Relation of Blood Pressure and Serum Total Cholesterol to Severity of Atherosclerotic Lesions in Aorta, Coronary and Cerebral Arteries

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Summary

Macroscopic examinations were made on the aorta, the coronary and cerebral arteries of 132 autopsy cases with long follow-up of blood pressure and total serum cholesterol for more than 10 years.

The most outstanding finding in the present study was a significant positive correlation between the average of annual systolic pressure and the severity of atherosclerotic lesions in the aorta, the coronary and cerebral arteries. On the other hand, the average of annual diastolic pressure was related only to the severity of cerebral atherosclerosis.

Although a linear correlation was demonstrated between the average of total serum cholesterol and the severity of stenosing atherosclerosis of the coronary arteries, the total serum cholesterol value was found to be unrelated to the severity of the atherosclerotic lesions of the aorta and the cerebral arteries.

Additional Indexing Words:
Complicated lesion of aorta  Coronary stenosis  Interrelationship between atherosclerotic lesions

The relations of the blood pressure and serum cholesterol to the severity of the atherosclerotic lesions are not entirely clear as yet. Although numerous epidemiological studies have indicated close relationship of hypertension and serum lipid abnormalities to the coronary heart disease,1)-5) a few attempts have been made to relate the degree of atherosclerosis of the coronary artery at autopsy to the clinical data. Several investigators have reported absence of significant correlation between the serum cholesterol level and the pathological findings of the coronary arteries.6)-8) On the other hand, although a close correlation of the severity of cerebral atherosclerosis to the blood pressure is well known,9)-15) its relationship to the serum lipid abnormalities has not been widely investigated. In the present study, a pathological and clinical correlation was attempted in the autopsy cases with long follow-up of blood pressure.

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MATERIALS AND METHODS

From the autopsy files during the years 1965–1969 at the Yokufuen Geriatric Hospital, 132 cases with long follow-up of the blood pressure were selected for the study. There were 33 males and 99 females, and all the cases were above the age of 70 years because the materials were from a geriatric hospital. The blood pressure was checked regularly for 10 years or longer in all of these 132 cases, while determination of the total serum cholesterol was performed at least 5 times in 95 cases. The average of the total serum cholesterol was calculated in the latter cases.

The total serum cholesterol was determined by using the method originally described by Zlatkis and associates,\textsuperscript{16} and modified by Zak and associates.\textsuperscript{17} The averages of the annual blood pressure and of the total serum cholesterol were calculated excluding the values for the last 2 years of life.

The macroscopic examinations of the coronary arteries were performed according to the routine method in our laboratory.\textsuperscript{18,19} The stems and main branches of the coronary arteries were sectioned transversely at intervals of 3 mm., and longitudinal sections were added thereafter when necessary. The grade of the stenosis was recorded for each of the 3 arteries, that is, anterior descending branch, left circumflex branch and right coronary artery. Each grade was given an arbitrary score from 1 to 6 as shown in Fig. 1. Thus, the total scores were ranged theoretically between 3 and 18. A moderate coronary sclerosis was diagnosed when the total score was between 7 and 11, while a severe sclerosis was diagnosed when the score was 12 or more.

The cerebral portion of the carotid and vertebral arteries, together with the basilar artery and proximal portion of the anterior, middle and posterior cerebral arteries were examined macroscopically. The severity of cerebral atherosclerosis was classified into 4 grades: none, slight, moderate and severe.

The aorta was opened longitudinally, and the total areas of the thoracic and abdominal portions of the aorta were measured. The areas of the fibrous plaques, atheromatous and complicated lesions were measured independently thereafter and the percentages of the affected areas were calculated. The areas of fatty streaks were not measured, and therefore the total affected area in the present study means the total of the areas of fibrous plaques, atheromatous and complicated lesions.

Although the macroscopic examinations of the coronary and cerebral arteries were performed in all of 132 cases, the aorta was examined in 72 cases selected at random. The cases with positive serum test for syphilis were not included in the latter group.
RESULTS

1. Relations between age, sex and atherosclerosis

As seen in Table I, there was no statistically significant relationship between the age and the severity of atherosclerotic lesions examined in the present study. A significant negative correlation was demonstrated between the age and the average of annual diastolic pressure. There was no significant difference between males and females in the average of the annual blood pressure, the average of the total serum cholesterol and the severity of atherosclerosis as seen in Table II.

| Table I. Correlation-coefficients for Blood Pressure, Total Serum Cholesterol and Severity of Atherosclerosis Against Age |
|---|---|---|
| Age Vs | Average of annual systolic pressure | +0.024 |
| | Average of annual diastolic pressure | -0.285** |
| | Total serum cholesterol | +0.151 |
| | Total area of aortic lesions | +0.138 |
| | Area of complicated lesion of aorta | +0.044 |
| | Coronary atherosclerosis | +0.017 |
| | Cerebral atherosclerosis | +0.026 |

** highly significant (p < 0.01).

| Table II. Clinical Data and Severity of Atherosclerosis in Males and Females |
|---|---|
| Age (years) | Male | Female |
| Average of annual systolic pressure (mm.Hg) | 163.7±18.6 | 166.7±23.9 |
| Average of annual diastolic pressure | 86.3±9.4 | 87.6±10.7 |
| Total serum cholesterol (mg./100 ml.) | 194.5±22.4 | 204.5±25.9 |
| Total area of aortic lesions (%) | 33.0±32.2 | 37.2±26.5 |
| Area of complicated lesion of the aorta (%) | 14.8±34.2 | 16.0±26.8 |
| Coronary atherosclerosis (total score) | 8.2±2.9 | 8.2±3.9 |

2. Relations between blood pressure and atherosclerosis

A simple linear correlation analysis revealed a significant positive correlation between the average of the annual systolic pressure and the severity of stenosing atherosclerosis of the coronary artery, and between the averages of both annual systolic and diastolic pressure and cerebral atherosclerosis as seen in Table III and Figs. 2 and 3. Although a significant positive correlation was also demonstrated between the average of the annual systolic pressure and the area of the complicated lesions of the aorta, no obvious relationship was present between the blood pressure and the total area of atherosclerotic
lesions of the aorta. The relationship between the average of annual diastolic pressure and the severity of atherosclerotic lesions was not obvious except in the cerebral artery.

3. Relations between total serum cholesterol and atherosclerosis

As seen in Table III, a significant correlation was demonstrated only between the average of the total serum cholesterol and the severity of stenosing atherosclerosis of the coronary artery. The increase in the incidence of moderate and severe coronary atherosclerosis with the elevation of the average of the total serum cholesterol is evident in Fig. 2.

4. Interrelationship between the atherosclerosis in the aorta, the coronary and the cerebral arteries
Table IV. Interrelationship Between the Severity of Atherosclerotic Lesions of the Aorta, the Coronary and Cerebral Arteries

<table>
<thead>
<tr>
<th></th>
<th>Aorta Complicated lesion</th>
<th>Coronary</th>
<th>Cerebral</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aorta Total affected area</td>
<td>+0.670**</td>
<td>+0.140</td>
<td>+0.317**</td>
</tr>
<tr>
<td>Aorta Complicated lesion</td>
<td></td>
<td>+0.295*</td>
<td>+0.132</td>
</tr>
<tr>
<td>Coronary</td>
<td></td>
<td></td>
<td>+0.303**</td>
</tr>
</tbody>
</table>

* Significant (p < 0.05), ** Highly significant (p < 0.01).

The results were complicated as seen in Table IV. A significant positive correlation was observed between the severity of the coronary and cerebral atherosclerosis, between the coronary atherosclerosis and the area of the complicated lesions of the aorta, and between the cerebral atherosclerosis and the total area of atherosclerotic lesions of the aorta.

DISCUSSION

The absence of significant correlation between the severity of the atherosclerotic lesions and the age or sex in the present study were somewhat curious, but this result may be explained by the age distribution of the patients. Although a close correlation of the age and sex to the severity of the atherosclerotic lesion is well known, our previous investigation has revealed that
the relationship of the age and sex to the coronary atherosclerosis is not obvious in the patients over the age of 70. Similar results have been reported by previous investigators.19-21

There are controversies on the relationship between the total serum cholesterol and the severity of coronary atherosclerosis. Previous epidemiological studies have revealed a close correlation of hypercholesterolemia to the coronary heart disease,1-5 and a positive correlation between the severity of coronary atherosclerosis and total serum cholesterol value have been demonstrated in our previous study.13 Similar observations to ours have been reported by Rickert and associates15 and Schwartz and associates.25 On the other hand, Paterson and associates6,7 and Mathur and associates8 could not find any obvious relationship between the total serum cholesterol value and the pathological findings of the aorta, the coronary or cerebral arteries. The present study reconfirmed our previous observation that the severity of coronary atherosclerosis was significantly related to the total serum cholesterol value, although the calculated correlation coefficient was rather low. On the other hand, there was no obvious correlation between the total serum cholesterol and the severity of atherosclerosis of the aorta or cerebral artery in accord with our previous study13 and reports by Paterson and associates6,7 and Mathur and associates.8

A close correlation of the blood pressure to the severity of atherosclerosis in the aorta, the coronary or cerebral arteries have been pointed out by many investigators,9-15,18-20,23-26 although there are some contradictory reports.22,27 However, the studies on the blood pressure are frequently not without objections, especially when only one reading of the blood pressure is available. In order to exclude the influence of transient fluctuations of the blood pressure, only the cases with long follow-up of the blood pressure were included in the present study, and the average of the annual blood pressure was calculated. There was a significant positive correlation between the average of the annual systolic pressure and the severity of atherosclerosis of the coronary and cerebral arteries. It was interesting to have found that the area of the complicated lesion of the aorta was significantly greater in the presence of high systolic pressure, while there was no significant correlation between the total affected area of the aorta and the blood pressure. Unfortunately, the authors have no adequate explanation of this observation at the present time. Disagreeing with the previous investigations, the relationship between the diastolic pressure and the severity of the atherosclerosis was not obvious except in the cerebral artery. The result might be masked by a negative correlation between the age and the average of the annual diastolic pressure in the present series.

The interpretation of the complicated relationship between the severity
of atherosclerosis and the clinical variables is quite difficult. The interrelationship of the severity of atherosclerosis in the aorta, the coronary and cerebral arteries is also complicated, and it is apparent that the lesions in the different arteries do not necessarily progress parallel. There is no doubt that multiple general factors are playing major and minor roles for the development and/or progression of the atherosclerosis, while local reactions of the arteries to each factor are quite variable in the different parts of the arterial system. Extensive detailed studies on the histological and chemical characteristics of each artery may be of great help for understanding of the complexity of our present observations.

REFERENCES