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Relation of Aortic Distensibility and Pulse Wave Velocity to the Degree of Coronary Artery Stenosis

Yuichi Ishikawa¹, Nobuhiro Miyazaki², Jun-ichi Mukohdani², Naoya Watanabe², Takahiro Taniguchi² and Mitsuhiro Yokoyama²

We investigated the correlation of aortic compliance and aortic pulse wave velocity (PWV) with the degree of the coronary stenosis. Invasive-PWV (IPWX) measurements were carried out in 38 male and 11 female patients, ranging in age from 17 to 71 years old (mean age 54.4 years old). We measured IPWV in ascending, thoracic and abdominal aorta and also in whole aorta by using catheter-tip manometer during diagnostic catheterization and coronary angiography. Tarazi's index (pulse pressure/stroke volume) and diastolic blood pressure decay (DBPD, Simon's method) were also measured as the indicator of the arterial compliance. Balcon's method and Gensini's method were used as the coronary stenotic index (CSI). IPWVs in ascending, thoracic and abdominal aorta were 9.42 ± 3.96 m/sec, 7.34 ± 2.17 m/sec and 8.42 ± 2.43 m/sec, respectively and the thoracic aorta was the most compliant aorta (p < 0.05). IPWV was positively correlated with Tarazi's index (r = 0.733, P < 0.001) and was negatively correlated with DBPD (r = -0.717, p < 0.001). IPWV was correlated to CSI by Gensini and Balcon, respectively (r = 0.568, p < 0.001 and r = -0.671, p < 0.001). In conclusion, IPWV was well correlated with other indices of arterial compliance and predicted the existence of the significant coronary stenosis. PWV was useful method to know the aortic characteristics in patients with arteriosclerosis.

Key Words
Pulse wave velocity, aortic distensibility, aortic arteriosclerosis, coronary arteriosclerosis.

INTRODUCTION

Pulse wave velocity (PWV) has been used as an index of the degree of aortic arteriosclerosis. (1) In this paper we evaluated the relation of PWV to other indices of vascular compliance such as Tarazi's index and diastolic blood pressure decay (Simon's method). The initial site of arteriosclerosis is at aorta, especially abdominal aorta. If the correlation between the severities of aortic and coronary arteriosclerosis exist, it is possible to predict coronary arteriosclerosis by measuring PWV in aorta. We investigated the relation of severity of aortic arteriosclerosis to severity of coronary arteriosclerosis in patients who underwent diagnostic catheterization and coronary angiography and found a close relationship.

SUBJECTS AND METHODS

Forty nine patients (38 male and 11 female) who underwent diagnostic
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catheterization were investigated, 35 patients with ischemic heart disease, 9 with chest pain syndrome, 3 with cardiomyopathy and 2 with congenital heart disease, ranging in age 17 to 71 years old (mean age 54.2 years old). The number of patients with 0 vessel disease was 19, patients with 1 vessel 14, patients with 2 vessel disease 8, and patients with 3 vessel disease 8.

THE MEASUREMENTS OF INVASIVE PULSE WAVE VELOCITY (PWV).

During diagnostic catheterization, we inserted a catheter-tip manometer (Miller 5F) from a femoral artery and advanced to the position 2 cm upper from the aortic valves and measured aortic pressure (reference position) and then drew back the manometer by 10 cm (ascending aorta), by 20 cm (thoracic aorta), and by 20 cm (abdominal aorta) and measured aortic pressure in each aortic site. We recorded the aortic pressure curves and electrocardiogram (ECG) simultaneously using angigram (Siemens) at 100mm/sec of paper speed. We calculated PWV as following equation: the distance between each manometer / the time from the onset of Q wave in ECG to the onset of the upstroke of pressure curve (Fig.1)

THE ASSESSMENT OF CORONARY STENOTIC INDEX (CSI)

We underwent diagnostic coronary angiography by Judkins' method with multi-projections and three doctors who did not know the results of PWV analysed the degree of severity of
coronary stenosis by the criteria of American Heart Association. We used two methods to calculate coronary stenotic index, namely Gensini's method and Balcon's method (4).

**Figure 2.**
Measurement of aortic compliances

**STATISTICAL ANALYSIS**
We expressed the values as mean ± standard deviation. For statistical analysis, we used student's test. Sensitivity, specificity and predictive value were calculated respectively as following: Sensitivity = true positive / true positive + false negative, specificity = true positive /true positive + false negative, specificity = true negative / true negative + false positive, predictive value = true positive / true positive + false positive.

**RESULTS**

**PWV IN EACH AORTA**
PWV in ascending aorta, thoracic aorta, and abdominal aorta were 9.42 ± 3.96 m/sec, 7.34 ± 2.17 m/sec, and 8.42 ± 2.43 m/sec, respectively. The thoracic aorta was the most compliant vessel compared with ascending aorta (p < 0.005) and abdominal aorta (p < 0.05) (Fig.3).

**PWV AND AORTIC COMPLIANCE**
PWV was well correlated to Tarazi’s index as shown in Fig.4. (y = 0.105x-0.080, r = 0.733, p < 0.001). PWV was also correlated to DBPD as shown in Fig.5. (y = - 0.178x + 2.845, r = - 0.717, p < 0.001). DBPD was correlated to Tarazi’s index (y = - 0.1504x + 2.560, r = - 0.893, p < 0.001) (Fig.6).

**PWV AND CSI**
PWV was positively correlated to CSI by Gensini’s method method (y = 6.864x - 32.70, r = 0.568, p = 0.001) (Fig.7) and also correlated to CSI by Balcon’s method (y = - 6.906x + 130.4, r = - 0.671, p < 0.001) (Fig.8).
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Figure 4.
Correlation of Tarazi's index with invasive pulse wave velocity.

Figure 5.
Correlation of diastolic blood pressure decay with invasive pulse wave velocity.

Figure 6.
Correlation of diastolic blood pressure decay with Tarazi's index.
PULSE WAVE VELOCITY AND CORONARY STENOSIS

\[ N = 49 \]
\[ Y = 6.864x - 32.70 \]
\[ r = 0.568 \quad P < 0.001 \]

**Figure 7.** Correlation of coronary stenotic index (Gensini) with invasive pulse wave velocity.

\[ N = 49 \]
\[ Y = -6.906x + 130.4 \]
\[ r = -0.671 \quad P < 0.001 \]

**Figure 8.** Correlation of coronary stenotic index (Balcon) with invasive pulse wave velocity.

PREDICTION OF CORONARY ARTERY STENOSIS BY PWV

When the PWV more than 7.5m/sec was defined as abnormal, sensitivity, specificity and predictive value to estimate coronary artery stenosis were 83%, 90%, and 93%, respectively (Table).
DISCUSSION

In this study we showed three distinct findings. First, abdominal aortic PWV was faster than thoracic aortic PWV and this indicated that atherosclerosis in abdominal aorta was severer than in thoracic aorta. Second, PWV was well correlated with the independent indeces of aortic distensibility such as Tarazi’s index and DBPD. Third, the progression of aortic atherosclerosis was correlated with the progression of coronary atherosclerosis.

McDonald (5) and Farrar (6) reported independently that PWV became faster along the aorta in dog and monkey, respectively. Lathman (7) reported that in nine healthy subjects, there was no difference in PWV in ascending, thoracic and abdominal aorta and iliac artery. In our study including patients with coronary heart disease, abdominal PWV was faster than thoracic PWV. This finding indicated that abdominal aortic atherosclerosis progressed faster than thoracic aortic atherosclerosis.

PWV was well correlated with the Tarazi’s index and DBPD. Ventura (8) also reported the correlations between PWV, Tarazi’s index and DBPD. These findings suggested that aortic mechanical characteristics in systolic and diastolic phase were changed simultaneously as atherosclerosis progressed. However we should note that these mechanical properties change not only by atherosclerosis but other factors such as blood pressure, calcification, drugs and salt intake (9).

It has been controversial whether there was a correlation between aortic and coronary atherosclerosis. In pathological study, Stenby reported (10) that there was a close relationship between aortic and coronary atherosclerosis. In the present study, we showed that patients with faster PWV (more than 7.5 m/sec) had good chances to have coronary atherosclerosis and all patients whose PWV

Table Relationships between invasive pulse wave velocity and numbers of diseased coronary arteries.

<table>
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<tr>
<th>CAG</th>
<th>0VD</th>
<th>1VD</th>
<th>2VD</th>
<th>3VD</th>
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<tr>
<td>I-PWV</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>13</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>7.5</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>1</td>
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<td>2</td>
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</tr>
<tr>
<td>9</td>
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sclerosis progressed faster than thoracic aortic atherosclerosis.
was more than 10 m/sec had significant coronary stenosis.

In conclusion, there was a significant correlation between PWV and the indices of aortic distensibility.

REFERENCES