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

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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, elecroneurographic examinations, chemical industry

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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 cellulae 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 haematopoetic 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 l).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

	Chemical noxae				
	White spirit mg/m³	Toluene mg/m³	Butyl acetate mg/m³	Xylene mg/m³	Ethyl acetate mg/m³
Measured	389.1+9.3	457.1±9.7	294.7±10.9	455.8±7.8	383.8+.11.8
Allowed	300	375	750	435	1400

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

	Exposed group N=55		Control group N=35		P
	X	SD	X	SD	
Mean age	51.3	8.1	51.9	9.4	n.s.
Length of employment	20.8	7.2	21.3	8.7	n.s.
Length of exposure to organic solvents	15.4	6.4	-	-	-

n.s.-non significant difference

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

	Exposed group N=55 (100%)		Control group N=35(100%)		P
	Number	%	Number	%	
Smokers	34	61.8	22	62.8	n.s.
Regular alcohol consumers	13	23.6	8	22.9	n.s.
Occasional alcohol consumers	42	76.4	27	77.1	n.s.

n.s.- non significant difference

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

Conduction velocity	Exposed group N=55		Control group N=35	
	X	SD	X	SD
Motor conduction velocity (m/s)	49 9**	2.9	54.3	3.2
Terminal latency (msec)	a 7***	0.2	3.1	0.1
Sensitive conduction velocity (m/s)	51.6**	3.1	57.9	3.4

Statistical comparisons between the exposed and control group

*p<0.05

**p<0.01

***p<0.001

Table 5. Motor conduction velocity of the radial nerve in the exposed group relative to the length of occupational exposure

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

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

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

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

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

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).

Table 8. Symptoms in the exposed and control workers

	Exposed group N=55		Control group N=35		p
	Number	%	Number	%	
Numbness of the arm and leg	16	29.1	1	2.9	<0.05
Cramps in the shoulder and knee	10	18.2	1	2.9	<0.05
Weakness in the ann and leg	9	16.4	1	2.9	<0.01
Without symptoms	20	36.4	32	91.4	<0.01

Table 9. Correlation between symptoms and electromyoneurographic findings in the exposed group

Symptoms	Electromyoneurographic findings			
	Positive		Negative	
	Number	%	Number	%
Present	30	85.7	5	14.3
Absent	1	5.0	19	95.0

Table 10. Response time to acoustic and visual stimuli in the exposed and control group

Response time	Exposed group		Control group	
	X (sec)	SD	X (sec)	SD
Acoustic stimulus	0.19**	0.02	0.16	0.01
Visual stimulus	0.25**	0.03	0.21	0.02

Statistical comparisons between the exposed and control group
*p<0.05

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 neuronic 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 sheath, with the relative sparing of the axons. This process begins at the nodes of Ranvier and results in the slowing 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 degeneration was originally described as "dying back" neuropathy. 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 neuropathy in exposed individuals may represent a combination 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 individual 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 reduction in sensitive and motor conduction velocity of thnificant reduction 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 include intermittent numbness and tingling in the hand and foot and motor weakness in the foot or hand. Extensor 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 symptoms (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 development 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 neurological morbidity include preemployment or preplacement 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 electromyoneurographic examination, the presence of neurotoxic effects of these agents in the working environment has been discovered. The former results of neuropsychological examination in workers exposed to chemical noxiousness indicate the incidence of toxic neuropathies of sensory-motor type predominantly, with symmetrical involvement of distal ends of the longest nerves or prolonged terminal latencies with the decrease 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 RADIJALNI NERV EKSPONOVANIH RADNIKA

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

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

Radnici eksponovanih grupa su se češće žalili na trnjenje ruku i nogu 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 provodljivosti 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 statistički značajno vec'a u eksponovanoj u odnosu na kontrolnu grupu, pri čennu 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 noksi registrovanih u ovoj industriji. *Acta Medica Medianae 2003; 42 (3): 9-13.*

Ključne reči: *hemijske nokse, organski rastvarači, n. radijalis, elekrroneurografsko i.spitivanje, hemijska industrija*