC\%  

<table>
<thead>
<tr>
<th>FEV\textsubscript{1}/VC%</th>
<th>10-20</th>
<th>21-30</th>
<th>31-40</th>
<th>41-50</th>
<th>51-60</th>
<th>61-70</th>
<th>71-80</th>
<th>80</th>
<th>No. of Cases</th>
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<tr>
<td>10-20</td>
<td>3</td>
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<td>23</td>
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<td>21-30</td>
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<td>9</td>
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<td>23</td>
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<td>31-40</td>
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<td>33</td>
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<td>41-50</td>
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<td>23</td>
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<td>33</td>
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<td>51-60</td>
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<td>39</td>
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<td>61-70</td>
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<td></td>
<td>19</td>
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<td>71-80</td>
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<td>8</td>
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<td>8</td>
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<td>80</td>
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</table>

(3) Presence of Ta waves defined as depression of the P-R segment of 0.5 mm or more in the standard or unipolar leads.\textsuperscript{2}

(4) Mean frontal QRS axes of over +75° (normal range −30° to +75°).\textsuperscript{8}

(5) S waves over 5 mm in depth in V\textsubscript{5}-V\textsubscript{6} precordial leads as Goodwin and Adbin\textsuperscript{9} observed that the average depth in all cases with acquired right ventricular hypertrophy, was 5.3 mm.

Statistical Methods

The cases were divided into groups of 10 percent of FEV\textsubscript{1}/VC percent as follows: 11-20, 21-30, 31-40, 41-50 and so on. The incidence of electrocardiographic features (1 to 5) in the various groups of FEV\textsubscript{1}/VC percent was expressed as percent of the total number of cases in that group and in all further discussion this percentage would be referred to merely as "incidence." The incidence of these electrocardiographic features was correlated against various groups of FEV\textsubscript{1}/VC percent by calculation of the correlation coefficient 'r' and its significance assessed using statistical tables in Documenta Geigy.\textsuperscript{10}

Results

The patients studied here ranged from those with no airway obstruction FEV\textsubscript{1.0}/VC percent of over 70 percent to those with very severe airway obstruction, FEV\textsubscript{1.0}/VC ratio of 10 percent to 20 percent (Table 1).

The incidence of all the electrocardiographic features in the different groups of FEV\textsubscript{1.0}/VC percent showed significant negative correlations with increasing severity of airway obstruction. Fall in FEV\textsubscript{1.0}/VC percent under 40 percent resulted in a marked rise in the incidence of all the electrocardiographic features (Table 2).

There were significant negative correlations of arterial oxygen tension with frontal P and QRS axes (Table 3). The arterial carbon dioxide (Paco\textsubscript{2}) tension showed a significant positive correlation with frontal P wave axes, while with frontal QRS axes a positive correlation of Paco\textsubscript{2} failed to reach a level of statistical significance.

Table 2—Correlation of Incidence of Electrocardiographic Features with Various Levels of FEV\textsubscript{1}/VC\%

<table>
<thead>
<tr>
<th>FEV\textsubscript{1}/VC%</th>
<th>10-20</th>
<th>21-30</th>
<th>31-40</th>
<th>41-50</th>
<th>51-60</th>
<th>61-70</th>
<th>71-80</th>
<th>80</th>
<th>r</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>P over 2.0 mm</td>
<td>66</td>
<td>50</td>
<td>33</td>
<td>28</td>
<td>22</td>
<td>23</td>
<td>16</td>
<td>8</td>
<td>−0.663</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Ta waves</td>
<td>67</td>
<td>33</td>
<td>27</td>
<td>8</td>
<td>11</td>
<td>13</td>
<td>15</td>
<td>16</td>
<td>−0.73</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>P axes over +75°</td>
<td>33</td>
<td>75</td>
<td>70</td>
<td>64</td>
<td>20</td>
<td>13</td>
<td>11</td>
<td>28</td>
<td>−0.724</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>S wave greater than 5 mm in V\textsubscript{5}-V\textsubscript{4}</td>
<td>100</td>
<td>67</td>
<td>50</td>
<td>17</td>
<td>21</td>
<td>22</td>
<td>10</td>
<td>25</td>
<td>−0.835</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>QRS axes over +75°</td>
<td>100</td>
<td>86</td>
<td>55</td>
<td>16</td>
<td>12</td>
<td>12</td>
<td>9</td>
<td>0</td>
<td>−0.923</td>
<td>&lt;0.005</td>
</tr>
</tbody>
</table>

Discussion

The results of the present study demonstrate that in chronic bronchitis, with or without emphysema, there is a correlation between airway obstruction as assessed by FEV\textsubscript{1.0}/VC percent and blood gases on the one hand and the incidence of various electrocardiographic features suggestive of involvement of the right side of the heart.

Spodick and associates\textsuperscript{11} reported that with increasing severity of airflow obstruction, as measured by the second second fraction of timed vital capacity, there was a significant correlation with verticalization of P and QRS axes; whereas the correlations with Ta waves and S waves greater than 2 mm in V\textsubscript{5}-V\textsubscript{6} were of borderline significance. In the present study significant correlation of airway obstruction with the incidence of all the electrocardiographic features studied indicates that all these features are influenced by increasing airway obstruction. Caird and Wilcken\textsuperscript{2} did not find any relationship of FEV\textsubscript{1.0} with P wave axes, direction of P wave in aVL and the presence of Ta waves. They argued that changes in P axes and direction of P wave in aVL occur at a much earlier stage of the disease and are not related to ventilatory capacity within the range studied. In the present study not only was the incidence of most of these electrocardiographic features studied high (even in those with little or no airways obstruction) but the incidence of all the features correlated with increasing severity of airways obstruction.

Numerous workers\textsuperscript{12-14} have shown that pulmonary hypertension is correlated with the degree of arterial desaturation and of hypercapnia. In this study the presence of significant correlation of P axes with arterial oxygen and carbon-dioxide tensions, probably indicates that changes in P axes result from raised pulmonary arterial pressure. However, it may be argued that this correlation is
secondary to airway obstructions. The relationship of QRS axes with blood gases is more complex in that though there is a significant negative correlation with a PaO₂ but with Paco₂ it failed to reach a level of statistical significance. A significant negative correlation of PaO₂ with frontal QRS axes is due to two factors: (a) reduction in PaO₂ is due to worsening of ventilation/perfusion mismatch which in its turn is due to anatomic changes in the lungs and (b) reduction in PaO₂ which leads to reflex pulmonary vasoconstriction. The anatomic changes in the lungs and pulmonary vasoconstriction affect frontal QRS axes; hence with decreasing PaO₂ there is a rightward deviation of frontal QRS axes. On the other hand a rise in Paco₂ occurs much after a fall in PaO₂ and hence Paco₂ did not correlate to a significant degree with frontal QRS axes.

Spodick and co-workers suggested that the electrocardiographic changes accompanying increasing airway obstruction and arterial blood gases in chronic bronchitis and emphysema are due to several mechanisms: (a) hyperinflation of lungs which changes the conditions of transmission or cardiac action currents, (b) depression of the diaphragm which alters the anatomic relationship of the heart to the electrode positions, (c) hypoxia and changes in body chemistry which alter cardiac metabolism and (d) pulmonary hypertension resulting from vasoconstriction and reduced pulmonary vascular bed as a result of destructive parenchymal changes. In cases with little or no airway obstruction these electrocardiographic changes are due to positional changes of the heart while in those with severe airway obstruction both positional changes and hypertrophy or dilation or both of the right side of heart are likely to be responsible for the very high incidence of these electrocardiographic features.

In view of the very significant negative correlation of FEV₁/VC percent with the increasing incidence of electrocardiographic abnormalities, a more aggressive approach to treatment of patients with airway obstruction with bronchodilators, oxygen and diuretics is warranted so that the onset of frank cor pulmonale be delayed as long as possible.

ACKNOWLEDGMENTS: I wish to thank Chairman, Repatriation Commission for permission to publish this paper, to Statistics section of Central Office, Repatriation Department for statistical analysis of the results, and Mr. Van Rooyen for typing the manuscript.

REFERENCES

5 Ciba Guest Symposium: Terminology, definitions and classifications of chronic pulmonary emphysema and related conditions. Thorax 14:286-299, 1959
10 Documenta Geigy: Scientific tables, Basle, Geigy, 1962, p 61

Editorial Expression

This clinical study again supports the concept that the rightward P and QRS vectors which are short of the present criteria for diagnosing right ventricular hypertrophy (RVH), but more rightward than is usually found at this age, correlates well with disturbed pulmonary function and blood gas abnormalities. It suggests that those electrocardiograms that cardiologists now read as rightward for age undoubtedly represent mild to modest degrees of RVH (cor pulmonale).

The study also suggests that the ECG changes

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