Autopsy Study of Atherosclerosis at Madras, South India

By Abraham C. Kulangara, M.A., Ph.D. and R. Subramaniam, M.D., M.R.C.P.

Until the publication of a method for the quantitative appraisal of atherosclerosis by Gore and Tejada in 1957, our knowledge of the incidence of these lesions was based on subjective estimations. Subsequently, however, quantitative data from Agra and Vellore in India and also from other parts of the world have been published.

The food habits differ very much between the north and south of India and the available studies of a South Indian population are those conducted at Vellore, which is a rural small town. It was therefore decided to examine the urban population at Madras city. The mortuary of the Government General Hospital, Madras, is the only place in this city where medicolegal autopsies are carried out. About 600 autopsies are conducted in a year at this mortuary and they provide an ample source of material. The frequency and severity of atherosclerotic lesions in these bodies form the subject of the present study.

Material and Methods

Specimens were obtained from autopsies at the mortuary; no selection was made based on the cause of death. Each specimen consisted of the heart and the entire aorta with about 8 cm. of the iliac (common and external) arteries and 10 to 12 cm. of the innominate and common carotid arteries attached to it. For convenience, the arteries of the neck are designated here as the innominate on the right side and the common carotid on the left side. The coronary arteries and the aorta and its branches mentioned above were cut open along their length, their inner surfaces were wiped clean, and the lesions were counted and measured. The lesions were visually appraised without the aid of stains or other devices. They were classified and the atherosclerotic index was calculated according to the method suggested by Gore and Tejada. The coronary arteries and their branches are considered as one blood vessel, as are the two iliac arteries, for purposes of this study.

When the indices were classified according to age and sex, highly skewed distributions were obtained, particularly in the first few decades. Such skewness, probably due to the stepwise and logarithmic weighting used in the method, has given rise to artificially high mean values in some groups (see mean recalculated in one case, footnote to table 2). The stepwise nature of the atherosclerotic index also makes mean values based on a few specimens more unreliable than usual. The values in table 2 should be examined with these observations in mind. Chi-square tests have been made in order to determine the significance of differences.

Results

The sample consists of 263 hearts and 259 aortas, obtained from persons ranging in age from 6 to 94 years. About 63 per cent of the sample were men.

Frequency of Occurrence

Blood vessels with an index value above 0.033 are considered to show significant atherosclerosis and the number of such vessels in each decade gives an idea of the frequency of occurrence of the disease. Table 1 gives the distribution according to age and sex for the aorta and coronary arteries and also the percentage of arteries that are affected. At least two thirds of the aortas are diseased by the second decade and after the fourth decade no aorta is free from involvement. The data also showed that about 35 per cent of the innominate and the common carotid arteries are affected by the second decade and almost all of them by the fifth decade. The coronary arteries are less frequently affected (table 1); about 10 per cent are diseased in the second decade, some are free from lesions even in the sixth and seventh decades, and there is one

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from a 94-year-old subject that is entirely free from lesions. The frequency in the iliac arteries is very similar to that in the coronary arteries.

It may be pointed out here that the frequencies in both sexes are similar, none of the arteries showing a significant sex difference in any decade.

**Extent and Severity of Lesions**

The atherosclerotic index is a combined measure of the extent and severity of lesions. The mean and range of indices in the various arteries are given in table 2. The arteries examined here may be arranged in a series, based on the mean indices. The aorta of both sexes is the most heavily diseased, next come the coronary arteries of the men and the iliac arteries of both sexes, then the innominate and the common carotid arteries of both sexes, and finally the coronary arteries of the women.

The mean index of the aorta increases gradually until the fourth decade, after which it increases rapidly. By the fifth decade it is above 10, a value that some aortas show even in the third decade (table 2). The most commonly affected part of the aorta is its posterior wall, especially the zone of origin of the intercostal arteries. The lipid spots and streaks observed in the first few decades occurred mostly in this zone.

Comparison of indices shows some sex differences. The values for the coronary arteries in men and women are significantly different \((p < 0.05)\) in the fourth, fifth, and sixth decades. They seem to be different in the other decades as well, but the number of specimens examined in the seventh and later decades is considered inadequate. Thus the mean indices in women lag almost two decades behind those in men. The mean aortic indices in the fifth decade and the mean iliac indices in the fourth decade also appear to be different. There is no sex difference among the mean indices of the innominate and the common carotid arteries, except in three cases which are based on inadequate numbers. Thus, the coronary arteries are the only ones that show a persistently large difference between the mean indices of the two sexes.

**Discussion**

Conclusions based on autopsy studies, about the incidence of a disease in the population, are subject to bias from various sources. An important factor, relevant to the present sample, may be mentioned here. Destitute persons and those in the lowest socioeconomic level form the great majority of cases on which autopsy is performed here. Our sample, however, is comparable to that from Vellore in

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**Table 1**

**Distribution of Atherosclerosis in Relation to Age and Sex**

<table>
<thead>
<tr>
<th>Age decade</th>
<th>Number examined</th>
<th>Male</th>
<th>Per cent affected *</th>
<th>Female</th>
<th>Per cent affected *</th>
<th>Male</th>
<th>Per cent affected *</th>
<th>Female</th>
<th>Per cent affected *</th>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>0</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>2</td>
<td>26</td>
<td>12</td>
<td>36</td>
<td>8</td>
<td>65</td>
<td>34</td>
<td>77</td>
<td></td>
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<tr>
<td>3</td>
<td>48</td>
<td>23</td>
<td>32</td>
<td>16</td>
<td>84</td>
<td>32</td>
<td>81</td>
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<td>4</td>
<td>40</td>
<td>58</td>
<td>14</td>
<td>57</td>
<td>95</td>
<td>14</td>
<td>93</td>
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<td></td>
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<tr>
<td>5</td>
<td>29</td>
<td>83</td>
<td>11</td>
<td>55</td>
<td>100</td>
<td>10</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>11</td>
<td>100</td>
<td>3</td>
<td>67</td>
<td>100</td>
<td>3</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>80</td>
<td>2</td>
<td>100</td>
<td>100</td>
<td>2</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>3</td>
<td>100</td>
<td>3</td>
<td></td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>1</td>
<td>100</td>
<td>0</td>
<td></td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>164</td>
<td>99</td>
<td>1</td>
<td>163</td>
<td>96</td>
<td></td>
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</tr>
</tbody>
</table>

* The number of arteries with an atherosclerotic index above 0.03 expressed as a percentage of the number examined.
### Table 2

**Mean Atherosclerotic Indices (Values in Parentheses Indicate Range)**

<table>
<thead>
<tr>
<th>Age, decade</th>
<th>Male</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Female</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coronary arteries</td>
<td>Aorta</td>
<td>Iliac</td>
<td>Iliac</td>
<td>Common carotid</td>
<td>Coronary arteries</td>
<td>Aorta</td>
<td>Iliac</td>
<td>Iliac</td>
<td>Common carotid</td>
</tr>
<tr>
<td>1</td>
<td>0 (0–0.033)</td>
<td>0.017 (0–0.973)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0.03 (0–0.33)</td>
<td>0.525 (0–3.33)</td>
<td>0.122 (0–1)</td>
<td>0.112 (0–1)</td>
<td>0.13 (0–1.33)</td>
</tr>
<tr>
<td>2</td>
<td>0.069 (0–3.7)</td>
<td>0.464 (0–0.33)</td>
<td>0.042 (0–2.13)</td>
<td>0.19 (0–0.53)</td>
<td>0.14 (0–0.53)</td>
<td>0.03 (0–0.33)</td>
<td>0.525 (0–3.33)</td>
<td>0.122 (0–1)</td>
<td>0.112 (0–1)</td>
<td>0.13 (0–1.33)</td>
</tr>
<tr>
<td>3</td>
<td>1.81 (0–53.3)</td>
<td>1.65 (0–19)</td>
<td>0.511 (0–3.33)</td>
<td>0.412 (0–8.2)</td>
<td>0.374 (0–6.4)</td>
<td>0.047 (0–0.33)</td>
<td>1.26 (0–0.33)</td>
<td>0.155 (0–0.33)</td>
<td>0.089 (0–0.33)</td>
<td>0.104 (0–0.53)</td>
</tr>
<tr>
<td>4</td>
<td>1.41 (0–10)</td>
<td>5.98 (0–33.3)</td>
<td>3.35 (0–10)</td>
<td>1.11 (0–10)</td>
<td>1.38 (0–10)</td>
<td>0.201 (0–0.33)</td>
<td>2.63 (0–0.33)</td>
<td>0.554 (0–0.33)</td>
<td>1.45 (0–0.33)</td>
<td>0.68 (0–4.37)</td>
</tr>
<tr>
<td>5</td>
<td>17.5 (0–91)</td>
<td>31.3 (0–33.3)</td>
<td>23.1 (0–10)</td>
<td>6.96 (0–51.4)</td>
<td>5.55 (0–22.6)</td>
<td>0.033 (0–0.33)</td>
<td>19.7 (0–33.3)</td>
<td>0.533 (0–64)</td>
<td>0.46 (0–0.33)</td>
<td>0.033 (0–18.1)</td>
</tr>
<tr>
<td>6</td>
<td>10.5 (0.133–53.3)</td>
<td>23.9 (5.13–55)</td>
<td>27.7 (3.33–91)</td>
<td>4.7 (0.093–10)</td>
<td>4.53 (0–10)</td>
<td>0.182 (0–0.33)</td>
<td>23.8 (9.1–44.2)</td>
<td>9.34 (0.033–18)</td>
<td>0.033 (0–1.33)</td>
<td>0.683 (3.33–6.73)</td>
</tr>
<tr>
<td>7</td>
<td>19.7 (0.033–73)</td>
<td>22.6 (10–37)</td>
<td>15.1 (3.33–28)</td>
<td>5.05 (0.33–10)</td>
<td>5.6 (1.01–10)</td>
<td>15.7 (3.33–28)</td>
<td>13.2 (7.3–19)</td>
<td>14.7 (1.33–28)</td>
<td>10.0 (2–0.03)</td>
<td>10.0 (2–0.03)</td>
</tr>
<tr>
<td>8</td>
<td>34.0 (10–82)</td>
<td>28.0 (10–55)</td>
<td>22.0 (10–37)</td>
<td>19.0 (10–28)</td>
<td>9.7 (9.1–10)</td>
<td>0</td>
<td>26.1</td>
<td>28.0</td>
<td>28.0</td>
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</table>

* A single extreme index of 53.3, recorded in this group, has made the mean value artificially high. The mean, calculated after excluding this extreme value, is 0.763.
this respect. Therefore, it is probably significant that a much greater involvement of the aorta and coronary arteries is evident from the present sample. The mean aortic indices of the Agra and Vellore samples agree, whereas indices obtained in the present study are four to five times those values\(^2, 3\) in the second, third, and fourth decades. The difference is large, about two to three times, even in the later decades. In two decades, the mean values obtained here are even higher than the maximum values found at Agra.

The high mean indices obtained in the present study make these data comparable to those recorded in the United States.\(^3, 5\) Gore et al.,\(^3\) after examining material from the United States, British West Indies, India, and Japan, came to the conclusion that aortic and coronary atherosclerosis are relatively mild in India. Their data from India are corroborated by the study from Agra.\(^2\) Thus, the impression that atherosclerosis is not severe in India has been gaining ground. The present study provides the first data in disagreement with this view. Judged by the mean indices at various decades, aortic atherosclerosis is almost as severe at Madras as it is in the United States. An index value of five, a turning point in the progress of the disease, is reached in the fourth decade in the data from the United States and in the present study, but only between the fifth and sixth decades in the data from Agra and Vellore.

As already mentioned, a large difference between the mean indices of coronary arteries of men and women in almost all decades is evident from our data. The mean coronary indices in men at Madras are much higher than the Agra values and are similar to the values obtained in the United States.\(^3\) The considerably lower values obtained here for the coronary arteries in women agree with values for the aorta from Agra.\(^2\) and Vellore.\(^5\) Separate data for the sexes are not available from Vellore, and the differences between the coronary indices of men and women from Agra do not seem to be significant in any decade. Groom et al.\(^9\) reported a significant sex difference at all decades in the coronary arteries and aorta, but others\(^7\) have found that a sex difference occurs only in the fourth decade in the coronary, iliac, and renal arteries. Roberts et al.\(^8\) could find no sex difference in atherosclerotic lesions, although they found that a larger number of men had vascular catastrophes than women. Wig et al.\(^12\) thought that, unlike the data for clinical coronary heart disease, there was no appreciable difference between the sexes in either the frequency or the severity of lesions in the coronary arteries. The frequency of coronary atherosclerosis in the present series does not appear to be different in the sexes, but the severity and extent of the lesions are much greater in the men.

**Summary**

A sample of 263 hearts and 259 aortas, ranging in age from 6 to 94 years, has been examined for atherosclerotic lesions. The atherosclerotic index for the aorta and the coronary, iliac, innominate, and common carotid arteries has been computed and the data have been analyzed according to sex and age groups. The arteries may be arranged in the following descending series, beginning with the one most heavily diseased: the aorta in both sexes; the coronary arteries of men; the iliac, innominate, and common carotid arteries of both sexes; the coronary arteries of women. The aorta is also the most frequently affected blood vessel.

The frequency of atherosclerotic involvement of the coronary arteries is the same in both sexes, but the extent and severity of lesions are much greater (two to four times) in men than in women. Consistently large differences between the sexes have been observed only in the coronary arteries. The mean atherosclerotic indices of the aorta and coronary arteries in men indicate a much greater severity of the disease at Madras than so far reported from any other place in India, the severity being very similar to that reported from the United States.

**Acknowledgment**

We are grateful to Professor C. B. Gopalakrishna, M.D., and to the other staff members of the Depart-
ment of Forensic Medicine for their cooperation in placing the autopsy material at our disposal.

References

Of the time for Beginning These Studies & of Common-Place Books

Anatomy in the proper sense of the word, that is, unmixed with the use of the parts & the doctrine of diseases cannot be learned too soon. Galen, in the beginning of his second book of anatomical dissertations, mentions it as the common practice of ancient physicians, who of course instructed their sons in their own art, to exercise them from their childhood to dissections, by which means the knowledge of the parts of the body were as deeply fixed in their memories as the elements of speech, & he judged it a disadvantage that the different method of learning the profession forced him to begin anatomy later. The same may be said of botany, the history of the materia medica, & an acquaintance with the sight of it. So that he cannot begin upon these too soon, if he would, as he must learn them as soon as he can.—William HEBERDEN. An Introduction to the Study of Physic. New York, Paul B. Hoeber, Inc., 1929, p. 118.
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