Effects of Mental Stress on Peripheral Circulation Evaluated by Accelerated Plethysmogram

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Abstract

The effects of mental stress on peripheral circulation evaluated by accelerated plethysmogram were studied in 12 healthy male subjects. Pulse rate, APG index, and the ratios of wave height (b/a, c/a, and d/a) were examined before and during mental arithmetic.

1) Pulse rate increased significantly from 64.8±14.8 beats/min before mental arithmetic to 73.1±18.9 beats/min during mental arithmetic (P=0.006).
2) The APG index decreased significantly from 88.8±20.5 before mental arithmetic to 64.4±27.5 during mental arithmetic (P=0.011).
3) The d/a decreased significantly from -13.6±17.4 before mental arithmetic to -22.0±14.5 during mental arithmetic (P=0.011). The b/a and c/a did not change significantly.

These data suggest that we need to be attentive to the mental state of subjects when APG is measured.

I Introduction

Accelerated plethysmogram (APG) is obtained by differentiating digital plethysmogram wave twice. Sano et al.[6] attempted to evaluate peripheral hemodynamics by measuring the APG. They classified APG waveforms into seven types and calculated APG index based on the properties of inflexion point. They investigated its relationship to age, blood pressure, diseases, and physical training[7]. The results showed that APG could serve as an indicator to assess the effectiveness of medical check-ups and physical therapy. We also previously measured APG and confirmed improvements in peripheral hemodynamics after physical or dietary therapy[3,4].

In addition, measurement of fingertip pulse plethysmography is influenced by the mental state. Takemiya et al.[8] reported the influences of mental arithmetic on circulation using a differential digital plethysmogram (△DPG). Their results showed the decreaseof △DPG-P wave amplitude evoked by mental arithmetic. However, there were no reports that examined the influence of mental arithmetic on peripheral circulation evaluated by APG.

The purpose of this study is to examine the effects of mental stress on peripheral circulation evaluated by an accelerated plethysmogram.

II Methods

In this study, 12 male subjects participated, aged 18 to 23 years old. Table 1 shows the physical characteristics of subjects.

Peripheral hemodynamics was assessed by placing Blood Circulation Checker (Future Wave Inc., BC-001) at the tip of the right index finger more than two hours after a meal at room temperature (24-25°C). Each subject was instructed to sit in a chair and maintain the measurement site (finger tip) at the level of the heart. APG index were calculated using the following formula (Fig. 1)[7]:

Table 1. Physical characteristics of subjects.

	Mean	SD	Min	Max
Age (years old)	20.3	1.5	18	23
Height (cm)	171.9	6.4	160.0	180.0
Weight (kg)	62.4	6.5	52.2	74.0
% body fat (%)	10.3	3.1	5.3	14.9

$$X = -b + c + d$$

The wave height of an inflexion point "a", from the base line, was set at 100, and the relative wave height of the other inflexion points "b", "c" and "d" was calculated. APG index were calculated by determining the mean value of five measurements.

Subjects carried out mental arithmetic without speaking for about one minute.

Statistical analysis was perfrmed using SPSS 10.0J for Windows. Analysis of the difference between rates, before and during mental arithmetic, used a paired t-test. A significant standard was set at 5%.

III Results

Pulse rate increased significantly from 64.8±14.8 beats/min before mental arithmetic to 73.1±18.9 beats/min during mental arithmetic ($p=0.006$). The APG index decreased significantly from 88.8±20.5 before mental arithmetic to 64.4±27.5 during mental arithmetic ($p=0.011$). The d/a decreased significantly from -13.6±17.4 before mental arithmetic to -22.0±14.5 during mental arithmetic ($p=0.011$). The b/a and c/a did not change significantly.

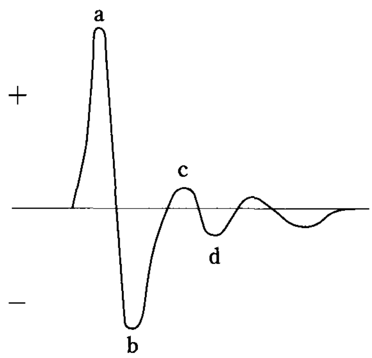

Fig. 1 Inflexion points a, b, c and d of APG.

Table 2. Changes in pulse rate and APG before and during mental arithmetic.

	Before mental arithmetic	During mental arithmetic
Pulse rate (beats/min)	64.8±14.8	73.1±18.9**
APG Index	88.8±20.1	64.4±27.5*
b/a (%)	-95.7±12.3	-86.5±11.3
c/a (%)	4.3±12.2	0.1±15.1
d/a (%)	-13.6±17.4	-22.0±14.5*

* : p<0.05, ** : p<0.01 (Mean±SD)

Ⅳ Discussion

The APG wave patterns were considered to reflect basic changes in the arterial wall such as arteriosclerosis due to aging, wall tension, intravascular pressure, and the state of myocardial contraction. Arteriosclerosis of arterioles and larger and more elastic arteries seem to be the main causative factor for changes in APG pattern influence on *b/a*. On the other hand, the wall stress of vessels have an influence on the *d/a* ratio[9].

In this study, the *d/a* decreased significantly during mental arithmetic. Significant changes were not observed in *b/a* and *c/a* during mental arithmetic. Therefore a decrease in the value of the APG index depends on a decrease of d/a.

The reason for this was an increase in the wall stress of vessels caused by mental arithmetic. The rise in the pulse rate that was observed in this study was influenced by sympathetic nerves that were exerted in the cardiovascular system. The d/a was influenced by the wall stress of vessels. It seems reasonable to conclude from these data that the decrease in d/a can be derived from the increasing influence of vasoconstriction via sympathetic nerve activity. Therefore we need to be careful of the mental state of subjects when APG is being measured.

On the other hand, significant changes were not observed in b/a and c/a. Arteriosclerosis of arterioles and larger arteries seem to be the main causative factor for changes in APG pattern influence on b/a[9]. The c/a receives an influence from aging[2,5,7]. Because subjects were young male students in this study, an influence from arteriosclerosis was not observed.

Homma et al.[1] investigated the influence on APG by restricting the inflow of blood using a cuff. In this study, we were not carrying out the measurement of blood pressure of subjects at the same time as the measurement of APG. The reason is because simultaneous measurement of blood pressure exerts an influence on blood flow. When such an experiment is designed, we need to examine simultaneous measurement of APG and blood pressure.

In conclusion, these data suggest that we need to be attentive to the mental state of subjects when APG is measured.

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