Response to Psychological Test in Elderly Patients with Hand-Arm Vibration Syndrome and Healthy Controls

Md. Shawkatuzzaman LASKAR1*, Mieko IWAMOTO1, Junko YONEDA2, Hazuki YAMAUCHI2, Toshihiro FUKUDA2, Minoru NAKAMOTO1 and Noriaki HARADA1

1 Department of Hygiene, Yamaguchi University School of Medicine, Ube 755, Japan
2 Yamaguchi University School of Allied Health Sciences, Ube 755, Japan

Received May 12, 1997 and accepted July 7, 1997

Abstract: We investigated the parasympathetic nervous response to psychological test using heart rate variation (HRV) during deep breathing in elderly patients with hand-arm vibration syndrome and healthy controls. Average age (SD) of 16 patients with vibration-induced white finger (VWF), 13 patients without VWF and 12 healthy controls was 60.1 (2.8), 60.6 (4.2) and 58.8 (3.8), respectively. After an initial supine rest for 40 min, psychological test (Stroop color word test and mirror drawing test) was performed for 20 min. The indexes of HRV (Mean R-R, SD, RMSSD and CV) were calculated. Blood pressure and heart rate were also measured. The indexes of HRV did not differ between the groups before exposure. The SD, RMSSD and CV of the patients without VWF during supine deep breathing after 3 min post-exposure supine rest were significantly lower than those of the control group (p<0.05). The Mean R-R of the patients without VWF significantly increased (p<0.05). Blood pressure did not differ in either before or after exposure measurements. The results suggest that the post-exposure response of the parasympathetic nervous system to psychological test reduced in the patients without VWF.

Key words: Hand-arm vibration syndrome, Psychological test, Parasympathetic response

It has been suggested that exposure to hand-arm vibration might affect autonomic nervous functions and has been demonstrated on the basis of subjective symptoms complained with higher prevalence rates by patients with hand-arm vibration syndrome than healthy controls1,2. In clinical neurology the responses of cardiovascular reflexes have been used to examine the function of the autonomic nervous system3-4. It has been accepted that respiratory sinus arrhythmia in supine deep breathing is vagally mediated, and variation of heart rate parameters due to respiratory arrhythmia is considered as an indicator of the parasympathetic nervous function5-6.

In this study, we examined a group of elderly patients with hand-arm vibration syndrome and healthy controls to evaluate the parasympathetic nervous activity using heart rate variation. Because the heart rate variation decreases with increasing age7, we manipulated levels of cardiac sympathetic and parasympathetic activity of the subjects exposing them to psychological test and measured R-R intervals in supine deep breathing before exposure and after 3 min post-exposure supine rest. Blood pressure and heart rate were also measured.

We studied 41 male subjects. Sixteen of them with age-range 55 to 66 (60.1 ± 2.8) years, were workers exposed to vibration and experienced attacks of vibration-induced white finger during the past year (VWF(+) group), 13 with age-range 54 to 65 (60.6 ± 4.2) years, were workers exposed to vibration but did not experience attacks of vibration-induced white finger (VWF(-) group) and 12 healthy workers with age-range 51 to 61 (58.8 ± 4.0) years, were examined as a
control group. The patients had been under treatment for hand-arm vibration syndrome. The average years (SD) exposed to vibration in patient groups were 21.6 (8.1) and 18.1 (8.2), respectively. Four subjects in the control group had the experience of vibration exposure; however, the average hours of operation per year were less than 100 hr. The subjects refrained from caffeine and tobacco during the experimental session, and abstained from any medication for at least 24 hr before the experiment.

After explanation of the experimental session, informed consent paper was signed by every subject. After setting of electrodes for electrocardiograph (ECG) measurement, the subjects were instructed to begin a 40-min resting baseline period, followed by a 20-min psychological tests performance period as shown in Figure 1. The psychological tests, modified Stroop color word test (CWT) for 10 min and mirror drawing test (MDT) for 8 min, were performed in sitting position. The experiment room temperature was maintained at 25 ± 1°C.

CWT consisted of four color words (red, blue, green and yellow), randomly projected in the center of the computer screen (NEC PC-9801DX) in a color print other than the color name. The color words were appeared in incongruent colors and the subjects were asked to identify the color they saw and to disregard the appeared word. The responses were to be given by depressing one of four microswitches on the keyboard with an incongruent color name gumtaped on it (i.e., on the microswitch for the color blue, the word blue was written in the color red).

For MDT, different kinds of figures with approximately 7 mm wide outline were reflected from the floor of the apparatus by a vertical mirror. Direct vision of the figures was masked by a horizontal shield. The task was to trace the figures as quickly and accurately as possible with a color pencil while looking only at the mirror reflections.

The R-R interval was measured by ECG in supine deep breathing for two min of regular inspiration and expiration in five second intervals (6 cycles a minute) before exposure and after 3 min post-exposure supine rest. The ECG signal was recorded and stored on FM tape by a data recorder (TEAC R-61) and was played back and fed into a microcomputer (NEC PC-9801D) with an analog to digital converter with the frequency of sampling 250 Hz and then processed on a microcomputer (NEC PC-9821 V12). The traditional indexes of HRV\(^8\) such as mean length of R-R interval (Mean R-R), SD, root mean square of R-R interval differences (RMSSD) and CV were calculated. Automated noninvasive blood pressure and heart rate determinations were made before and immediately after exposure to psychological test in sitting position using a digital device for blood pressure and heart rate measurements (CRITIKON DINAMAP\(^TM\)).

Student t-test was used to test intergroup differences. Comparison of parameter measures within the individual group before and after psychological test exposure was performed by paired t-test. \(P<0.05\) was considered to indicate a significant difference.

Table 1 shows the variations in heart rate (Mean R-R, SD, RMSSD and CV). The CV is obtained by dividing the standard deviation by the mean value. The indexes of HRV did not statistically differ between the patients with VWF, the patients without VWF, and the controls during supine deep breathing before exposure. However, the SD, RMSSD and CV of the patient groups tended to be smaller than those of the controls. The SD, RMSSD and CV of the patients without VWF during supine deep breathing after 3 min post-exposure supine rest were significantly lower than those of the controls (Student t-test, \(p<0.05\)). On the other hand, the values of the patients with VWF were larger than those of the controls; however, the differences were not significant. The Mean R-R interval of the patients without VWF during supine deep breathing after 3 min post-exposure supine rest was significantly larger than the value of the same group before exposure (paired t-test, \(p<0.05\)).

Table 2 shows the before exposure cardiovascular measurements and the responses to psychological test. Blood pressure values did not statistically differ among the patients with VWF, the patients without VWF, and the controls in either before or after exposure measurements. The heart rate of the patients with VWF significantly increased immediately after exposure (paired t-test, \(p<0.05\)).

There was no difference among the three groups in age and between the two patient groups in exposure time to vibration. The localized subjective symptoms, such as numbness, cold-feeling and joint pain in the upper limbs, and the subjective symptoms not localized in the upper limbs, such as head-heaviness, insomnia, and forgetfulness, were highly prevalent in the two patient groups than in the control.
group; however, there was no significant difference between the patients with VWF and the patients without VWF in prevalence of these symptoms.

The HRV during a deep breathing test is associated with the activity of the parasympathetic nervous system and is decreased in autonomic neuropathies9). During respiration the heart rate rises during inspiration and begins to fall at the end of it and during expiration10). Respiratory sinus arrhythmia is mediated by the parasympathetic nervous system which is strongly affected by age11). In this study, we used six cycles a minute (five seconds in and five seconds out) for deep breathing, which are considered to be most suitable6), because deep breathing or breathing at slow rates (6/min) in the supine position increases variation due to respiratory parasympathetic input. Coefficient of variation values obtained in supine resting position has been regarded as an indicator of the parasympathetic nervous activity12). The variability in heart rate has been widely used to evaluate the function of the autonomic nervous system in diabetic patients3, 4,13).

The indexes of HRV (Mean R-R, SD, RMSSD and CV) did not statistically differ between the patients with VWF, the patients without VWF, and the controls during supine deep breathing before exposure. The Mean R-R of the patients without VWF during supine deep breathing after 3 min post-exposure supine rest was significantly larger than the value of the same group before exposure. This finding indicates the reactive bradycardia in the patients without VWF. The SD, RMSSD and CV of the patients without VWF during supine deep breathing after 3 min post-exposure supine rest were significantly lower than those of the control group which indicate reduced response of the parasympathetic nervous system in the patients without VWF. On the other hand, the indexes of HRV of the patients with VWF during supine deep breathing after 3 min post-exposure supine rest tended to be larger than those of the control group and heart rate of the patients with VWF significantly increased after exposure; however, blood pressure values did not statistically differ among the patients with VWF, the patients without VWF, and the controls in either before or after exposure measurements. The R-R interval of the patients with VWF did not increase during supine deep breathing after 3 min post-exposure supine rest. Thus, the presence of extensive sympathetic influence due to exposure to psychological test may be excluded in this study.

Harada et al.14) have observed similar finding that the CV during deep breathing was smallest in the younger subgroup of the patients with VWF followed by the patients without

### Table 1. Variations in heart rate during supine deep breathing before and after post-exposure supine rest

<table>
<thead>
<tr>
<th>Subjects</th>
<th>No</th>
<th>Mean R-R (ms)</th>
<th>Standard deviation (ms)</th>
<th>RMSSD (ms)</th>
<th>Coefficient of variation (%)</th>
<th>Mean R-R (ms)</th>
<th>Standard deviation (ms)</th>
<th>RMSSD (ms)</th>
<th>Coefficient of variation (%)</th>
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</thead>
<tbody>
<tr>
<td>VWF(+) group</td>
<td>16</td>
<td>951 ± 152</td>
<td>46.1 ± 21.5</td>
<td>28.5 ± 14.8</td>
<td>4.9 ± 2.3</td>
<td>955 ± 143</td>
<td>50.8 ± 17.6</td>
<td>33.9 ± 15.1</td>
<td>5.4 ± 2.1</td>
</tr>
<tr>
<td>VWF(−) group</td>
<td>13</td>
<td>858 ± 81</td>
<td>40.6 ± 19.5</td>
<td>27.4 ± 18.6</td>
<td>4.8 ± 2.4</td>
<td>881 ± 85*</td>
<td>33.8 ± 12.2*</td>
<td>19.1 ± 7.7*</td>
<td>3.9 ± 1.5*</td>
</tr>
<tr>
<td>Control group</td>
<td>12</td>
<td>920 ± 136</td>
<td>53.5 ± 22.3</td>
<td>30.4 ± 20.8</td>
<td>5.8 ± 2.1</td>
<td>931 ± 154</td>
<td>48.7 ± 17.6</td>
<td>27.4 ± 11.3</td>
<td>5.3 ± 1.8</td>
</tr>
</tbody>
</table>

All data were expressed as mean ± SD. *: p<0.05, significant as compared with control group by using Student t-test. #: p<0.05, significant as compared with before exposure value of the same group by using paired t-test. RMSSD, root mean square of R-R interval differences; ms, millisecond.

### Table 2. Before exposure cardiovascular measurements and responses to psychological test

<table>
<thead>
<tr>
<th>Subjects</th>
<th>No</th>
<th>Systolic blood pressure (mmHg)</th>
<th>Diastolic blood pressure (mmHg)</th>
<th>Heart rate (beats/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Before test</td>
<td>After test</td>
<td>Before test</td>
</tr>
<tr>
<td>VWF(+) group</td>
<td>16</td>
<td>141.4 ± 21.1</td>
<td>145.8 ± 17.7</td>
<td>84.0 ± 12.9</td>
</tr>
<tr>
<td>VWF(−) group</td>
<td>13</td>
<td>141.7 ± 20.0</td>
<td>147.3 ± 17.8</td>
<td>89.0 ± 9.1</td>
</tr>
<tr>
<td>Control group</td>
<td>12</td>
<td>145.2 ± 18.3</td>
<td>145.7 ± 17.3</td>
<td>89.0 ± 9.8</td>
</tr>
</tbody>
</table>

All data were expressed as mean ± SD. *: p<0.05, significant as compared with before exposure value of the same group by using paired t-test.
VWF when compared with the control subgroup; however, the CV of the elder subgroup of the patients with VWF was not smaller than that of the control subgroup but the CV of the patients without VWF was smaller with statistically significance. Virokannas reported a comparison made of the patients with VWF under and over 45 years of age with the controls during quiet breathing test where the response of the autonomic nervous system tended to reduce in the group at the age of under 45 years.

The present results therefore suggest that the post-exposure response of the parasympathetic nervous system to psychological test might be reduced in the patients with hand-arm vibration syndrome but without VWF. At the present time, we can not explain the reason why we could not get similar results in the patients with VWF. We consider that there may be several limitations in this study, such as (i) respiratory sinus arrhythmia is strongly affected by age; (ii) indicators, used to evaluate the autonomic nervous function, were not so suitable; (iii) we could not evaluate the sympathetic nervous system activity because we did not have measurements during exposure period and (iv) it is difficult to control respiratory rate during exposure to psychological test. Further studies with modified methodological approach are appreciated to clarify why the responsibility of the patients with VWF is different from that of the patients without VWF.

References