Quantitative Survey on Lesions of Aortic Atherosclerosis in Sendai Area

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The atherosclerotic index (AI) of the aorta in Sendai area was studied with 603 consecutive autopsy materials according to the method of Gore and Tejada. The mean AI calculated in every decade from the 1st to 9th was 0.002, 0.391, 0.850, 1.436, 2.085, 4.821, 6.279, 12.658 and 15.522, respectively. AI increased with age gradually up to the 5th decade and remarkably in the subsequent decades. A comparative study of AI between Sendai and certain other geographic areas in Japan available in the literature revealed that there were no significant differences according to individual area up to 60 years of age, whereas a distinct difference was observed in the subsequent ages. Sendai area took the lowest rank in AI which was comparable to the value obtained from the Bantu in South Africa.

Calcification was observed in 74 cases, 69 of which belonged to the group after 60 years of age, while the youngest was in the 3rd decade. The abdominal aorta and the aortic arch were the sites of the most frequent involvement. As to the relationship between AI and basic diseases, cases of myocardial infarction and aortic aneurysm in ages after 50 years and of malignant nephrosclerosis generally had high AI values, while cases of malignant neoplasm showed low AI values. No significant change in AI was observed among cases of cerebral hemorrhage, myocardial infarction, chronic glomerulonephritis and diabetes mellitus. There were no confirmable correlations between AI and systolic blood pressure or heart weight.

It has been accepted that the severity of atherosclerosis varies considerably according to geographic factors, races, environments and nutritional conditions. The atherosclerotic index (AI) which was proposed by Gore and Tejada1 is a simple but excellent indicator in the estimation of the grade of atherosclerosis and has been adopted by WHO for surveys of aortic diseases. Gore and his coworkers2,3 applied AI to comparative studies of atherosclerosis in several geographic areas.

The present paper deals with AI of the aorta of inhabitants in Tohoku district, which is located in the northeast of the Main Island of Japan and is known for high incidence of cerebral infarction and hemorrhage.4 The results obtained will be compared with those from other areas in Japan5-8 and foreign countries.8 A relationship of AI to basic diseases or certain other factors of patients will further be discussed.

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MATERIALS AND METHODS

Formalin fixed aortas were examined for the quantitative estimation of atherosclerosis. The materials were obtained from 603 consecutive autopsy cases of both sexes at the Department of Pathology, Tohoku University School of Medicine, during the years of 1962–63.

A sketch of the internal aortic surface in regard to atherosclerotic involvement was made on unstained materials from the portion just beneath the aortic valves to the bifurcation of iliac arteries. estimations of types and extensions of atherosclerotic alteration and calculations of AI were done in the same procedure as that proposed by Gore and Tejada. Intimal lesions were divided into 4 types: grade 1 of lipid streaks, spots or patches; grade 2 of elevated, smoothly surfaced, fibrous plaques of variable lipid content; grade 3 of plaques with ulceration, necrosis or hemorrhage; and grade 4 of calcified plaques. In order to define the area of surface involvement, the aortas were divided into the following 5 groups: group O with surface involvement less than 5 per cent; group A, 6 to 15 per cent; group B, 16 to 33 per cent; group C, 34 to 50 per cent; and group D, more than 51 per cent. AI was calculated in each instance.

Fig. 1. Distribution of individual AI.
RESULTS

1) **AI in Sendai area**

The age distribution of individual AI (Fig. 1) demonstrated that individual variation increased with age, and particularly in old ages. It was further noticeable that cases with mild lesions were generally prominent in every decade.

The mean AI significantly rose with advancing age in both sexes (Table 1), and in particular conspicuously after the 7th decade. The lesions in males were usually predominant and about a decade ahead of those in females.

Four of 56 cases in the 1st decade had slight lesions of grade 1, and the youngest one was at 3 years of age.

<table>
<thead>
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<th>Decade</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases</td>
<td>Mean AI</td>
<td>Cases</td>
<td>Mean AI</td>
</tr>
<tr>
<td>1</td>
<td>34</td>
<td>0.002</td>
<td>22</td>
</tr>
<tr>
<td>2</td>
<td>19</td>
<td>0.548</td>
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<td>12.296</td>
<td>11</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>16.529</td>
<td>5</td>
</tr>
</tbody>
</table>

| Total  | 393   | 210    | 603   |

2) **Extension of atherosclerosis with age**

Graphic representation of the involved areas in each type of grades 1 to 4 which was expressed in percentage of the whole aortic surface (Fig. 2) disclosed that the grade 1 type showed a rapid rise during the first 3 decades until an almost constant level was reached in all subsequent decades except for the 9th. However, according to average profiles (Table 2), i.e., the percentage of average surface extent of each type to that of entire lesions, the value of grade 1 type was the highest in the 2nd decade and gradually decreased with age thereafter. Grade 2 type increased gradually in the first four decades and rapidly in the subsequent decades. Grades 3 and 4 had generally low rates, but there were significant elevated in their...
incidences in old ages.

3) Calcification

Calcification was observed in 74 cases (50 males and 24 females) and the incidence was roughly increased in parallel with advancing age (Table 3). The youngest one was in the 3rd decade but 69 cases were in decades over the 6th.

As to the relationship of calcification to the extent of atherosclerosis, the lesions of groups O, A, B, C and D were observed in 0, 8, 14, 14 and 34 cases, respectively.

Table 3. Incidence of calcification in each age group

<table>
<thead>
<tr>
<th>Decade</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>20</td>
<td>26</td>
<td>15</td>
<td>98</td>
<td>74</td>
</tr>
<tr>
<td>Incidence in per cent</td>
<td>0</td>
<td>0</td>
<td>2.2</td>
<td>2.9</td>
<td>2.1</td>
<td>15.3</td>
<td>23.8</td>
<td>34.9</td>
<td>61.5</td>
<td></td>
</tr>
</tbody>
</table>

In order to characterize the pattern of calcification in the aorta, topographic incidence of calcification was determined in five segments: Segment I, the ascending aorta; Segment II, proximal half of the aortic arch; Segment III, distal half of the aortic arch; Segment IV, the descending thoracic aorta and Segment V,
Calcification was frequently observed in two or more separate regions in the same aorta; i.e., cases with two, three and four lesions were observed in 20.3%, 18.1% and 13.5% of total cases, while cases with single lesion were in 47.3%, but none had five lesions. The lesion was most frequently observed in Segment V (54 cases), which was followed by Segments III (36 cases), II (33 cases), IV (18 cases) and I (6 cases).

4) **AI and basic diseases**

The examined cases were divided into three major groups according to postmortem diagnosis; a) atherosclerotic and hypertensive diseases, b) malignant neoplasms and c) tuberculosis and liver cirrhosis.

a) **Atherosclerotic and hypertensive diseases.** This group comprised 15 cases of myocardial infarction, 15 of aortic aneurysm, 12 of malignant nephrosclerosis, 8 of cerebral hemorrhage, 7 of cerebral infarction, 9 of chronic glomerulonephritis and 11 of diabetes mellitus. Graphic representation of AI of individual cases with reference to age of each group was compared with the mean AI of Sendai area (Fig. 3). In the group of myocardial infarction as well as of aortic aneurysm, cases over
50 years of age generally had high values of AI. A moderate increase of AI was common in malignant nephrosclerosis, although there was no case of severe lesions. Cases of cerebral hemorrhage and infarction had no definite patterns. A majority of cases of chronic glomerulonephritis and diabetes mellitus were found in ages under the 7th decade and generally had AI values below the mean.

b) Malignant neoplasms. This group was composed of 234 cases and occupied 39% of the total. The mean AI of 15 subgroups, each of which comprised more than five cases, was studied in relation to the mean age. Cases of carcinoma of the lung (24), of the urinary bladder (7), of the prostate (5) and of the pharynx (5) generally had a high mean AI. On the contrary, cases of carcinoma of the stomach (56), leukemia (35), carcinoma of the pancreas (15), carcinoma of the esophagus (14), reticulum cell sarcoma (13), carcinoma of the uterus (12), carcinoma of nasal sinuses (9), carcinoma of the liver (7), carcinoma of the breast (6), carcinoma of the intestine (5) and carcinoma of the gallbladder (5) showed lower indexes.

c) Tuberculosis and liver cirrhosis. In 65 cases of tuberculosis and 24 cases of
liver cirrhosis, the mean AI was calculated and correlated to age. No definite tendencies were observed in both groups.

5) Blood pressure, heart weight and AI

There were no significant relations between AI and systolic blood pressure or heart weight.

DISCUSSION

It has been generally accepted that atherosclerosis develops in association with aging. Values of individual AI in the present study (Fig. 1) exhibited only a minimum increase during the first 4 decades but a remarkable rise with age in the subsequent decades. The graphic representation of the mean AI in reference to age in several geographic areas in Japan summarized from previous reports5-8 is given in Fig. 4, together with the results of the present study. It is of interest that there are no significant differences among individual lines in the diagram under the age of 40 years, while distinct differences are found in subsequent ages. The result of the present study is represented by the lowest line in this graph. This seems to be against our expectation that the northeastern Japan may have a high AI in view

Fig. 5. Comparison of AI in Sendai with those in foreign countries.
of the high incidence of hypertensive cerebral hemorrhage in this area. However, it has been an established fact that AI of the aorta has no significant relationship to cerebral hemorrhage or hypertension. Hypertension is responsible for the induction of cerebral hemorrhage, but it does not accelerate atherosclerosis of the aorta.

The atherosclerotic lesions of the aorta in certain geographic areas of the world summarized in Fig. 5 based on the results available in the literature\textsuperscript{5,3,9} and compared with those of the present study. U.S.A. (Boston and Los Angeles), New Orleans and Jamaica rank high and are followed by Costa Rica, Guatemala and India, which are comparable with Osaka (Wada) and western Japan in AI values. Our results obtained from Sendai area showed the lowest AI value which was comparable with that of the Bantu in South Africa.

AI is derived from the following calculation: 
\[ (W/30) \times \left\{ (a/10) \times 1 + (b/10) \times 10 + (c/10) \times 100 + (d/10) \times 100 \right\}. \]

In this expression $W$ denotes the extent of atherosclerosis, and $a, b, c$ and $d$ denote the average profiles of types of atherosclerosis from grades 1 to 4, respectively. The ratio of $a, b, c$ and $d$ depends much on geographic differences as well as on aging. For example, the average relative frequency of each of the four types of aortic lesions in reference to age in Sendai and New Orleans is demonstrated in Fig. 6. In both Sendai and New Orleans a progressive shift with
age from grade 1, prevalent in the first three decades, to a gradual increase in the proportion of grades 2-4 in the subsequent decades. In New Orleans, however, the lesions generally occur earlier and are severer.

The incidence of grade 4 or of lesions with calcification in several geographic areas are listed in Table 5. U.S.A. (Boston and Los Angles) takes the highest rank and is followed by New Orleans, Sapporo, Western Japan, Osaka, Jamaica, Guatemala, India and Sendai in the descending order. This order bears a close parallelism to that of the mean AI except for Jamaica, which has a high ratio of AI in spite of low incidence of calcification. It is considered that severe lesions, e.g., grades 3 and 4 contribute much in raising AI in the calculation. Concerning this, Nakajima and Katayama pointed out in their comparative study on coronary sclerosis between western Japan and Boston that lesions with calcification were severer in Boston than in Japan. The severity of calcification was evaluated in the present study by its topographic incidence in the aorta. The abdominal aorta and the aortic arch were the site of frequent involvement. Calcification was less frequently found in the ascending and descending thoracic aorta. These suggest that the local factors such as hemodynamics or structure of the vascular wall are in part responsible for the induction of the lesion in addition to the general factors as nutrition.

Cases of myocardial infarction and aortic aneurysm in ages after 50 years generally had high values of AI. This would be attributed to the fact that these diseases usually develop upon atherosclerotic lesions. Matsuoka stated that atherosclerosis in the aorta and its large branches was not responsible for the induction or development of hypertension. In the present study, there are no significant correlations between AI and systolic blood pressure or heart weight.

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References


