THE EFFECT OF NOXIOUS IN CHEMICAL INDUSTRY ON THE RADIAL NERVE IN EXPOSED WORKERS

Jovica Jovanović, Milan Jovanović and Mirjana Arandjelović

The aim of this paper is the analysis of electroneurographic and neurological findings at workers in chemical industry. An analysis of the working conditions in the cartridge and drying sections of paint and lacquer industry has shown an above permitted level of white spirit and toluene. The exposed group comprised 55 workers occupationally exposed to these noxae, whilst the control group included 35 workers who had never been exposed to the same agents. The exposed workers more frequently complained of numbness of the arm and leg, cramps in the shoulder and knee, and weakness in the arm and leg than did the control workers. The electromyoneurographic examination of the radial nerve showed that a decrease in motor and sensitive conduction velocity was more significant in the exposed group compared to the control. The reduction in motor and sensitive conduction velocity was in correlation with the length of exposure to the noxae. Terminal latency of the radial nerve was significantly longer in the exposed group compared to the control, with an increase proportional to the exposure length. The exposed workers had a significantly longer time of response to acoustic and visual stimuli. The results of the study suggest neurotoxic effects of the noxae detected in the cartridge and drying sections of paint and lacquer industry. Acta Medica Medianae 2003; 42 (3): 9-13.

Key words: chemical noxiousness, organic solvents, radial nerve, electroneurographic examinations, chemical industry

Institute of Occupational Health, Faculty of Medicine, University, Nis

Correspondence to: Jovica Jovanovic
Institute of Occupational Health
Vojislava Ilica bb, 18000 Nis, Serbia and Montenegro
E-mail: joca@medfak.ni.ac.yu

Introduction

The most common presented noxiousness in chemical industry are the mixture of organic solvents. Organic solvents are chemically heterogeneous compounds that all share the property of dissolving fats, oils, resin, cellulose acetate and cellulas nitrate. This common feature makes them widely used in industry, in particular in paint and lacquer production, manufacture of pesticides, plastics, explosives, rubber, cellulose, and air conditioners, as well as in pharmaceutical and leather industry (1,2).

The advent of industry has increased the need for different solvents. While only a few organic solvents were used at the turn of the last century, their number has today increased to several hundreds. Although the primary concern about their usage used to be related to their causing fire and explosion, their toxicological properties have to be considered as well. The most important toxicological properties of organic solvents are their ability to evaporate and to dissolve fats (1,2,3). By dissolving fats, organic solvents can damage haemato-poetic tissue, the reproductive system, the nervous system, skin and all parenchimatous organs rich in fats (4—11). Having the property to evaporate, they more rapidly contaminate the working environment and, if inhaled, may lead to the poisoning of exposed workers. A danger to health becomes greater and the problem of protection more complex when, in an effort to meet specific production requirements, various mixtures of organic solvents have to be used.

Aim

The aim of this study was to analyze the working environment and occupational hazards in the cartridge and drying sections of paint and lacquer factory, and to assess the effects of prolonged exposure to organic solvent mixtures upon the peripheral nervous system in exposed workers.

Subjects and methods

The analysis of the working conditions, the examination of technological work process and the assessment of physical and chemical factors in the cartridge and drying sections of paint and lacquer industry were done. The concentration of harmful chemical substances was determined by the methods of titration, spectrophotometry and nephelometry.
The study included 90 workers divided into two groups. The exposed group comprised 55 workers engaged in the cartridge and drying sections of paint and lacquer industry. The control comprised 35 workers with no contact with harmful chemical noxae at their workplaces. The examination of the workers included clinical examination (work, personal and family anamnesis, symptoms and physical signs), neurological examination and psychological evaluation. The electromyoneurographic examination was performed in the standard way using two-channel Dantec cantata 2000 with superficial skin electrodes in order to determine:

1. Sensitive conduction velocity of radial nerve,
2. Motor conduction velocity of radial nerve,
3. Terminal latency of radial nerve.

Response time to light and sound was measured by a psychologist using Denitron PM 95 reactiometer. The statistical analysis of the obtained data involved the calculation of the arithmetic mean and standard deviation and the tests of statistical significance and differences.

Results

The analysis of the working conditions in the cartridge and drying sections of paint and lacquer industry suggests the presence of organic solvents (white spirit and toluene) that is above the maximum allowed value (table 1). The exposed and control group were of similar structure with respect to age, length of employment, smoking habits and alcohol intake (table 2 and table 3). The analysis of the electromyoneurographic findings on the radial nerve in both the exposed and control group revealed that reduction in motor and sensitive conduction velocity was more statistically significant in the exposed workers compared to controls (table 4). By analyzing the values of motor conduction velocity on the radial nerve in the exposed group relative to the length of occupational exposure to organic solvents, it was established that longer exposure at workplaces leads to a proportional and statistically significant reduction in conduction velocity (table 5). Sensitive conduction velocity of the radial nerve in the exposed group reduces concomitant with an increase in the length of employment (table 6). Terminal latency increased in parallel with the length of employment, marking the most remarkable increase in the subgroups of workers with the length of occupational exposure over 20 years (table 7). The exposed workers more frequently complained of numbness of the arm and leg, cramps in the shoulder and knee, weakness in the arm and leg than did controls (table 8). A high degree of correlation was found in the exposed group between the symptoms and the results of electromyoneurographic findings \((p<0.01)\) (table 9). Response time to acoustic and visual stimuli was significantly longer in the workers from the exposed group compared to the workers from control \((p<0.05)\) (table 10).

### Table 1. Results of chemical noxae measurement

<table>
<thead>
<tr>
<th>Chemical noxae</th>
<th>Exposed group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>White spirit mg/m³</td>
<td>389.1±9.3</td>
<td>457.1±9.7</td>
</tr>
<tr>
<td>Toluene mg/m³</td>
<td>294.7±10.9</td>
<td>455.8±7.8</td>
</tr>
<tr>
<td>Butyl acetate mg/m³</td>
<td>3838±118</td>
<td>3800±118</td>
</tr>
<tr>
<td>Xylene mg/m³</td>
<td>300</td>
<td>375</td>
</tr>
<tr>
<td>Ethyl acetate mg/m³</td>
<td>750</td>
<td>435</td>
</tr>
</tbody>
</table>

### Table 2. Age and length of employment in the exposed and control group

<table>
<thead>
<tr>
<th></th>
<th>Exposed group</th>
<th>Control group</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=55</td>
<td>N=35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean age</td>
<td>51.3</td>
<td>51.9</td>
<td>n.s.</td>
</tr>
<tr>
<td>Length of employment</td>
<td>20.8</td>
<td>21.3</td>
<td>n.s.</td>
</tr>
<tr>
<td>Length of exposure to organic solvents</td>
<td>15.4</td>
<td>6.4</td>
<td>n.s.</td>
</tr>
</tbody>
</table>

n.s.- non significant difference

### Table 3. Alcohol intake and smoking habits in the exposed and control group

<table>
<thead>
<tr>
<th></th>
<th>Exposed group</th>
<th>Control group</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>N=55 (100%)</td>
<td>N=35(100%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number</td>
<td>%</td>
<td>Number</td>
<td>%</td>
</tr>
<tr>
<td>Smokers</td>
<td>34</td>
<td>61.8</td>
<td>22</td>
</tr>
<tr>
<td>Regular alcohol consumers</td>
<td>13</td>
<td>23.6</td>
<td>8</td>
</tr>
<tr>
<td>Occasional alcohol consumers</td>
<td>42</td>
<td>76.4</td>
<td>27</td>
</tr>
</tbody>
</table>

n.s.- non significant difference

### Table 4. Electromyoneurographic findings on the radial nerve in the exposed and control group

<table>
<thead>
<tr>
<th>Conduction velocity</th>
<th>Exposed group N=55</th>
<th>Control group N=35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motor conduction velocity (m/s)</td>
<td>49.9**</td>
<td>2.9</td>
</tr>
<tr>
<td>Terminal latency (msec)</td>
<td>0.2</td>
<td>3.1</td>
</tr>
<tr>
<td>Sensitive conduction velocity (m/s)</td>
<td>51.6**</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Statistical comparisons between the exposed and control group

\*p<0.05  
\**p<0.01  
\***p<0.001
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Table 5. Motor conduction velocity of the radial nerve in the exposed group relative to the length of occupational exposure

<table>
<thead>
<tr>
<th>Length of occupational exposure (years)</th>
<th>Number</th>
<th>X(m/s)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9</td>
<td>13</td>
<td>54.9</td>
<td>3.2</td>
</tr>
<tr>
<td>10-19</td>
<td>15</td>
<td>51.1*</td>
<td>2.4</td>
</tr>
<tr>
<td>20-29</td>
<td>15</td>
<td>49.9*</td>
<td>2.5</td>
</tr>
<tr>
<td>30-40</td>
<td>12</td>
<td>43.2**</td>
<td>3.1</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>49.9**</td>
<td>2.9</td>
</tr>
</tbody>
</table>

Statistical comparisons relative to the 0-9 year exposed subgroup
* p<0.05  
** p<0.01  
*** p<0.001

Table 6. Sensitive conduction velocity of the radial nerve in the exposed group relative to the length of employment

<table>
<thead>
<tr>
<th>Length of occupational exposure (years)</th>
<th>Number</th>
<th>X(m/s)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9</td>
<td>13</td>
<td>56.4</td>
<td>2.9</td>
</tr>
<tr>
<td>10-19</td>
<td>15</td>
<td>52.1*</td>
<td>3.2</td>
</tr>
<tr>
<td>20-29</td>
<td>15</td>
<td>51.2*</td>
<td>2.7</td>
</tr>
<tr>
<td>30-40</td>
<td>12</td>
<td>46.1**</td>
<td>2.4</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>51.6**</td>
<td>3.1</td>
</tr>
</tbody>
</table>

Statistical comparisons relative to the 0-9 year exposed subgroup
* p<0.05  
** p<0.01  
*** p<0.001

Table 7. Terminal latency of the radial nerve in the exposed group relative to the length of employment

<table>
<thead>
<tr>
<th>Length of occupational exposure (years)</th>
<th>Number</th>
<th>X(m/s)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-9</td>
<td>13</td>
<td>3.2</td>
<td>0.1</td>
</tr>
<tr>
<td>10-19</td>
<td>15</td>
<td>3.5*</td>
<td>0.2</td>
</tr>
<tr>
<td>20-29</td>
<td>15</td>
<td>3.9**</td>
<td>0.2</td>
</tr>
<tr>
<td>30-40</td>
<td>12</td>
<td>4.1**</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td>55</td>
<td>3.7**</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Statistical comparisons relative to the 0-9 year exposed subgroup
* p<0.05  
** p<0.01  
*** p<0.001

Discussion

Exposure to organic solvents is a daily experience for a great many workers. Although chemically heterogeneous, these compounds are often discussed as a group because of their similar toxicological effects and a high frequency of exposure to their various combinations (12,13).

Exposure to high concentrations of solvent vapors results in acute narcosis, whilst lower levels may lead to transient intoxication syndrome similar to that seen with ethanol consumption (5,7,9,14).

Organic solvent syndrome is the mildest form of the chronic effect marked by symptoms of irritability, fatigue and reversible difficulty to concentrate. Workers exposed to solvents may exhibit numerous syndromes, depending on the intensity and duration of exposure and ranging from a mild decrease in nerve conduction velocity to neuro-and encephalopathy. Epidemiological studies have frequently shown a decrease in response time, dexterity, speed and memory and abnormalities in peripheral nervous system function in workers with prolonged solvent exposure (3, 6,7,8,15).

Professional risk evaluation was performed according to the environmental monitoring results (toluene, xylene, white-spirit, ethyl-acetate, butyl-acetate, acetone) where the concentrations of toluene and white-spirit were above maximal permitted threshold, by clinical and by electromyoneurographic investigation. There is statistically significant frequency of preclinical sensitive and sensomotory nerve damage and the prolongation of terminal latencies.
Our study has shown that toxic damage of neu-
ronic transmission is a consequence of sensor motor
toxic peripheral polyneuropathy. These results are in
accordance with the results of other authors (1, 2, 5, 9,
10, 15, 16).

Two basic forms of damage to peripheral nerves
have been identified as responsible for the peripheral
neuropathies associated with occupational exposure to
organic solvents. Segmental demyelination results
from primary destruction of the neuronal myelin she-
ath, with the relative sparing of the axons. This process
begins at the nodes of Ranvier and results in the slo-
wing of nerve conduction. Axonal degeneration is
associated with metabolic derangement of the entire
neuron and is manifest in degeneration of the distal
portion of the nerve fiber. Myelin sheath degeneration
may occur secondarily. This form of axonal dege-
neration was originally described as “dying back” neu-
ropathy. In many instances, axonal degeneration and
segmental demyelination may coexist, presumably due
to the secondary effects derived from damage to each
system (1, 17). The clinical manifestations of neuro-
pathy in exposed individuals may represent a com-
bination of both pathologic processes (2, 17, 18).

Electrophysiological tests that assess peripheral
nerves, including electromyogram and nerve conduction
measurements, are important tools in assessing
the extent and severity of neurological disorders in
workers exposed to industrial organic solvents. These
techniques are often useful in the evaluation of indi-
vidual patients. These studies have given a particular
contribution to early detection of subclinic lesions of
the peripheral nervous system, which is of great value
given that the nervous system has a limited capacity for
regeneration.

Our study has revealed a statistically significant re-
duction in sensitive and motor conduction velocity of
significantly reduced in conduction velocity of motor and
sensitive nerves in relation to the control group
(3, 5, 6, 8, 16). A statistically significant difference has been
found between the groups that are moderately and highly
exposed to mixtures of organic solvents with respect to
degree of conduction velocity reduction (2, 4, 9).

The initial manifestations of these disorders in-
clude intermittent numbness and tingling in the hand
and foot and motor weakness in the foot or hand. Exten-
sor muscle groups usually manifest weakness before
flexors do (3, 18).

In our study, the most frequent symptoms that
appear in the exposed workers include numbness, cramps
and weakness in the arm and leg. These symptoms
occur in 63.6 % workers exposed to organic solvents.
Other authors record even a higher percentage of sym-
ptoms (1, 2, 19). A statistically significant difference
in the occurrence of symptoms typical of peripheral
neuropathy is noticed in painters exposed to mixtures of
organic solvents (20, 21, 22). These symptoms may be
early indicators of the peripheral nervous system’s
chronic exposure to organic solvents. Development of
these symptoms is usually insidious. A very slow de-
velopment of numbness and tingling of the fingers and
toes occurs within several weeks and may be followed
by motor weakness (1, 2, 23, 24).

Prevention of occupationally induced neurological
disorders can be accomplished through workplace
medical and environmental control programs. The goal of
environmental control is to reduce concentrations of
organic solvents in the working environment by various
measures. Medical strategies designed to reduce neu-
rological morbidity include preemployment or pre-
placement evaluation and periodic medical monitoring.
The goal of preemployment or preplacement evaluation
pertaining to neurological disorders is to avoid the
placement of individuals with a preexisting disease at jobs
with exposure that might exacerbate these conditions.

Conclusion

The monitoring of the working environment in
the cartridge and drying sections of paint and lacquer
industry has revealed the presence of toluene and white
spirit above the allowed values. By the analysis of the
symptoms and results of clinical and electromyoneu-
rographic examination, the presence of neurotoxic
effects of these agents in the working environment has
been discovered. The former results of neuropsychol-
ogical examination in workers exposed to chemical
noxiousness indicate the incidence of toxic neuro-
pathies of sensory-motor type predominancy, with
symmetrical involvement of distal ends of the longest
nerves or prolonged terminal latencies with the de-
crease of nerve conduction velocity.

The results suggest an urgent need for preventive
measures that would protect the health of exposed
workers.

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UTICAJ ŠTETNOSTI U HEMIJSKOJ INDUSTRIJI NA RADIALNI NERV EKSPONOVANIH RADNIKA

Jovica Jovanović, Milan Jovanović i Mirjana Arandelović

Cilj rada je analiza elektromioneurografskih i neuroloških nalaza kod radnika hemijske industrije. Analizom uslovaradne sredine u pogonima šaržiranja i odležavanja industrije boja i lakova utvrđeno je prisustvo vajtšpirita i toluena iznad dozvoljenih vrednosti.

Eksponovane grupu je činilo 55 radnika profesionalno eksponovani ovim noksama, dok je u kontrolnoj grupi bilo 35 radnika koji nikada u svom radnom veku nisu bilo izloženi hemijskim noksama.

Radnici eksponovanih grupa su se češće žalili na trnjenje ruku i noge grčeve u ramenima i kolenima i slabost u nogama i rukama u odnosu na radnike kontrolne grupe. Elektroneurografski nalaz na radijalnom nervu pokazao je znatno manje brzine motorne i senzitivne pro-

vodiivosti u eksponovanoj u odnosu na kontrolnu grupu. Registrovano je smanjenje ovih brzina sa dužinom ekspozicije noksama na radnom mestu. Terminalna latenca na n. radijalisu je stu-

atistički značajno veća u eksponovanoj u odnosu na kontrolnu grupu, pri čemu njena vrednost u eksponovanoj grupi raste sa dužinom eksponovanog radnog staža. Radnici eksponovane grupe su imali statistički značajno duže vreme reakcije na akustičku i vizuelnu draž u odnosu na radnike kontrolne grupe. Rezultati ovog rada ukazuju na neurotoksične efekte noks registrowanih u ovoj industriji.

Ključne reči: hemijske noks, organski rastvarači, n. radijalis, elektroneurografski i spi-

tivanje, hemijska industrija