SPECIFIC FEATURES OF VIBRATION-INDUCED DISORDERS

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ABSTRACT
AIM: Assessment of the specific clinical manifestations of hand-arm vibration syndrome (HAVS) or whole-body vibration syndrome (WBVS).

PATIENTS AND METHODS: Seventy-six patients (34 with HAVS and 33 with WBVS) were examined analysing the data from their medical history, clinical examinations and autonomic nervous system study, capillaroscopy, distal Doppler ultrasound study, vibrotactile sense, roentgenography, and electromyography.

RESULTS: HAVS manifests mainly in the upper limbs as microcirculatory disturbances: RR 2.59; 95% CI (1.64 - 4.10), Raynaud’s syndrome: RR 16.50; 95% CI (2.33 - 117.04), increased vascular resistance in the digital arteries of the hands: RR 9.71; 95% CI (3.28 - 28.75); distal autonomic neuropathy of the upper limbs: RR 15.04; 95% CI (3.91 - 57.88); sensory polyneuropathy predominantly of the upper limbs: RR 21.00; 95% CI (3.01 - 146.57); median neuropathy: RR 2.09; 95% CI (1.33 - 3.28). In patients with WBVS we observed predominantly degenerative changes of the lumbar spine segment: RR 2.49; 95% CI (1.55 - 3.99); lumbosacral radicular symptoms: RR 8.53; 95% CI (3.73 - 19.52).

CONCLUSION: Dose-dependant, microcirculatory, peripheral vascular, peripheral nerve and musculoskeletal disorders of the upper limbs were found in HAVS and musculoskeletal and peripheral nerve injuries of the spine and the lower limbs were found in WBVS.

Key words: hand-arm vibration syndrome, whole-body vibration syndrome, clinical characteristics

INTRODUCTION
Occupational exposure to vibrations induces a wide spectrum of pathological vascular, neural and musculoskeletal alterations described as vibration disease caused by local and/or whole-body vibration impact. The internationally recognised terms are hand-arm vibration syndrome and whole-body vibration syndrome.1-4 Currently, the universally accepted “gold standard” for diagnosing and determining the disease stage is the Stockholm scale5, which is a subjective measure and registers only the anamnestic data from the patient6. Assessment based only on this scale does not take into account possible dissimulation and aggravation, and therefore there is a great potential for mistakes concerning the precise defining and staging of the disease.

The largest number of cases of occupational diseases by the end of 2007 in Bulgaria was registered in Plovdiv region - 5848, with vibration-induced and related to physical overload pathology being among the leading elements in the structure of occupational diseases.7

The aim of the present study was to perform comparative analysis and assessment of the clinical manifestations of hand-arm vibration syndrome (HAVS) or whole-body vibration syndrome (WBVS) in order to define its specific characteristics.

PATIENTS AND METHODS
Seventy-six patients, treated in the Department of Occupational Diseases between 2004 and 2009, were investigated. They were allocated to 2 groups: group I was of 34 patients with hand-arm vibration syndrome, and group II - 33 patients with whole-body vibration syndrome. The analyzed data included disease history, physical examination, data from the clinical studies of the autonomic nervous system and the neurovascular reactivity, including cold provocation test, thermistor thermometry, capillaroscopy, distal Doppler ultrasound study, roentgenography and electroneurography. The results were analyzed with the software package EPIINFO using Student-Fisher t-test and assessment of relative risk (RR) with a level of statistical significance $p < 0.05$. 
RESULTS

The first group of patients with hand-arm vibration syndrome included 34 men with mean length of service 13 ± 7 yrs and mean age 51 ± 13 yrs. The second group included 33 patients (11 females and 22 males) with whole-body vibration syndrome (mean age 53 ± 5 yrs, length of service 17 ± 7 yrs). The patients exposed to local vibrations were miners, chain-saw woodcutters, rotary hammer workers, and turners. The group of patients exposed to whole-body vibrations included truck drivers, dumper drivers, tractor drivers, excavator operators, skid steer operators, crane operators, and bulldozer operators.

Complaints of patients with hand-arm vibration syndrome were predominantly localized in the upper limbs. Symptoms related to peripheral nerve damage like tingling, formication, burning sensation in the hands, sweating or dryness of the palms and the fingers, pain in the hands, forearms and arms, the neck and between the scapulae, trophic changes of the skin and the neck and between the scapulae, trophic changes of the skin and the fingers, especially following exposure to cold, tingling of the fingers - 94% (32 patients). The musculoskeletal disturbances presented with pain and weakness in the fingers, wrists, forearms, elbows, shoulders, humero-cervical regions in 70.59% (24 patients).

The characteristic clinical alterations in hand-arm vibration syndrome and whole-body vibration syndrome are presented on Table 1. There was a statistically significant increase in the frequency of finger paleness, paresthesias and pain syndrome in the upper limbs with the increase of length of service, and respectively, with increased exposure to vibrations (p < 0.05.).

Concomitant low back pain syndromes were found in 15% of vibration disease patients.

Statistically significant increase of relative risk of the following alterations was found in the patients with hand-arm vibration syndrome: microcirculatory disturbances in the upper limbs: RR 2.59; 95% CI (1.64 - 4.10), Raynaud’s syndrome with finger paleness and cyanosis: RR 16.50; 95% CI (2.33 - 117.04), peripheral vascular disturbances with increased vascular resistance, predominantly in the digital arteries of the hands found on Doppler sonography: RR 9.71; 95% CI (3.28 - 28.75), distal autonomic neuropathy of the upper limbs: RR 15.04; 95% CI (3.91 - 57.88), predominantly sensorypolyneuropathy of the upper limbs: RR 21.00; 95% CI (3.01 - 146.57), neuropathy of the median nerve, resulting mainly from carpal tunnel syndrome, confirmed by electromyography: RR 14.56; 95% CI (2.04 - 104.06), cervical spondylosis with or without osteochondrosis established on roentgenography: RR 2.09; 95% CI (1.33 - 3.28).

In group II, the predominant alterations included low back pain syndromes (97%) with secondary peripheral nerves symptoms of damage of lumbar sacral spinal cord roots, presented predominantly as excitatory and deficit sensory and autonomic, and more rarely as motor and reflex disturbances in the lower limbs. These facts determine also the more pronounced subjective data of low back pain and leg pain with tingling. In many patients there were pain syndromes in the upper section of the spine (64%) with cervical radicular syndromes presenting with pain, tingling of the upper limbs, changes in palmar and finger skin colour and sweating.

A statistically significant increase of relative risk of the following alterations was found in the WBVS patients: degenerative alterations of the lumbar spine: RR 2.49; 95% CI (1.55 - 3.99), lumbar sacral radicular syndromes: RR 8.53; 95% CI (3.73 - 19.52).

Palesthesiometry data show severe or moderate decrease in vibrotactile perception in the fingers in 100% (n = 34) of the patients with HAVS, and predominantly moderate and mild in vibrotactile perception in 96.97% (n = 32) of WBVS patients. The vibrotactile sense is significantly associated with the levels of cumulative exposure to vibration impact in work environment.

DISCUSSION

Local vibration impact is related to paresthesias, stiffness, decreased hand muscle strength, disturbed manipulative dexterity. T. Kákosy et al. describe the following disturbances in patients with HAVS: vascular in 90%, affecting peripheral nerves in 51%, Raynaud’s syndrome in 33%, X-ray alterations in 37%, carpal tunnel syndrome in 85%, ulnar neuropathy in 4%. R. Sauni et al. describe Raynaud’s syndrome in 49%, sensory disturbances in 66%, carpal tunnel syndrome with median neuropathy in 56%, musculoskeletal injuries in 75% of the patients with hand-arm vibration syndrome and statistically significant dose-dependence on vibration exposure. Our data confirm the findings of other authors of leading microcirculatory and peripheral nerve and musculoskeletal clinical manifestations in the upper...
Specific Features of Vibration-Induced Disorders

M. Hirata and Н. Sakakibara describe significantly slowed sensory nerve conductivity in the distal parts of the upper limbs due to focal neuropathy of the fingers, the carpal tunnel, Guyon’s channel in 53% of the patients. Our studies found electromyographic data for upper limb neuropathy in 50% of the patients. These data determine the necessity of investigation of upper limb peripheral nerve conductivity in cases of hand-arm vibration syndrome. The cold provocation test is a valuable objective tool for monitoring of vibration induced neurovascular disturbances with dose-effect relation between the cold-provoked vasomotor response and the cumulative vibration exposure. Thermistor thermometry of the limbs, combined with distal Doppler sonography and cold provocation test correlate significantly with each other and with the stage of vibration disease, making their application for objective assessment of autonomic neurovascular injuries in vibration disease appropriate.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Syndromes</th>
<th>Hand-arm vibration syndrome n = 34</th>
<th>Whole-body vibration syndrome n = 33</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>n (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Microcirculatory</td>
<td>32 (94.12)</td>
<td>12 (36.37)</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Raynaud’s</td>
<td>17 (50)</td>
<td>1 (3.03)</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Peripheral vascular</td>
<td>30 (88.23)</td>
<td>3 (9.09)</td>
<td>0.0001</td>
<td></td>
</tr>
<tr>
<td>Distal autonomic neuropathy of:</td>
<td>- Upper limbs</td>
<td>31 (91.18)</td>
<td>2 (6.06)</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>- Lower limbs</td>
<td>5 (14.71)</td>
<td>13 (39.39)</td>
<td>0.02</td>
</tr>
<tr>
<td>Polynural sensory syndrome in:</td>
<td>- Upper limbs</td>
<td>28 (84.85)</td>
<td>3.03 (1)</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>- Lower limbs</td>
<td>1 (2.94)</td>
<td>9.09 (3)</td>
<td>N.S.</td>
</tr>
<tr>
<td>Neuropathy of:</td>
<td>n. medianus</td>
<td>15 (44.12)</td>
<td>1 (3.03)</td>
<td>0.0001</td>
</tr>
<tr>
<td></td>
<td>n. ulnaris</td>
<td>2 (5.88)</td>
<td>1 (3.03)</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>n. peroneus/tibialis</td>
<td>4 (2.94)</td>
<td>6 (18.18)</td>
<td>N.S.</td>
</tr>
<tr>
<td>Radicular syndrome:</td>
<td>- cervical</td>
<td>27 (79.41)</td>
<td>21 (63.64)</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>- lumbosacral</td>
<td>5 (14.71)</td>
<td>22 (62.97)</td>
<td>0.0001</td>
</tr>
<tr>
<td>Musculoskeletal:</td>
<td>Humeral epicondylitis</td>
<td>24 (70.59)</td>
<td>30 (90.91)</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>Humero-scapular periarthritis</td>
<td>9 (26.47)</td>
<td>3 (9.09)</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>Cubital joint arthrosis</td>
<td>6 (17.65)</td>
<td>1 (3.03)</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>Spondylosis and/or osteochondrosis:</td>
<td>3 (8.82)</td>
<td>-</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>- cervical</td>
<td>28 (82.35)</td>
<td>13 (39.39)</td>
<td>0.001</td>
</tr>
<tr>
<td></td>
<td>- lumbosacral or spinal disc herniation</td>
<td>12 (35.29)</td>
<td>29 (87.88)</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>Interphalangial joints arthrosis</td>
<td>1 (2.94)</td>
<td>-</td>
<td>N.S.</td>
</tr>
<tr>
<td></td>
<td>Focal osteoporosis</td>
<td>4 (2.94)</td>
<td>-</td>
<td>N.S.</td>
</tr>
</tbody>
</table>

N.S. – P > 0.05.

limbs significantly associated with the exposure to local vibrations.

M. Hirata and H. Sakakibara describe significantly slowed sensory nerve conductivity in the distal parts of the upper limbs due to focal neuropathy of the fingers, the carpal tunnel, Guyon’s channel in 53% of the patients. Our studies found electromyographic data for upper limb neuropathy in 50% of the patients. These data determine the necessity of investigation of upper limb peripheral nerve conductivity in cases of hand-arm vibration syndrome. The cold provocation test is a valuable objective tool for monitoring of vibration induced neurovascular disturbances with dose-effect relation between the cold-provoked vasomotor response and the cumulative vibration exposure. Thermistor thermometry of the limbs, combined with distal Doppler sonography and cold provocation test correlate significantly with each other and with the stage of vibration disease, making their application for objective assessment of autonomic neurovascular injuries in vibration disease appropriate.

C. Aström et al. determine significant correlation between whole-body vibrations exposure and the increased risk for musculoskeletal alterations in the neck, the shoulders and the wrists similar to those caused by local vibration impact as well as dependence on the cumulative time of exposure. Whole-body vibration syndrome determines increased risk of low back pain syndromes with
secondary peripheral nerve disturbances in the lower limbs. The pathologic findings in drivers included predominantly alterations in the spine, but also in the hands and wrists. Our investigation found increased risk of musculoskeletal abnormalities in the lumbosacral part of the spine with secondary sensory nerve alterations in the lower limbs, significantly associated with the whole-body vibration impact, and possible synergic effect of static physical load and unfavourable microclimate.

Palpatesthesiometry is a valuable method for objective assessment of alterations in deep sensitivity in vibration disease. Vibrotactile sense is associated with the levels of cumulative exposure to local and whole-body vibration impact.

The risk from manifestation of the described typical clinical signs increases with the increase in the cumulative vibration dose.

Integrated assessment with a complex of laboratory methods is needed for the diagnosis and determination of the stage of vibration disease. Vibration disease lowers the quality of life of the patients.

CONCLUSIONS

We found a dose-dependent correlation between the cumulative duration of the vibration impact and the sensory neural disturbances, peripheral neuropathies in the limbs and musculoskeletal injuries of the upper limbs and the neck has been found in the investigated patients. Local vibrations cause peripheral vascular, microcirculatory, peripheral nerve and musculoskeletal injuries in the upper limbs, and whole-body vibrations - primarily musculoskeletal and peripheral nerve injuries of the spine and the lower limbs. Longer service and higher daily vibration exposure are associated with more pronounced clinical manifestations and pathological alterations of the nervous, vascular and musculoskeletal systems. The applied complex of diagnostic methods significantly contributes to the objective assessment of the pathological alterations. The application of a complex of laboratory methods to diagnose and make an integral evaluation, in order to stage the vibration disease, is appropriate.

REFERENCES


ХАРАКТЕРНЫЕ ОСОБЕННОСТИ ВИБРАЦИОННО ОБУСЛОВЛЕННОЙ ПАТОЛОГИИ

3. Стойнева, С. Дерменджиев

РЕЗЮМЕ

ЦЕЛЬ: Оценить характерные клинические проявления при вибрационной болезни вследствие локального воздействия (ВБЛВ) или общего вибрационного воздействия (ВБОВ).

МАТЕРИАЛ И МЕТОДИКА: Анализированы аномальные данные, объективный клинический статус, исследования автономной нервной системы, капилляроскопия, дистальная доплеровская сонография, виброощущение, рентгенография, электроневрография у 76 больных (34 с ВБЛВ и 33 с ВБОВ).

РЕЗУЛЬТАТЫ: Проявления при ВБЛВ наблюдается преимущественно в верхних конечностях: микроциркуляторные нарушения RR 2.59; 95% CI (1.64 - 4.10); синдром Райнауд - RR 16.50; 95% CI (2.33 - 117.04); повышенное сосудистое сопротивление в дистальных артериях рук - RR 9.71; 95% CI (3.28 - 28.75); дистальная автономная невропатия в верхних конечностях - RR 15.04; 95% CI (3.91 - 57.88); преимущественно сенсорная полиневропатия в верхних конечностях - RR 21.00; 95% CI (3.01 - 146.57); невропатия н. medianus - RR 14.56; 95% CI (2.04 - 104.06); цервикальный спондилез с/без остеохондроза - RR 2.09; 95% CI (1.33 - 3.28).

У больных с ВБОВ преобладают дегенеративные изменения поясничного отдела позвоночника - RR 2.49; 95% CI (1.55 - 3.99); люмбосакральные радикулярные синдромы - RR 8.53; 95% CI (3.73 - 19.52).

ЗАКЛЮЧЕНИЕ: Устанавливаются дозозависимые микроциркуляторные, перифернососудистые, периферонервные и мышечнокостные нарушения в верхних конечностях у больных с ВБЛВ и мышечноскелетные и периферонервные повреждения в позвоночнике и в нижних конечностях у больных с ВБОВ.