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博 士 論 文

Influences of physical activity in stroke patients with hemiplegia on Pulse Wave Velocity

(脳卒中片麻痺患者における身体活動が脈波伝播速度(PWV)に及ぼす影響)

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Influences of physical activity in stroke patients with hemiplegia on Pulse Wave Velocity

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Abstracts:

The objective of this study was three-fold: 1. To measure brachial-ankle PWV (baPWV) in fifteen stroke patients with hemiplegia (9 males and 6 females; 60 ± 10 years old) 2. To examine changes in baPWV due to rehabilitation by physiotherapy; and 3. To evaluate the effects of an increase in physical activities on baPWV.

Bapwv decreased significantly from $1,885 \pm 374$ before rehabilitation to $1,770 \pm 374$ cm/sec after rehabilitation ($p < 0.0005$) on the paralyzed side and from $1,714 \pm 374$ to $1,568 \pm 364$ cm/sec ($p < 0.001$) on the non-paralyzed side. The serum total cholesterol level did not evidence significant change. The FIM, which represents the degree of functional independence, increased significantly from 52 ± 21 to 75 ± 29 ($p < 0.0005$). A significant positive correlation ($r = 0.58$, $p < 0.05$) was observed between Δ FIM and Δ baPWV on the paralyzed side.

In stroke patients with motor disorders due to hemiplegia, baPWV was significantly higher on the paralyzed side than on the non-paralyzed side, suggesting a decrease in the arterial extensibility due to motor paralysis. Furthermore, baPWV was improved by rehabilitation, and this improvement was related to an increase in physical activities. It is hence concluded that baPWV may be considered an effective index of the rehabilitation.

Key Words: Stroke, Pulse Wave Velocity, Physical Activity

1. Introduction

Many patients with stroke such as cerebral infarction and cerebral hemorrhage have hypertension, diabetes mellitus, hyperlipidemia, or risk factors for atherosclerosis due to aging. These patients often show motor disorders due to hemiplegia with a resultant decrease in physical activities. Also, the vascular elasticity of the whole body has been long known to decrease with progression of atherosclerotic disorders or aging.

Recently, a technique for examination of the pulse wave velocity (PWV) by simultaneous sphygmomanometry of the 4 limbs has been developed. This technique has been widely adopted as a clinical index for the assessment of atherosclerosis [1-3]. There have been reports on the effects of long-term training on arterial stiffness based on the measurement of PWV [4-6]. However, according to our review, there has been no report on the assessment of the effect of rehabilitation in stroke

patients with motor paralysis based on the measurement of PWV.

The objective of this study was to measure brachial-ankle PWV (baPWV) in stroke patients with hemiplegia, to examine changes in baPWV due to rehabilitation by physiotherapy, and to evaluate the effects of an increase in physical activities on baPWV.

2. Subjects and methods

The subjects were 15 stroke patients with hemiplegia (9 males and 6 females; 60 ± 10 years old) 27 ± 15 days after the onset of stroke. The diagnosis was cerebral hemorrhage in 9 and cerebral infarction in 6 patients whereas the paralyzed side was the left in 9 patients and the right in 6. Of these patients, 11 were hypertensive, and 5 were diabetic. The subjects were enrolled in the study with informed consent.

Individualized rehabilitation programs were carried out in these patients by physiotherapists for 40 minutes a day, 5 days a week. The mean period of rehabilitation by physiotherapy was 59 ± 32 days.

BaPWV and the difference in the blood pressure between the upper and lower limbs (ankle-brachial index: ABI) were measured before and after this period on the paralyzed and non-paralyzed sides and comparatively analyzed using a formPWV/ABI (Colin Corporation, Komaki, Japan).

The physical activity levels before and after rehabilitation period were also rated according to the functional independence measure (FIM) [7]. The FIM instrument consists of an 18-item, 7-level scale of independent performance in self-care, sphincter control, transfers, locomotion, communication, and social cognition.

To investigate whether changes of the physical activity were related to changes in the PWV, the relationship between the degree of the FIM'S improvement (Δ FIM) and the change in baPWV (Δ baPWV) before and after rehabilitation period was evaluated.

Total-cholesterol concentration was measured using enzymatic, colorimetric tests on the automated analyzer (Hitachi 747, Tokyo, Japan) before and after rehabilitation period. The values obtained were expressed as the mean $\pm$ standard deviation.

The values of baPWV before and after rehabilitation were compared by Wilcoxon's rank sum test,

those on the paralyzed and non-paralyzed sides were compared by Student's t-test, and the relationship between ΔFIM and ΔbaPWV was examined using Pearson's correlation coefficient, all at the $p<0.05$ level of significance.

3. Results

Table 1 outlines the physical characteristics of the subjects pre- and post- rehabilitation and the baPWV and ABI scores in the paralyzed and non-paralyzed sides. BaPWV decreased significantly from $1,885 \pm 374$ before rehabilitation to $1,770 \pm 374$ cm/sec after rehabilitation ($p < 0.0005$) on the paralyzed side and from $1,714 \pm 374$ to $1,568 \pm 364$ cm/sec ($p < 0.001$) on the non-paralyzed side. In addition, baPWV was greater on the paralyzed side than on the non-paralyzed side both before ($p < 0.0001$) and after ($p < 0.001$) rehabilitation. However, no change was observed in the ABI either on the paralyzed or non-paralyzed side. Total serum cholesterol level was 184 ± 33 before compared to 178 ± 38 mg/dl after rehabilitation showing no significant change. The FIM, which represents the degree of functional independence, increased significantly from 52 ± 21 to 75 ± 29 ($p < 0.0005$).

BaPWV on the paralyzed side was $1,907 \pm 437$ cm/sec in the patients with cerebral hemorrhage and $1,852 \pm 290$ cm/sec in those with cerebral infarction indicating no significant difference. Similarly the scores in the non-paralyzed side were $1,716 \pm 427$ and $1,714 \pm 317$ cm/sec, respectively.

Table 1 The values of pulse wave velocity (PWV) and ankle-brachial index (ABI) on the paralyzed and non-paralyzed sides and the physical characteristic of the stroke patients with hemiplegia

	Before	After
baPWV on paralyzed side (cm/sec)	1885 ± 374 #	1700 ± 374 *, #
baPWV on non-paralyzed side (cm/sec)	1714 ± 374	1568 ± 364 **
ABI on paralyzed side	1.09 ± 0.08	1.04 ± 0.09
ABI on non-paralyzed side	1.07 ± 0.08	1.03 ± 0.1
Complications		
Hypertension	11/15	-
Diabetes mellitus	5/15	-
Total Cholesterol(mg/dl)	184 ± 33	178 ± 38
FIM motor score	52 ± 21	75 ± 28 *

PWV :Pulse wave velocity ; Before vs After. ABI : Ankle-brachial index ; * $p < 0.001$

FIM : Functional independence measure ; Paralyzed side vs non-paralyzed side # $p < 0.0001$

** $p < 0.001$.

Figure 1 shows the effect of an increase in physical activities after rehabilitation by physiotherapy on baPWV. A significant positive correlation ($r=0.58$, $p<0.05$) was observed between Δ FIM and Δ baPWV on the paralyzed side.

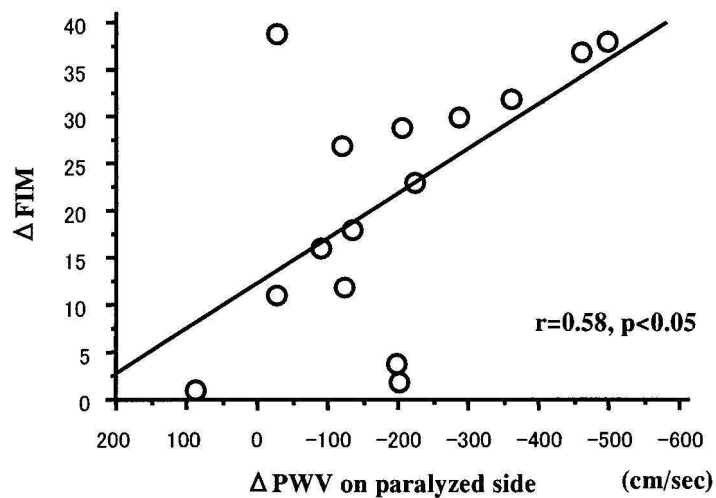


Figure 1 The relationships between the recovery of physical activity and the changes of pulse wave velocity (PWV)

4. Discussion

In stroke patients with hemiplegia, a decrease in the quantity of daily physical activities is considered to be a factor of deterioration of fitness. Thus it is important to maintain and promote the remaining motor functions by rehabilitation [8-9]. Miyachi et al [10] reported that the regular aerobic exercise prevents age-associated increases in arterial stiffness, and relieves increased arterial stiffness in middle-aged and aged individuals with no history of regular exercise.

PWV, calculated non-invasively and easily from the results of simultaneous sphygmomanometry in 4 limbs, is the velocity of transmission of pulses produced by ejection of blood from the heart through the blood vessels. Since it reflects the degree of hardening of the arterial wall, it is widely used as a clinical index.

In this study, we measured baPWV in stroke patients with hemiplegia, examined the effects of

rehabilitation by physiotherapy according to its changes, and evaluated the effect of an increase in physical activities on baPWV.

Yoshimoto [11] reported that baPWV was significantly higher in a group with cerebrovascular disorders than in a group with no cerebrovascular disorders. According to our results, baPWV was higher in stroke patients with hemiplegia before rehabilitation by physiotherapy, but it did not differ between those with cerebral hemorrhage and those with cerebral infarction. Also, it was noteworthy that baPWV was significantly higher on the paralyzed side than on the non-paralyzed side and that it decreased significantly on both sides after rehabilitation.

These results suggest an improvement in arterial stiffness in stroke patients with hemiplegia as an effect of rehabilitation by physiotherapy. Since no change was observed in the serum total cholesterol level between before and after rehabilitation, an increase in physical activities is

considered to be a cause of this effect. Arai [12] studied PWV in those who underwent health screening and reported that it was increased more markedly in those who had no habit of regular exercise and in whom the daily physical activity level was low. Also, Kakiyama et al. [13] reported results of measurement of PWV suggesting improvements in arterial stiffness due to training in middle-aged and aged individuals who continued low-intensity training on a bicycle ergometer for 3 years.

In this study, we evaluated the effect of an increase in physical activities after rehabilitation by physiotherapy on baPWV in stroke patients with hemiplegia. The significant positive correlation between Δ FIM and Δ baPWV observed in this study is considered to suggest a close relationship between an increase in physical activities and an improvement in baPWV. However, the number of patients examined in this study was small, and the goal of rehabilitation attained by physiotherapy

varied widely from the wheelchair level to the ambulatory level. The severity of motor paralysis and physical activity level were also diverse. Further evaluation of the effects of exercise intervention adjusted to the level of motor paralysis and the relationship between exercise loading and systemic endurance capacity is considered necessary.

5. Conclusions

In stroke patients with motor disorders due to hemiplegia, baPWV was significantly higher on the paralyzed side than on the non-paralyzed side, suggesting a decrease in the arterial extensibility due to motor paralysis. Additionally baPWV was improved by rehabilitation and this improvement was related to an increase in physical activities. Therefore we suggest that baPWV should serve as an index of the rehabilitation effect.

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