The Value of the Macruz Index in the Diagnosis of Atrial Enlargement

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The electrocardiographic diagnosis of atrial enlargement is a common problem. The established criteria, based on voltage, configuration, and duration of the P wave, very often fail to confirm the diagnosis even in cases of known atrial enlargement.

In 1958, Macruz, Perloff, and Case proposed a simple formula for electrocardiographic recognition of right, left, and combined atrial enlargement. The Macruz index has been widely used in recent years. It is based on the measurement of the P-R interval, P-wave duration, and P-R segment (time between end of electric atrial systole and onset of electric ventricular systole). According to the above authors, the ratio of the P-wave duration to the P-R segment as measured in standard lead II in normal persons, is relatively constant within the limits of 1.0 and 1.6, with an average value of 1.2.

In cases of right atrial enlargement the duration of the P wave hardly changes, but the P-R interval increases, so that the ratio falls below the normal range.

Left atrial enlargement, on the other hand, does not affect the P-R interval, but the P wave lengthens at the expense of the P-R segment. The result is a ratio above the normal maximal limit of 1.6.

In combined atrial enlargement, both P-R interval and P wave are prolonged. It follows that in such cases the ratio may be normal.

We studied the value of the Macruz index in the differential diagnosis of atrial enlargement in patients with proved or suspected atrial hypertension.

Materials and Method

The electrocardiograms of 164 patients were studied. In 88 cases the pressure in the right atrium was determined by venous catheterization with a simultaneously recorded electrocardiogram. When the pressure in the left atrium could not be measured directly through the bronchus, elevation of the pulmonary “capillary wedge” pressure was accepted as proof of left atrial hypertension.

A further 76 cases in which the atrial pressures are unknown were included in this study. These covered conditions of congenital and acquired heart disease of known etiology in which atrial overload could be deduced from the radiologic features: 33 cases of isolated mitral valve lesions; 13 cases of combined mitral and aortic lesions; 10 cases of isolated aortic valve lesions; 10 cases of atrial septal defect (secundum type); 10 cases of chronic cor pulmonale.

In all cases the P-R interval (from beginning of P to the commencement of QRS), the P-R segment and the duration of P wave were carefully measured in standard lead II and the ratio was determined according to Macruz' instructions. When the P-R segment was found to slope downward, its onset was considered to be the point where a line extended from the previous T-P segment crossed the descending limb of the P wave. Lead II was assumed to give a correct reflection of the P-R interval in most cases. The heart rates varied between 70 and 120 per minute. All patients had sinus rhythm and none was receiving digitalis or quinidine at the time of catheterization.

Results

Pressures above 7 mm. Hg in the right atrium and 15 mm. Hg in the left atrium or in the "capillary wedge" were considered to indicate atrial hypertension. Our results are tabulated in tables 1 and 2. The cases in which the atrial pressures were known, were divided into four groups according to whether they...
had left, right, or bilateral atrial hypertension or normal pressures in both atria. Average values for the various measurements are given. The average index value of 1.7 for the left atrial group is in agreement with Macruz’ criteria. No clear distinction could be made between the groups with right atrial hypertension, with bilateral atrial hypertension, or with normal atrial pressures (fig. 1).

Table 2 gives the corresponding values for the 76 cases in which the pressures are unknown. The average value for the Macruz index falls within the normal limits of 1.0 to 1.6 except in the 14 cases with combined mitral and aortic valve lesions where the average value for the index was slightly below the accepted normal (fig. 2).

In figure 3 we compared atrial pressures with the Macruz index. No correlation whatsoever was found between height of right atrial pressure and the size of the index. Wyss, Schaub, and Bühmann report a good correlation between the P-R segment index and mean left atrial pressure obtained during rightsided cardiac catheterization for patients with left atrial dilatation. A tendency for higher indices to be associated with high left atrial pressures is also apparent from our diagram.

**Discussion**

The index of Macruz is based on the fact that normal depolarization of the atria originates in the sinoatrial node and invades the

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**Table 1**

*Average Values for the Various Measurements Made in Cases Where the Atrial Pressures Were Known*

<table>
<thead>
<tr>
<th></th>
<th>No. of cases</th>
<th>P wave</th>
<th>P-R segment</th>
<th>P-R interval</th>
<th>Macruz index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left atrial hypertension</td>
<td>19</td>
<td>.097</td>
<td>.055</td>
<td>.152</td>
<td>1.7</td>
</tr>
<tr>
<td>Right atrial hypertension</td>
<td>21</td>
<td>.08</td>
<td>.07</td>
<td>.15</td>
<td>1.14</td>
</tr>
<tr>
<td>Bilateral atrial hypertension</td>
<td>28</td>
<td>.086</td>
<td>.068</td>
<td>.154</td>
<td>1.25</td>
</tr>
<tr>
<td>Normal atrial pressures</td>
<td>17</td>
<td>.073</td>
<td>.075</td>
<td>.148</td>
<td>.98</td>
</tr>
</tbody>
</table>

**Table 2**

*Acquired or Congenital Heart Disease with Lesions Predisposing to Atrial Enlargement*

<table>
<thead>
<tr>
<th></th>
<th>No. of cases</th>
<th>P wave</th>
<th>P-R segment</th>
<th>P-R interval</th>
<th>Macruz index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mitral ring lesions</td>
<td>33</td>
<td>.087</td>
<td>.065</td>
<td>.152</td>
<td>1.33</td>
</tr>
<tr>
<td>Combined valvular disease</td>
<td>14</td>
<td>.089</td>
<td>.08</td>
<td>.169</td>
<td>1.11</td>
</tr>
<tr>
<td>Atrial septal defect</td>
<td>9</td>
<td>.094</td>
<td>.076</td>
<td>.170</td>
<td>1.23</td>
</tr>
<tr>
<td>Cor pulmonale</td>
<td>10</td>
<td>.08</td>
<td>.06</td>
<td>.14</td>
<td>1.33</td>
</tr>
</tbody>
</table>
right atrial muscle in concentric waves. Left atrial depolarization is initiated on arrival of this wave at the atrial septum. The electrical stimulus next reaches the atroventricular node and then completes the depolarization of the right atrium while left atrial depolarization continues until the end of the P wave. The terminal portion of the descending limb of the P wave is thus exclusively determined by depolarization of the left atrium (fig. 4, according to Macruz\(^1\)). It follows that enlargement of the left atrium will predominantly cause an increase in the duration of the P wave without affecting the P-R interval, since transmission of the stimulus to the atroventricular node is normal. The increase in the numerator of the \(\frac{P}{P-R}\) segment ratio causes the high ratios in cases of left atrial hypertrophy.

On the other hand, with enlargement of the right atrium, the transit time of the stimulus between sinoatrial and atroventricular nodes is prolonged with a more or less normal P wave duration. The ratio \(\frac{P}{P-R}\) segment decreases as the value of the denominator increases.

Enlargement of both atria will increase both numerator and denominator of the ratio and the \(\frac{P}{P-R}\) may therefore remain normal. Macruz pointed out, however, that in such cases distinct prolongation of both P wave and P-R segment would be present.\(^1\)

The Macruz index was greater than 1.6 in 52 per cent of our cases of proved left atrial hypertension. Kahn et al.\(^3\) found a high index in 44 per cent of cases with lesions predisposing to left atrial enlargement. In a similar series Macruz\(^1\) and M. de Oliveira\(^4\) found high indices in 71 and 59 per cent, respectively, of cases with left atrial enlargement. A high index would thus indicate left atrial enlargement, although it is not excluded by a normal index.

In our cases of right atrial hypertension the Macruz index was 1.0 in 52 per cent of cases. It was less than 1.0 in 10 per cent of cases, while 25 per cent of cases had indices greater than 1.6. A more or less similar distribution of indices was seen in our cases of bilateral hypertension—1.0 in 45 per cent and greater than 1.6 in 17 per cent.

Evaluation of the Macruz index in our series of acquired heart lesions failed to distinguish between left and right atrial enlarge-
Summary and Conclusions

The Macruz index for the diagnosis of atrial enlargement is based on sound physiologic principles. The electrocardiograms of 88 patients with proved atrial hypertension and 76 patients with heart lesions predisposing to atrial enlargement were studied.

Two thirds (108) of the patients had normal indices between 1.0 and 1.6; 52 per cent of cases of left atrial hypertension had indices greater than 1.6.

The index did not allow of a distinction between right atrial hypertension and combined atrial hypertension. Apart from disadvantages through errors of measurement, the Macruz index appears to be of only limited value in the differential diagnoses of atrial enlargement. Magnification of the conventional electrocardiogram would undoubtedly increase the diagnostic precision of this new criterion.

References

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