

OBSERVATIONAL STUDY ON THE ROLE OF INTERRUPTED EXPOSURE IN OCCUPATIONAL LEAD POISONING

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Abstract: Lead poisoning continues to be of interest in current research. In the present study we sought to bring back into focus the importance of stopping exposure to lead poisoning, as a first step in the therapeutic protocol of poisoning. We used the calculation of temporary work disability days and also we analyzed 40 cases of lead poisoning through an observational correlation study including 100 male subjects who worked at least 10 years in a non-ferrous metallurgy, between 1996 -2005. We concluded that the average duration of disruption of lead exposure calculated retrospectively / subject was 33 days, equivalent to half-life of toxic in blood – an important element in toxicokinetics, done by triad „hospitalization-sanatorium recovery-sick leave. Sanatorium recovery played an important role in achieving this goal.

Key-words: lead, saturnism, temporary work disability, recovery.

Abbreviation: temporary work disability (TWD), half-life ($T_{1/2}$), lead (Pb), blood lead level (BLL).

INTRODUCTION

Occupational poisoning with Pb is generated especially by inorganic compounds. Time of exposure until the appearance of poisoning is estimated from 2-3 months to 2-3 years. Pathological picture of Pb poisoning has gradually become less severe and changed progressively in subclinical nonspecific symptoms (Alessio et al., 1999; Crepet et al., 1993). In a classic matter, Pb poisoning is manifested clinically by one or more of the following syndromes: astheno-vegetative syndrome, digestive syndrome, nervous syndrome, pseudo-rheumatoid syndrome, anemia syndrome (Niculescu, 1985; 2003). The followings are described as sequelae of chronic Pb poisoning: chronic saturnine nephropathy (tubulo-interstitial nephropathy, nefrosclerosis), effects on the cardiovascular system (arteriosclerosis, hypertension, coronary disease, myocardium effects), effects on fertility, both in women and in men, teratogenic, mutagenic, carcinogenic effects (Mogos et al., 1988; 1990; Cotrau et al., 1991).

Currently, in some public health books Pb poisoning is systematized as follows:

- Acute poisoning: represented by saturnine colic, complicated with acute renal failure, hypertension, hemolysis, encephalopathy;
- Chronic poisoning: mucous manifestations (Burton's gingival line, Gubler's spots on the oral mucosa), nephropathy, irritability and neurological picture similar to vascular encephalopathy, sensory and motor upper limb polyneuritis, normo- or hypochromic anemia, with or without haemolysis (Flahault et al., 2003).

ATSDR (USA) proposed a classification of signs and symptoms using the severity of Pb toxicity (ATSDR, 1990):

- Mild toxicity: myalgia, paresthesia, fatigue, irritability, drowsiness, occasional abdominal discomfort;
- Moderate toxicity: joint pain, fatigue, dysfunction in concentration, tremble, headache, diffuse abdominal pain, vomiting, weight loss, constipation;
- Severe toxicity: paresis, paralysis, encephalopathy with coma, gingival line, abdominal colic.

Pilat describes the status of „carrier of Pb”, which the period is following discontinuation of contact with the toxic and progressive elimination of metal accumulated in the body during exposure. Return to the physiological state absorption can be affirmed only when Pb returned to physiological values, including urine lead level (Pilat et al., 1966). Increased absorption of Pb is established by laboratory investigations.

US standards require discontinuation of exposure when BLL values > 50µg% (fully paid leave or change employment) till lower values <40µg% (Levin et al., 2000). The following maximum intervals shall be provided for assessing BLL:

BLL values:	Testing interval: (Chief Directorate of Occup. Health and Safety, 2002)
< 20mg %	12 month
20 – 30mg %	6 month
40 – 50mg %	3 month
≥ 60mg %	at medical recommendation

In developed countries, following the introduction of high standards of industrial hygiene, symptomatic Pb poisoning has become extremely rare now. Subject of current scientific concern is the adverse effect of Pb in



the general population and children in particular, which represent the most susceptible category.

MATERIAL AND METHODS

The research was conducted on a sample of 100 subjects, named group of study subjects who are employed in the Sintering Section of the non-ferrous metallurgical company Sometra S.A. Copsa – Mica from Sibiu county. 40 of the 100 subjects were declared with occupational Pb poisoning. This study group has undergone extensive review by a trial-type correlation, held back by a period of 10 years, from 1996 until 2005. We watched some individual characteristics such as number of hospitalizations in Occupational Disease Dept. Of Sibiu County Hospital and their frequency (in subjects with multiple admissions), diagnosis, presence of complications and sequelae of occupational Pb poisoning, associated diseases. Using the occupational Pb poisoning criteria we have divided the whole group into smaller groups, as follows:

- A group comprising subjects who were hospitalized at least once in 10 years in the Occupational Disease Dept. of Sibiu County Hospital (subjects with Pb poisoning or increased Pb absorption);
- A group comprising subjects exposed but “healthy”, which were not hospitalized or diagnosed with the illness in the 10 years that we followed up.

For each year during the period 1996-2005 we quantified the number of healthy subjects, subjects with increased absorption or Pb poisoning and subjects in different stages of saturnism (I, II or III). At the end of this time interval we have compared the two groups (healthy and poisoned subjects).

Selecting criteria for the study subjects were: gender (only male) aged 30 to 40 years, absence of symptoms and clinical signs of disease, history of occupational lead poisoning and the number of admissions for this diagnosis, certified occupational exposure to inorganic Pb (oxide: litharge) in the Sintering section, with a length of exposure in this section at least 10 years.

In order to analyze occupational poisoning cases in different stages (I=reversible; II= forms of acute severe anemia; and III=sequelae), we used:

- data from clinical observation sheets of those subjects who were hospitalized in Sibiu County Hospital during the period 1996-2005;
- computerized data base of occupational medicine Dept. Of the Public Health Directorate of Sibiu county, created by a special dedicated software to monitor the health of employees from Sometra S.A. Copsa Mica (Bardac et al., 1997).

Statistical processing of results was performed with analytical software applications of epi.info program and SPSS.12 (Statistical Package for the Social Sciences), which is software for predictive analysis: regression models, trends, etc... (SPSS, 2005). We have analyzed the following statistical indicators: percentage values, central tendency (mean values), frequency, dispersion (standard deviation, variance, range), distribution, correlation using t test and Levene test for equality of variances.

RESULTS

Pathological picture, over those 10 years, consisted of: 29 admissions for acute forms (saturnine colic), 26 admissions of cases with persistent anemia, complicated cases by the occurrence of sequelae (nephropathy), combination of a neurotic syndrome and hyperuricemia. In the 10 studied years we quantified 81 admissions for occupational Pb poisoning, (72 admissions for poisoning, and nine admissions for increased absorption of Pb).

The 81 admissions totaled up a number of 1948 TWD days (approximately 5 years), which is a significant figure on the need for sick leave interruption exposure.

These admissions included a number of 48 subjects (40 subjects with occupational Pb poisoning, and 8 subjects with increased absorption of Pb). Correlating the number of admissions to the number of subjects shows that some subjects with Pb poisoning (17) were hospitalized several times during 1996-2005. Table 1 represents the weight of subjects classified by frequency of admissions, the number of subjects with a single hospitalization in 10 years being close to the number of subjects with multiple admissions.

Table no. 1

Weight of subjects classified by frequency of Hospital admissions

No of saturnism cases	Frequency of admissions					
	1	2	3	4	5	6
40	23	6	9	1	0	1
Weight of hospitalized subjects	57,5%	15%	22,5%	2,5%	0%	2,5%

Analyzing the situation in terms of number of admissions in the second part of the studied interval (2001-2005), the weight of admissions is 86% compared

with 1996-2000, which is consistent with the exposure lifetime to Pb (Figure 1).

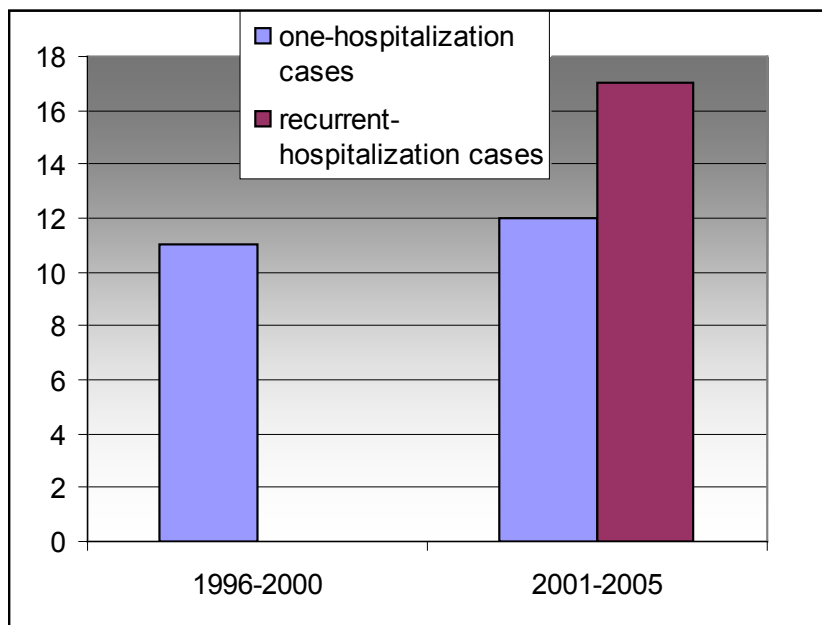


Fig. 1: Distribution of cases with Pb poisoning in the last five years, compared with the first five years of the 1996-2005 interval

In summary, we stated developments in health subjects following the criterion of the presence or absence of occupational Pb poisoning at the end of 1996-2005 interval as follow: - 1996 (first year of the study group exposed to Pb): only one case of poisoning stage I (reversible) and one case with increased uptake of Pb; - end of 2005 (the tenth year of study) revealed that 39 subjects still had contracted Pb poisoning, some with repeated poisoning over the 10 years, others with sequelae (nephropathy), and a number of another 7 subjects were admitted for increased absorption of Pb.

We note that all subjects were exposed to the same concentrations of Pb (significant) in Sintering Section, had wear compulsory full personal protective equipment, were periodically reviewed by medical examinations, and the vast majority of poisoning cases have followed a recovery program in Occupational Diseases Sanatorium of Avrig (55 cases, representing 73% of all cases admitted for illness).

Results are presented in Table 2.

Table no. 2

The main features of the study group during 1996-2005

Total no. of subjects	No of „healthy” subjects	No. of subjects with different saturnism stages (I, II, III):			No. of subjects with increased Pb absorption	No. of hospitalizations	No. of TWD days
		Stage I	Stage II	Stage III			
100	52	17	21	2	8	81	1948
			14 with colic 7 with anemia	Nephropathy		33 with back-sliding	

Therapeutic protocol in cases of occupational poisoning and increased absorption of Pb supposes that, after the admission in the Occupational Diseases Dept. of Sibiu County Hospital, subjects had to follow a rehabilitation program for two weeks at the Sanatorium in Avrig, which

also have the role to extend the period of interruption of Pb exposure. The Sanatorium was closed early 2006, by government decision. Some subjects (particularly those with poisoning relapses) followed several recovery admissions in Avrig, as shown in Table 3.

Table no. 3

Weight of subjects classified by frequency of Sanatorium admissions

No. of subjects	Frequency of Sanatorium admissions			
	1	2	3	4
35	23	5	6	1
Weight	66 %	14 %	17 %	3 %

Among subjects who followed the recovery cure in sanatorium, 30 were poisoned (86%) and five subjects had increased Pb absorption (hospitalized but not reported as occupational disease).

Analysis of the number of TWD days for all cases reveals results expressed in Table 4:

Table no. 4

Distribution of TWD days in the number of hospitalized, sanatorium recovered and sick cases

No. of cases		
Sibiu County Hospital admissions	Sanatorium recovery admissions	Medical certificate for TWD
81	55	41
No. of TWD days (total = 1948)		
711	860	377
No. of TWD days / subject (mean value)		
9	15	9

It appears that the greatest number of TWD days was given for recovery (860 days = 45%, on average 15 days / subject). Through a simple mathematical calculation we

obtained an average of 33 TWD days / subject (9+15+9), in 10 years. Statistical processing of results is presented in Table. 5.

Table no. 5

Statistical analysis comparing the group of healthy subjects (group 1) with the group of hospitalized subjects (group 2)

Variables	groups	average	Standard deviation	p Levene test	p t test
Age	1	36,67	3,37	0,316	0,312
	2	37,08	3,10		
No. of hospitalizations	1	0,00	0,00	0,000	0,000*
	2	1,69	1,09		
No. of hospital days / subject	1	0,00	0,00	0,000	0,000*
	2	14,42	14,33		
Nr. of sick days	1	0,00	0,00	0,000	0,000*
	2	7,48	6,38		
Nr. of recoveries	1	0,00	0,00	0,000	0,000*
	2	1,15	1,03		
Nr. of Sanatorium days	1	0,00	0,00	0,000	0,000*
	2	17,54	15,86		
Nr. of poisoned cases	1	0,00	0,00	0,000	0,000*
	2	1,50	1,24		
Nr. of acute forms (colic)	1	0,00	0,00	0,000	0,001*
	2	0,54	1,01		
Lifetime of work	1	15,92	3,95	0,927	0,823
	2	16,10	4,11		

Group 1 = healthy subjects (N=52)

Group 2 = hospitalized subjects (N=48).

*Statistically significant.

DISCUSSIONS

In human blood half-life of Pb was estimated at 36 days (Rabinowitz, 1991). To better understand the distribution and pharmacokinetics of Pb in the body, Rabinowitz has proposed a three segmental model:

1. blood compartment (with $T_{1/2} = 36$ days);
2. soft tissue compartment (with $T_{1/2} = 40$ days);
3. bone compartment (with $T_{1/2} \gg 27$ years).

O'Flaherty has developed a model for Pb exchange between body compartments (in children and adults). The model includes the Pb circuit from exposure (inhalation or ingestion) to the lungs and gastrointestinal tract, followed by exchanges between blood, liver, kidneys, low perfused tissues, richly perfused tissue, bone compartment and gastric or renal excretion (O'Flaherty, 1993). Regarding Pb toxicokinetics, circulatory compartment holds a crucial role in the development of toxicity (O'Flaherty et al., 1982).

It was estimated that half of the Pb absorbed under conditions of constant exposure is rapidly excreted in about three weeks (Ossian, 2009). In our study, the average of interruption length of exposure for subjects with poisoning was 33 days (hospitalization + recovery + sick leave), which corresponds to $T_{1/2}$ of Pb in blood. Thus, interruption exposure for Pb poisoning is particularly important in the recovery of the individual. Full therapeutic scheme "hospitalization-sanatorium recovery- sick leave" was the best option for normalization of BLL after an episode of intoxication.

The presence of two poisoning cases stage III (nephropathy with chronic renal failure) shows that the range studied (10 years) was too short for the development of renal sequelae. According INRS, chronic renal failure is estimated to install after 10 years of exposure (INRS, 2004). The dominance of poisoning cases with stage II is an indicator of a defective risk management in the investigated company. We believe that significant weight of subjects with multiple admissions for poisoning show a greater susceptibility. We found no statistically significant correlation between frequency of hospitalizations and age or working lifetime of the subjects.

In conclusion, we believe that analysis of the number of TWD days in hospitalized subjects, and also in sanatorium recovery is very important for calculating the length of interruption of Pb exposure / subject, which is at least equal to $T_{1/2}$ of Pb in blood, according to the toxicokinetic model. Recovery in Sanatorium was an effective way to achieve this goal.

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