ABSTRACT

Chronic neurotoxicity of lead is a major problem in all countries around the world. Long-term exposure to lead in the environment has recently become of interest as a possible risk factor for cognitive impairment in the involved workers. The consequences for the brain after cessation of the exposure are also subject to research.

Our study aimed at investigating and analyzing the cognitive impairment in workers in professional contact with lead.

Seventy-two men in chronic professional contact with lead aerosols were examined. They were aged 39.4 ± 10.4 (19 - 58) years, their average duration of service was 13.0 ± 8.7 (1 - 33) years, and the mean blood lead concentration was 43.4 ± 9.0 µg/dl. The screening set included a subjective cognitive impairment questionnaire, a depression scale, a set of cognitive tests (MMSE, IST, DRT, CDT), and a scale for activities of daily living (4-IADL Score).

With the increase of blood lead levels, a statistically reliable trend was observed for decrease of MMSE, IST and CDT scores. Mild cognitive impairment manifesting with disturbance of construction praxis, planning, short-term memory and concentration could probably be related to the toxic effects of lead.

Keywords: blood lead level, professional exposure to lead, cognitive impairment

INTRODUCTION

In recent years, there has been a number of publications discussing the cumulative lead (Pb) dose and the concentration of lead in blood. Data on the relationship with cognitive disturbances are also available. Nevertheless, the threshold for adverse effects on human health and the role of lifetime exposure as a factor for chronic disease are yet to be clarified [1]. The association between lead concentration in blood and cognitive functioning is considered more apparent in professional groups with high lead exposure, but the relationship between bone lead levels and the decline in cognitive function is stronger in studies of older individuals with lower blood lead concentration [2, 3, 4].

The recommendation of the World Health Organization for adults is to maintain the blood lead concentration below 10 µg/dL. Some studies demonstrated cognitive impairment in workers with blood lead concentration of 20-40 µg/dL. There is no “safe” threshold, but blood lead levels below 5 µg/dL are known not to increase short- and long-term risk and to require no further management [5]. Nevertheless, even a low level of lead may have a negative impact on cognitive function. Long-term cumulative lead exposure may be associated with faster cognitive decline and with accelerated cognitive aging [6-11]. A decrease of Mini-Mental State Exam (MMSE) score <24 with increase of the levels of lead in blood and patella has been reported. High levels of lead in the patella may correspond to approximately 5 years of aging relative to the baseline MMSE score [12]. Low-level cumulative exposure to lead may adversely the visuospatial/visuomotor domain of cognition [13]. Cognitive impairment in chronic lead exposure may be regarded as a subclinical symptom of CNS damage.

MMSE is a well-known neuropsychological instrument [14]. If used for screening, a combined administration with other tests is recommended in order to increase the sensitivity and reliability of the study. The Clock Drawing Test (CDT) [15] is considered suitable for the purpose.

The aim of the present study is to assess cognitive impairment in workers in professional contact with lead.

PATIENTS AND METHODS:

For the purpose of the study, 72 workers in chronic
professional contact with lead aerosols were examined. They had an average age of 39.4 ± 10.4 (19 - 58) years, an average length of service of 13.0 ± 8.7 (1 - 33) years, and mean lead concentration in blood of 43.4 ± 9.0 µg/dl.

The surveyed workers were divided into four age groups: up to 30 years, 30 to 40 years; 40 to 50 years, and over 50 years.

According to the duration of the exposure, the persons were divided into five groups: up to 5 years - 17 subjects; up to 10 years - 12; up to 15 years - 13; up to 20 years. – 17, and over 20 years - 13.

They were also grouped according to blood lead levels: below 40 µg/dl; 40-50 µg/dl; 50-60 µg/dl; 60-70 µg/dl, and above 70 µg/dl.

History of harmful habits, accompanying diseases and memory disorders was taken.

Neuropsychological testing was performed in all subjects. The Mini-Mental State Examination (MMSE), Isaacs Set Test (IST), Digit Repetition Test (DRT) and Clock Drawing Test (CDT) were applied. The 4-IADL score was used to look for impairment of the activities of daily living. All neuropsychological tests were performed in accordance with generally accepted requirements and rules. The assessment was made in line with the individual condition of the investigated person.

Study data were organized in MS Excel, and SPSS 12 software was used for analysis.

All surveyed persons gave informed consent for the survey.

RESULTS:

Education
Workers with specialized secondary education were predominant (n=24, 33.3%). Those with secondary education were 22 (30.55%), 22 (30.55%) had primary education, and 4 (5.56%) of the surveyed subjects had studied for 7 years.

Medical History
Twenty-four (33.3%) of the workers reported hypertension, 6 (8.33%) - nephrolithiasis, and 1 (1.38%) - diabetes mellitus. Non-smokers were 24 (33.3%) of the surveyed.

Subjective good health was reported by 36 participants (50%), very good - 20 (27.78%), average - 14 (19.45%) and poor – by 2 (2.76) workers.

Questionnaire for subjective cognitive disorders
We conducted a survey of subjective cognitive impairment in all subjects. All respondents answered “No” to the questions asked, i.e. they did not report subjective cognitive impairment.

Mini Mental State Examination (MMSE)
The most common score was 28 points in 22% (n = 16) of subjects, followed by 29 points - 13.89% (n = 10), and 30 points - 11.11% (n = 8). Positively screened persons according to MMSE with less than 24 points were 15.28% (n = 11), and those with less than 27 points were 37.28% (n = 27) (Figure 1).

Fig. 1. Distribution of MMSE results according to the number of persons screened
A statistically significant relationship between the age of the studied subjects and MMSE was found (p = 0.01), as well as between the exposure period and MMSE (p = 0.001). A statistically significant correlation was observed between blood lead levels and MMSE (p = 0.001).

With the increase of lead in blood, MMSE score was decreasing significantly (p = 0.001).

Of the positively screened individuals, 5 (6.95%) had blood lead values from 40 µg/dl to 50 µg/dl. There were no positively screened persons with blood lead concentration below 40 µg/dl.

**Isaacs Set Test for verbal fluency (IST)**

The most common result was 39 points (11.11%, n = 8), followed by 38 in 9.72% (n = 8), and 35 in 9.72% (n = 8) of the surveyed persons. There was a significant correlation between blood lead levels and IST score (p = 0.001).

With the increase of blood lead levels, the achieved IST score was reduced (p = 0.001).

**Digit Repetition Test (DRT)**

The most common result was the maximal – 10 points in 22.22% (n = 16) of the surveyed subjects. There was a significant relationship between blood lead levels and DRT score (p = 0.001). A correlation was found between age and DRT (p = 0.007), as well as between the duration of exposure and DRT (p = 0.027).

With the increase of blood lead levels, DRT score was reduced (p = 0.001).

Seven individuals (9.72%) were positively screened with blood lead concentration between 40 µg/dl and 50 µg/dl.

Eleven screened subjects (15.28%) achieved a score of <7 points, which identified them as positively screened according to DRT (Figure 2).

**Clock Drawing Test (CDT)**

The most common score was 9 points in 27.28% (n = 20) of the surveyed subjects.

With the increase of lead in blood, the achieved CDT score (p = 0.001) was reduced.

Only one positively screened subject had a blood lead concentration below 40 µg/dl, while 11 had concentrations between 40 µg/dl and 50 µg/dl.

Nineteen screened individuals (26.39%) achieved a score of <7, which identified them as positively screened according to CDT (Figure 3).
Fig. 3. Distribution of CDT results according to the number of individuals screened

DISCUSSION:
Mean values of MMSE, IST, DRT and CDT scores show a statistically significant tendency for a decrease with the increase of blood lead concentration.

**MMSE**
The relative share of positive screened persons through MMSE is high (15.28%). The MMSE test includes components which explore different cognitive domains, such as orientation to time and place, memory, attention, calculation, speech, gnosia, and praxis. There is a significant correlation between blood lead levels and MMSE, which coincides with the data of Weisskopf et al. [13].

**IST**
The test characterizes speech output and semantic memory. All patients achieved a score of >20 points which does not classify them as positively screened. This is consistent with literature data. Higher blood lead levels are associated with lower IST score.

**Digit Repetition Test (DRT)**
The test examines primarily short-term memory, concentration, and focusing ability. The data reveal a correlation between age and DRT score, as well as between the duration of the exposure and DRT. Higher blood lead levels are associated with lower DRT score.

**Clock Drawing Test (CDT)**
Nineteen screened persons (26.39%) achieved a score of <7, classifying them as positively screened according to CDT.

The distribution of surveyed workers by age revealed that there were no workers over 60 years of age. Specialized secondary and secondary education were predominant among the surveyed subjects. Advanced age and low level of education below 6 years are risk factors for cognitive impairment, and there are coefficients for correcting the results of cognitive tests accordingly.

CONCLUSIONS:
Our study found a lack of depressive symptoms and subjective cognitive complaints. The assessed persons had no evidence of severe cognitive impairment. Most positively screened subjects were detected using CDT (26.39%), followed by MMSE (15.28%), and DRT (15.28%). The greater part of positively screened workers had blood lead concentration between 40 µg/dl and 50 µg/dl.

Possible mild cognitive impairment manifesting with disturbance of construction praxis, planning, short-term memory and concentration could probably be attributed to the toxic effects of lead and has a potential to be a subclinical marker.

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