Kościuk Andrzej, Kos Michał, Drankowska Justyna, Tchórz Michal. Lead poisoning linked to occupational exposure - case reports. Journal of Education, Health and Sport. 2019;9(1):185-190. eISNN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.2546071
http://ojs.ukw.edu.pl/index.php/johs/article/view/6497

The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation. Part B item 1223 (26/01/2017).
1223 Journal of Education, Health and Sport eISSN 2391-8306 7

The authors declare that there is no conflict of interests regarding the publication of this paper.

Received: 03.01.2019. Revised: 11.01.2019. Accepted: 23.01.2019.

Lead poisoning linked to occupational exposure - case reports

Name	Andrzej Kościuk
Affiliation	Research Group in the Department of Toxicology, Medical University of Lublin
Country	Poland
Bio Statement	—

Principal contact for editorial correspondence.

Name	Michał Kos
Affiliation	Research Group in the Department of Toxicology, Medical University of Lublin
Country	Poland
Bio Statement	—
Name	Justyna Drankowska
Affiliation	Research Group in the Department of Toxicology, Medical University of Lublin
Country	Poland
Bio Statement	—
Name	Michal Tchórz
Affiliation	Department of Toxicology, Medical University of Lublin
Country	Poland
Bio Statement	—

Introduction

Lead is one of the first metals widely used by human cultures, with documented use from antiquity [1,2]. Its attributes- ductility, low melting point, and corrosion resistance contributed to its prominent role in various industries and products, including paints, pipes, plastics [1,3] .

The first symptoms of lead poisoning have been described as early as second century B.C., with cases of colic and paralysis following lead intake mentioned by physician from Greece, Nikander. Lead-sweetened wine was a crucial part of Roman elites' diet [4]. Along with water contamination from lead pipes, it caused significant exposure to lead toxicity among Romans [2]. Lead poisoning is, somewhat controversially, posited as an important factor in the decline of Roman Empire [4].

In XIX century, cases of lead poisoning became more recurrent due to rapid industrialisation. In the latter half of the century, this induced some governments, e.g. United Kingdom, to pass first occupational safety laws [5].

At high levels of exposure practically all tissues and organs are damaged, with functions of central nervous system, blood and kidneys especially impaired. Serious poisoning can be deadly. At low levels we observe a range of effects, from disturbance of biochemical processes, the most important being haeme synthesis, to psychological and neurobehavioural dysfunctions [6].

While acute poisoning became relatively rare, at least in countries with appropriate working conditions, low level exposure remains an intensively studied problem, especially in children, in which it can cause neurodevelopmental disorders [7].

Keywords: Lead poisoning, occupational exposure

Case reports

We hereby describe two patients with chronic lead poisoning related to occupational exposure.

A 57-year-old male, exposed to zinc and lead due to his job in zinc industry, was admitted to the hospital for evaluation of suspected lead poisoning. He had the following symptoms during past 12 months: vertigo and dizziness, hot flashes, paresthesia, red skin lesions on forearms. He was also reported to become more aggressive and nervous during this period. Physical examination did not reveal much, except for paresthesia in lower extremities. The MR of the head showed nonspecific demyelination in frontal and parietal lobes of the brain. A comprehensive blood testing was undertaken as well, including complete blood count, an electrolyte panel and glucose level; all results remained within reference range. The lead level in patient's blood was slightly elevated at 5,2 ug/dL. His relatively benign condition on admission precluded the staff from using chelation therapy, and he was treated with 5% glucose solution with an ascorbic acid. After scheduling lead level check- up, the therapy was continued in outpatient clinic.

Another patient, a 30-year-old male, was admitted to the Department of Toxicology and Cardiology due to suspected chronic lead poisoning. He had significant occupational exposure to lead as he repaired lead- acid batteries. For the last 8 months, he experienced recurrent episodes of intensive retrosternal pain, often coupled with painful sensations in epigastric region. He also mentioned nausea, vision impairment, headaches, paresthesia in the left arm and aching knee joints. The blood tests showed a few discrepancies, including slightly elevated level of liver enzymes, heightened CRP, a decreased amount of limphocytes and an increased number of neutrophiles. Blood lead level was elevated at 23,2 ug/dL. Subsequently, the patient underwent multifaceted examination, including neurological and ophthalmologic checkup, gastroscopy, and echocardiography. The investigation revealed slight left ventricular hypertrophy, probably related to hypertension or hypertrophic cardiomiopathy. Meanwhile, the lead level in blood has fallen to 15,52 ug/dL. The patient was discharged from hospital and advised to continue therapy in an outpatient clinic and decrease his lead exposure.

Discussion

Lead toxicity affects nearly every major organ and system of human body, with particularly visible influence on nervous tissue, hematopoiesis, kidneys, cardiovascular and reproductive systems. [1](Table 1) The adults with lead poisoning often present neurological symptoms ranging from lethargy to serious motor neuropathy [8]. Loss of myelin sheath in

peripheral neurons can impair nerve impulses' transmission, which leads to reduced motor activity, resulting in muscle weakness, fatigue and lack of muscles' coordination [9].

Table 1. Symptoms of lead poisoning [1]

length of exposure	typical symptoms
acute poisoning	fatigue, headaches, muscle pain, stomachache, vomiting, seizures, coma
chronic poisoning	persistent emesis, lethargy, encephalopathy, convulsions and coma, delirium

Both of our patients reported to experience moderate neurological symptoms, including headaches and numbness in upper or lower extremities since about a year. The older patient has also developed behavioral issues- he had outbursts of aggression. MRI scan of his head showed demyelination in the brain. The characteristic sign of severe lead poisoning in adults is bilateral wrist drop [8]. This symptom was observed in neither patient as it is usually visible only with much higher blood lead levels than those measured.

On the other hand, children with chronic, low level exposure suffer from central nervous system damage, including developmental disorders leading to intelligence impairment and other CNS dysfunctions [8]. In comparison to healthy children, kids exposed to lead toxicity often show aberrant behaviors, including depressive disorders, social withdrawal and odd body movements, aggressions and propensity to destruction [10].

High level exposure can lead to encephalopathy, with symptomatic irritability, attention deficits, dreariness, headaches, convulsions, memory disorders and hallucinations [3].

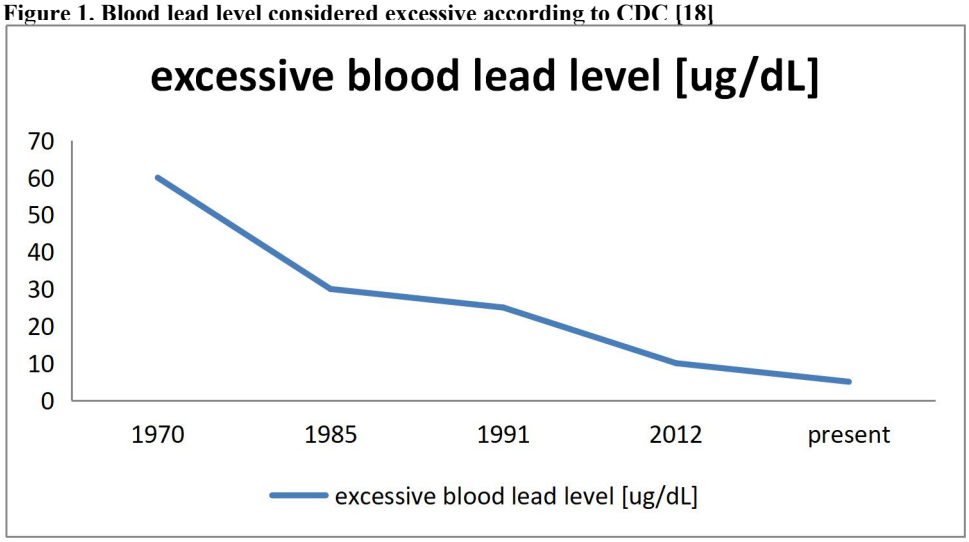
Anemia is another important symptom of lead poisoning, caused by restricted hemoglobin synthesis and increased rate of hemolysis. Lead suppresses hematopoiesis by hindering essential enzymes needed for haeme synthesis, and reduces erythrocytes' lifespan by weakening cell membranes. [1] The affected enzymes include δ-aminolevulinic acid dehydratase (ALAD), aminolevulinic acid synthetase (ALAS) and ferrochelatase [11].

Renal dysfunction includes both acute and chronic nephropathies. In acute form, one observes proximal tubular dysfunction giving rise to glycosuria, hyperphosphaturia, aminoaciduria (Fanconi's syndrome) . Long-term exposure to high levels of lead causes irreversible changes in the kidney such as interstitial fibrosis, glomerular sclerosis, tubular atrophy. The final result is renal failure, and every patient with lead level >60 ug/dL is at risk of developing such condition. Recent research proves that renal abnormalities can ensue even at blood lead level approaching 10 ug/dL, previously considered to be safe [3].

Lead poisoning can have a number of undesirable effects on cardiovascular system. Lead intoxication was demonstrated to stimulate atherosclerosis in animal experiments. Furthermore, chronic exposure was connected with atherosclerosis and cardiovascular mortality in humans as well [12]. One of our patients was diagnosed with mild cardiac hypertrophy. However, while it could be related to lead exposure, the presence of

cardiomiopathy in family history may suggest genetic predisposition to such diseases in this case. Some studies claim that low- level lead exposure is correlated with diseases such as hypertension and peripheral artery disease [12]. Other important disorders are ischemic coronary heart disease and cerebrovascular accidents [1].
Reproductive system is also susceptible to lead toxicity. Symptoms in men include infertility, abnormal spermatogenesis and prostatic function, chromosomal impairment, changes in libido and testosterone levels. Affected women are more vulnerable to miscarriage, infertility, preeclampsia, premature delivery and pregnancy hypertension [13]. Prenatal lead exposure was linked to toxic harm to the fetus' tissues [3].
Lead is absorbed primarily through inhalation and, to a lesser degree, through gastrointestinal tract. It is stored in three major tissue groups: blood, muscle and bones. Over 90% of all lead is deposited in bones, with biological $t_{1/2}$ =20-30 years; hence it is nearly impossible to remove it completely after significant exposure [8]. Pb^{2+} is principally eliminated with feces, with some smaller amount removed via urinary tract. Trace amounts of lead can also be eliminated through sweat, hair, nails and breast milk [14]. Children have higher total lead absorption compared to adults and higher percentage of all bodily lead deposited in soft tissues- two of the reasons for their increased susceptibility for lead poisoning [1,8].
Lead appears to have two primary mechanisms of toxicity, i.e. inducing oxidative stress and substituting other bivalent cations in diverse metabolic processes [1]. The first process consists of simultaneous production of reactive oxygen species and disabling cellular antioxidant mechanisms [15]. Lead has the ability to bond with sulfhydryl groups in antioxidants (e.g. glutathione), which inactivate them [1]. In analogous way, lead can interrupt enzymes like ALAD (blocking haeme synthesis) and gluthatione reductase, glutathione peroxidase and glutathione-S- transferase (contributing to reduction in glutathione activity) [16]. Lead can also supplant some bivalent cations, including Ca^{2+}, Fe^{2+}, Mg^{2+} and some monovalent ions e.g. Na^{+}. This can have a profound effect on cell functioning [17]. This process is most damaging in central nervous system, where Pb cations replace Ca^{2+} ions and cross blood-brain barrier. Afterwards they accrete in CNS in astroglial cells. The damage caused by lead accumulation is especially apparent in immature nervous system, where it impedes myelin sheath development. Lead can also influence some neurotransmitters, e.g. protein kinase C. [1]

Figure 1. Blood lead level considered excessive according to CDC [18]



Diagnosis is usually made on the basis of typical symptoms and blood lead level [8]. The evidence for negative effects of lead exposure even at very low thresholds prompted a revision of safe BLL guidelines.(Figure 1) The upper value for children reference range is

now 5 ug/dL. Current CDC/NIOSH reference BLL for adults is also 5 µg/dL [18]. Both of our patients exceeded this level and were eligible for therapy. It is important to note that even though one of our patients outstripped the threshold only minimally, he nevertheless showed some serious symptoms, like behavioral problems and CNS demyelination. Another useful diagnostic tool is zinc protoporphyrin (ZPP) level, which allows to asses lead exposure up to 3 months before patient's admission. ALA (aminolevulinic acid) elimination with urine and ALAD activity are also sensitive lead exposure indicators, but are not used very often. Treatment involves primarily removing the source of exposure and using chelation therapy to isolate lead from cell components and remove them from the body [8].

Conclusions

No biological function of lead in human body is known. All known effects of Pb are extremely harmful to humans, especially exposure in childhood which can culminate in serious behavioral and cognitive deficits in children. Even after Pb exposure ended, these outcomes persist well into adulthood [14].

Lead poisoning still appears to be a problem in some jobs and environments, particularly in cases of chronic low level exposure. Proper monitoring of workplace conditions and regular medical checkups for those at risk should be practiced to avoid cases of chronic poisoning in the future.

References:

1. Flora G, Gupta D, Tiwari A. Toxicity of lead: A review with recent updates. Interdiscip Toxicol. 2012; **Vol. 5**(2): 47–58. **doi:** 10.2478/v10102-012-0009-2
2. Gilbert S, Weiss B. A rationale for lowering the blood lead action level from 10 to 2 mg/dL. NeuroToxicology. 2006; 27: 693–701. doi: 10.1016/j.neuro.2006.06.008
3. Flora S, Flora G, Saxena G. Environmental Occurrence, Health Effects and Management of Lead Poisoning. In *Lead*. 2006; p. 158–228. Elsevier. https://doi.org/10.1016/B978-044452945-9/50004-X (accessed: 2018.12.27)
4. Needleman H. Lead poisoning. Annu Rev Med. 2004; 55: 209-222. doi: 10.1146/annurev.med.55.091902.103653
5. Tong S, Schirnding Y, Prapamontol T. Environmental lead exposure: a public health problem of global dimensions. Bulletin of the World Health Organization. 2000; 78 (9): 1068- 1077. https://www.who.int/bulletin/archives/78(9)1068.pdf (accessed: 2018.12.27)
6. WHO World Health Organization. Inorganic Lead. Environmental Health Criteria Number 165, Geneva. 1995. http://www.inchem.org/documents/ehc/ehc/ehc165.htm (accessed: 2018.12.28)
7. Tong S. Lead exposure and cognitive development: persistence and a dynamic pattern. Journal of Paediatrics and Child Health. 1998; 34: 114–118. https://doi.org/10.1046/j.1440-1754.1998.00187.x (accessed: 2018.12.29)
8. Gordon J, Taylor A, Bennett P. Lead poisoning: case studies. Blackwell Science Ltd Br J Clin Pharmacol. 2002; 53: 451- 458. https://doi.org/10.1046/j.1365-2125.2002.01580.x (accessed: 2018.12.29)
9. Sanders T, Liu Y, Buchner V, Tchounwou P. Neurotoxic effects and biomarkers of lead exposure: A Review. Res Environ Health. 2009; 24: 15–45. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2858639/ (accessed: 2018.12.29)
10. Hou S, Yuan L, Jin P, Ding B, Qin N, Li L et al.: A clinical study of the effects of lead poisoning on the intelligence and neurobehavioral abilities of children. Theoretical

Biology and Medical Modelling. 2013; 10:13. http://www.tbiomed.com/content/10/1/13 (accessed: 2018.12.29)
11. Piomelli S. Childhood lead poisoning. Pediatr Clin North Am. 2002; 49: 1285- 1304. DOI: 10.1016/S0031-3955(02)00097-4
12. Alissa E, Ferns G. Heavy Metal Poisoning and Cardiovascular Disease. Hindawi Publishing Corporation Journal of Toxicology Volume 2011, Article ID 870125, 21 pages. doi:10.1155/2011/870125
13. Flora S. Arsenic induced oxidative stress and its reversibility. Free Rad Biol Med. 2011; 51: 257–281. DOI: 10.1016/j.freeradbiomed.2011.04.008
14. Neal A, Guilarte T. Mechanisms of Lead and Manganese Neurotoxicity. http://pubs.rsc.org | doi:10.1039/C2TX20064C (accessed: 2018.12.23)
15. Flora S. Nutritional components modify metal absorption, toxic response and chelation therapy. J Nut Environ Med. 2002; 12: 53–67. https://doi.org/10.1080/13590840220123361 (accessed: 2018.12.28)
16. Ahamed M, Siddiqui M. Low level lead exposure and oxidative stress: Current opinions. Clin Chim Acta. 2007; 383: 57–64. https://doi.org/10.1016/j.cca.2007.04.024 (accessed: 2018.12.29)
17. Garza A, Vega R, Soto E. Cellular mechanisms of lead neurotoxicity. Med Sci Monit. 2006; 12**:** RA57–65. PMID: 16501435
18. ATSDR CASE STUDIES IN ENVIRONMENTAL MEDICINE (CSEM). Lead Toxicity. https://www.atsdr.cdc.gov/csem/csem.asp?csem=34&po=8#table4 (accessed: 2018.12.27)