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Neurotoxicity of exposures to aluminium welding fumes in the truck trailer construction industry

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Abstract

The aim of the study was to examine aluminium welders for central nervous changes due to the exposure to aluminium containing welding fumes.

A group of 44 aluminium welders in the train body and truck trailer construction industry (mean age: 43 years) with an average of 11.4 years of occupational exposure to aluminium welding fumes and a control group of 37 production workers (mean age: 40 years) of the same plants participated in this longitudinal study. Medical and neuropsychological examinations were performed in 1999 and 2001. Performance was measured with computerised (EURO-NES, motor performance, simple reaction time) and non-computerised test systems (verbal intelligence, standard progressive matrices, trail making, block design) and symptoms with a modified version of the questionnaire Q16. Data was analysed by multivariate analysis of variance including age, education, and alcohol marker as covariates (MANCOVA).

The pre-/postshift average Al-urine concentrations of welders were in the range of 130–153 μg/l. Welders showed significantly poorer performance in symbol-digit substitution, block design, and to some extent in switching attention. However, motor performance and other measures did not differ between welders and controls. Summing up, the results give no clear hints on neurological changes in Al-welders.

Keywords: Aluminium; Welders; Neurotoxicity; Welding fumes; Biomarker; Longitudinal

1. Introduction

Aluminium (Al) can be found in our environment i.e. in drinking water, food and pharmaceuticals. Occupationally, Al is used in the Al powder and metal industry and in Al foundries. At the working place the inhalative absorption dominates. From the lungs, Al is distributed into the whole organism. It is excreted merely by renal elimination. In occupationally exposed persons Al half-times can vary from days to months, depending on the individual duration of the exposure. Certainly, the bioavailability of different types of Al has to be considered (Letzel et al., 1999).

Al exposure in humans was associated with Alzheimer disease (AD) in the 1990's. However, no conclusive evidence was found that Al contributes to the development of AD (Armstrong et al., 1996; Doll, 1993; Savory et al., 1996).

Epidemiological studies conducted in workers occupationally exposed to Al in various industries, found deficits in some cognitive performance tests. However, the intellectual domain mainly affected varied (Rifat et al., 1990; Hosovki et al., 1990; Sjögren et al., 1990; Hänninen et al., 1994; Akila et al., 1999; Sjögren et al., 1990; Bast-Pettersen et al., 2000; Iregren et al., 2001). Altogether in previous studies on occupational exposure to Al, various changes of different intellectual domains are being discussed.

Bast-Pettersen et al. (2000) found better motor performance in aluminium welders compared to construction workers. However, there were significant relations between tremor

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and years of exposure and between reaction time and aluminium in air.

A recent longitudinal study of Al-welders in the automobile industry, found the motoric movement time of exposed workers prolonged compared to controls (Buchta et al., 2003). However, many other neurobehavioral tests failed to show exposure effects.

The actual study was conducted in a cohort from small and medium size companies. The aim was to examine a higher and longer exposed cohort of Al-welders for neurological changes in dispute.

2. Material and methods

2.1. Study design

This longitudinal study is comprised of three examinations of two cohorts, Al-welders and controls. At the present time, the data from the examinations in 1999 and 2001 can be presented (Fig. 1).

2.2. Cohorts

The two groups comprise employees of five German companies in the train body and truck trailer construction industry. In the first examination, 44 male Al-welders and an age and demographically similar control group of 37 non-exposed production workers of the same plants were included in the study. Thirty-three exposed and 26 non-exposed employees of these cohorts (participation rate: 75% for welders, 70% for controls) were examined again in the second examination. Data of 33 welders and 26 controls could be analysed (Table 1).

Inclusion criteria for welders was a minimum of Al welding of 2 years. Neurological diseases not due to the exposure like cerebrovascular diseases, diabetes, head injuries, as well as insufficient knowledge of the German language and exposure to neurotoxic solvents did lead to exclusion from the cohort. By nationality, 86% of the welders and 92% of the controls were Germans. The exposed employees had a mean exposure to welding fumes of 11.4 years.

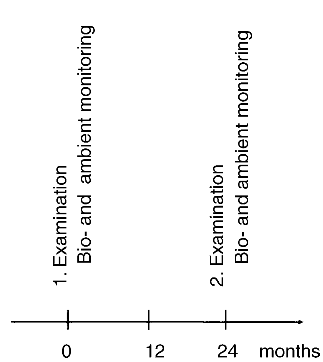

Fig. 1. Design of the longitudinal study on the neurotoxicity of Al-welding fumes.

Table 1
Demographic data of subjects with repeated measurements ($n = 59$)

	Exposed, $n = 33$		Controls, $n = 26$	
	Mean	S.D.	Mean	S.D.
Age (years)	43.3	9.2	39.7	6.6
Education (index)	1.3	0.5	1.2	0.6
CDT (U/l)	5.2	5.9	7.0	10.2
Al-welding (y)	11.4	5.8	–	–

Education index: 0, no elementary school; 1, primary school; 2, secondary school; 3, high school graduation; CDT, carbohydrate-deficient transferrin used as a biomarker for alcohol consumption.

Table 1 shows, that exposed and controls with repeated measurements are largely comparable in age, level of education (four categories: 0–3 and 0, low level), and level of carbohydrate-deficient transferrin in plasma (CDT), which was used as biomarker for alcohol consumption.

The study participants worked either in morning, afternoon or night shift. In order to prevent undue fatigue at the testing in either group, the workers were examined during dayshift between 08:00 and 13:00 h. A precondition was that they had worked on morning or afternoon shift the week before the examination.

2.3. Exposure assessment

We measured individual Al exposure by taking plasma (Al-P) and urinary (Al-U) samples pre and post shift and by personal air sampling for one shift. The monitoring was done close to the day of neurobehavioral testing. Furthermore we applied a questionnaire aimed at documenting the working conditions, working hours, and the individual leisure time exposure. Quantitative determination of Al in plasma and urine samples was carried out by graphite furnace–atomic absorption spectrometry. For calibration, the standard addition technique was used. The determinations were performed under a strict internal and external quality assessment scheme (Lehnert et al., 1999).

2.4. Medical examination

We used a standardised interview focussing on occupational history, education, illnesses, medication, accidents, current alcohol consumption. Furthermore, a physical examination including the neurological status was performed at the testing site.

2.5. Neurobehavioral methods

Neurobehavioral methods were administered to measure possible neurotoxic symptoms, premorbid intelligence, and deficits in the domains of motor performance. The screening was also used to detect differences in logical thinking, short