Polish J. of Environ. Stud. Vol. 19, No. 3 (2010), 579-585

Original Research

Diagnostic and Environmental Procedures in Accidental Mercury Vapor Intoxication – Experiences from an Outpatient Clinic

Joanna Kasznia-Kocot*, Beata Dąbkowska, Maja Muszyńska-Graca, Renata Złotkowska, Piotr Zygmunt Brewczyński

Institute of Occupational Medicine and Environmental Health,
Department of Environmental Health and Epidemiology, Kościelna 13, 41-200 Sosnowiec, Poland

Received: 8 September 2009
Accepted: 19 January 2010

Abstract

This paper presents examples of improper reactions to unintentional mercury spills. Seven families consisting of 22 people – 15 adults and 7 children – (including 2 breastfed babies) were exposed to metallic mercury vapors. U-Hg levels ranged from 14.5 to 222.8 μg/g creatinine. Among patients exposed to mercury vapor we noticed fatigue and weariness, excessive sleepiness, hyperexcitability, and headaches. A stomachache was reported by 3 adults, and a metallic taste in the mouth and a feeling of "thickening of mucous membranes" by 1 patient. In 2 cases allergic rash and erythema on the hands were observed, but 6 patients stayed asymptomatic. Among children, neuropsychological disturbances (intention tremor, EEG changes, emotional lability, withdrawal) were found in a 5-year-old girl (who also had the highest U-Hg value – 222.8 μg/g of creatinine), who stayed with family for 22 days after a mercury spill. This study emphasizes the need for continuous education of different groups of population regarding rules of properly handling metallic mercury vapor.

The algorithm of immediate reaction in cases of accidental exposure to metallic mercury vapor should be elaborated uppon and made available to medical professionals and emergency services.

Keywords: environmental exposure, mercury vapor, intoxication, mercury-urine, children, adult

Introduction

Mercury is a ubiquitous environmental toxin, exposure to which is a growing, health hazard worldwide. Three forms of mercury exist: elemental, inorganic, and organic. Each of them has a specific toxicity profile. Mercury exposure may occur in the environment, and in occupational and domestic settings.

Acute elemental mercury vapor intoxications are caused mainly by inhalation, and the lungs are a critical organ [1-3]. Apart from severe respiratory effects caused by airway irritation like interstitial pneumonia or pulmonary oedema, other symptoms such as headaches and fever are covered. Other health effects of acute mercury vapor intoxication, according to the literature, include neurobehavioral changes, renal damage, gastrointestinal symptoms, and gingivitis [4-6].

Acute occupational mercury intoxication is usually caused by high levels of vapors, as a consequence of industrial breakdown or inadequate working conditions [7, 8]. Acute environmental mercury intoxication is usually accidental and associated with residential exposure [9]. Despite the declining rate of hospitalizations due to acute poisoning,

*e-mail: kasznia_kocot@poczta.onet.pl
j.kasznia@imp.sosnowiec.pl

Polish children are often casualties of accidental domestic environmental exposure. According to data from the toxicological centre, acute intoxication among children and adolescents (up to 15 years) constitute about 30% of all phone consultations [10]. The awareness of parents and guardians regarding possible toxic effects of substances that are present at home is often insufficient.

The aim of this paper is to present cases of acute mercury vapor intoxication in domestic settings.

Material and Methodology

The observation comprised 7 families living in flats where metallic mercury was spilled. Altogether, 22 people (15 adults and 7 children, including 2 breastfed babies) were exposed to metallic mercury vapors. Medical activities undertaken at the Environmental Medicine Outpatient Clinic, included medical history, evaluation of health state, control of mercury levels in urine (U-Hg levels), and other biochemical parameters (and in special cases also pharmacotherapy).

Diagnostics of patients exposed to mercury vapor is presented in Fig. 1. Medical examinations were performed by physicians trained in environmental medicine. The range of procedures recommended by examinations included laboratory tests (blood count, urea, creatinine, liver function enzymes, urine test, and toxicological tests: concentration of mercury in urine, in selected cases also β_2 microglobulin assessments) as well as specialist consultations (psychological and neurological if needed).

U-Hg levels were determined by CV-AAS method. After mineralization of urine with potassium permanganate and concentrated sulphuric acid, the sample was reduced with stannous chloride in an aeration vessel, and elemental mercury was moved by aeration to a cold vapour mercury cell. Absorption of the signal was measured after the signal was stabilized by means of a UNICAM Solar 939 Atomic Absorption Spectrometer. Precision was 5-12%. Detection limit was 0.65 µg/l. The quality of the analysis was tested by internal and external quality control.

β_2 microglobulin (β_2-M) was evaluated by using the turbidymetric method with latex (SPINREACT), by means of a STAT FAX photocolorimeter. Latex with anti-human β_2-M antibodies comes into reaction with β_2-M, as antigen, and the complex causes the change of absorbance, which is recorded at a wavelength of 540 nm.

Environmental activities including compiling an environmental history concerning the source, the method and time of exposure to metallic mercury vapor, evaluating the extent of exposure through the measurement of mercury vapor in the air inside a flat after a mercury spill, and environmental intervention in order to remove mercury from the exposed person's surroundings (Fig. 1).

Results

Environmental History

Circumstances associated with metallic mercury vapor exposure of the investigated group are presented in Table 1. In one case the cause of mercury vapor poisoning was breaking a 1-liter jar containing an unspecified amount of mercury that was stored in the flat above, and which then traveled via plumbing pipes to the apartment at issue. The circumstances regarding the storage of such a dangerous substance in living quarters were not established.

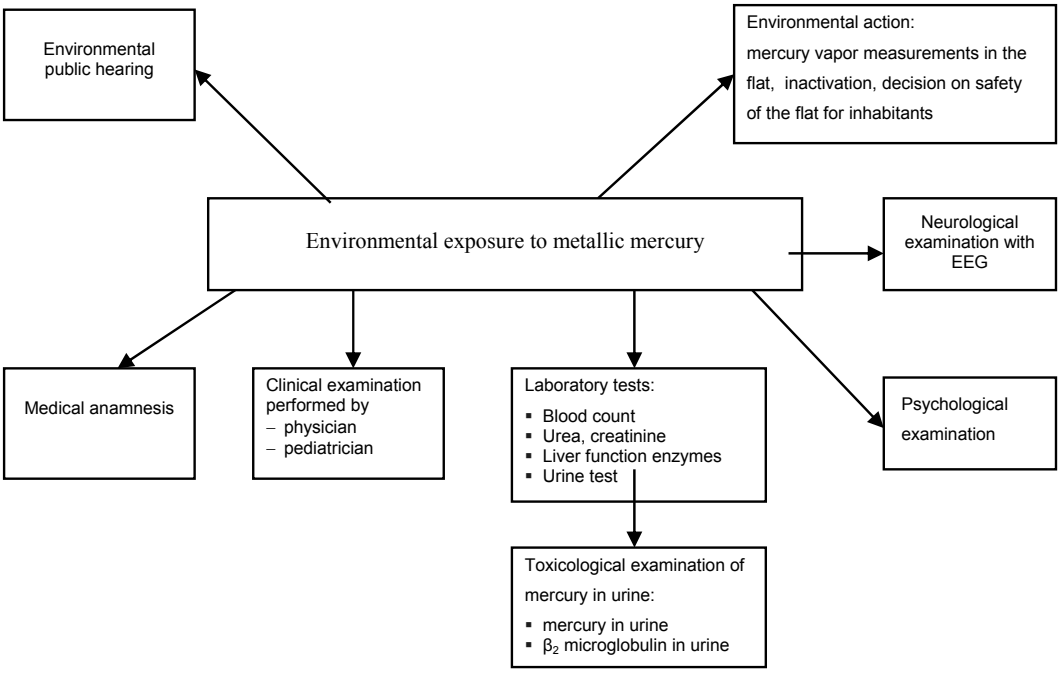

Fig. 1. Scheme of diagnostics in cases of environmental exposure to metallic mercury carried out at the Environmental Medicine Outpatient Clinic.

Table 1. Exposure to metallic mercury and methods of environmental action included in Environmental Medicine Outpatient Clinic documentation.

No.	Number of exposed people	Circumstances of exposure	Methods of mercury elimination used by tenants	First visit at Environmental Medicine Outpatient Clinic	Specialist services intervention
1	2 adults and 1 child (22 months, breast-fed)	Floor above – a jar with mercury was broken; mercury traveled along plumbing	Dustpan and broom, vacuum cleaner, beating carpets	12th day of exposure	11th day after flat contamination – mercury measurement; flat decontamination
2	2 adults and 2 children (4-year-old and breastfed 18-month-old)	Broken manometer used for measuring tightness of gas fittings	Vacuum cleaner, wet cloth, tearing off floor boards in contaminated kitchen	30th day of exposure	2nd day of contamination – mercury vapor measurement; flat decontaminated twice
3	2 adults and 1 child (6-year-old)	As above	Vacuum cleaner: one month after incident drops of mercury still present in the flat	30th day of exposure	30 days after exposure – mercury measurement; evacuation of tenants and decontamination performed twice
4 and 5	Family No 4: 2 adults Family No 5: 3 adults	As above	Chemical emergency services called	4th day of exposure	Mercury vapor measurement; flat decontamination performed twice
6	2 adults, 2 children (11-, 15-year-old)	As above	Toilet paper	3rd day of exposure	Mercury measurement on 3rd day, decontamination: after 1 month – drops of mercury still present, second decontamination
7	2 adults and 1 child (5-year-old)	As above	Vacuum cleaner, wet cloths, dustpan, broom drops of mercury present in flat 22 days after incident	22nd day of exposure; family doctor visit	23rd day after incident – mercury vapor measurement, eviction order, decontamination performed twice

In the remaining 6 cases, mercury was spilled in the autumn-winter season of 1999-2001 due to breaking industrial manometers used for measuring the pressure in gas fittings in blocks of flats. Only in 2 cases (family Nos. 4 and 5), was the chemical emergency service called after the accident in order to remove the spilled mercury, and the family did not try to remove this metal on their own. After the intervention of the chemical emergency service and the first mercury removal, concentration of mercury vapor was determined in the flat (the Sanitary-Epidemiological Station in Katowice or the Department of Chemical Hazards at the IOMECH). In both cases it was necessary to decontaminate the flats (twice).

In the remaining 5 cases, the families, often with the assistance of the crew of workers that broke a manometer, were removing spilled mercury using a dustpan and brooms, wet floor cloths, toilet paper, and, in 4 cases, with a vacuum cleaner (family Nos. 1, 2, 3, 7). It resulted in a considerable spraying of mercury in the flat so that drops of scattered metal were still found in the flat a month after the incident.

Tenants often made poor decisions. For instance, in family No. 2 mercury was spilled in the kitchen, and after attempts to remove it with a cloth and vacuum cleaner, the floor was torn off to get to mercury drops located between the floor boards, but the boards were thrown into the living room, which resulted in contamination of this room. In this case the owner's wife, who was breastfeeding, participated in the process of cleaning the flat. In another case the mother of a 4-year-old child and 18-month-old baby, after spilling mercury quickly left the flat together with children and took them to their grandparents. However, in 3 days she returned to the flat to help her husband to remove the spilled mercury. Moreover, she did not change her clothes and shoes when she returned to her children.

It is noticeable that families trying to remove mercury turned to specialist services late. These families were still living in the contaminated flats for 12, 22 and 30 days after the incident (Table 1). The patients presented themselves at the Environmental Medicine Outpatient Clinic with a referral from a family doctor, at different times from the moment of exposure to metallic mercury vapors (from 3 to 30 days).

Patient Complaints and Physical Examination

Among the most frequently reported complaints in patients exposed to mercury vapor were: fatigue and weariness, excessive sleepiness, and anxiety and headache (Table 2). Stomachaches were reported by 3 adults participating in removing mercury, and one of these patients additionally complained of a metallic taste in the mouth and feeling a "thickening of mucous membranes." In 2 cases allergic rash

Table 2. Complaints and symptoms in patients exposed to metallic mercury vapor.

No.	Complaints/clinical symptoms	No.	
1	Fatigue/weariness	13/22	(59%)
2	Excessive sleepiness	7/22	(31.8%)
3	Hyperexcitability	7/22	(31.8%)
4	Symptoms of depression	1/22	
5	Headache	6/22	(27.3%)
6	Increased perspiration	4/22	
7	Pains in muscles and shins	3/22	
8	Stomachache	3/22	
9	Metallic taste in mouth	1/22	
10	Feeling of "thickening" of mucous membranes	1/22	
11	Increased hair loss	1/22	
12	"Subtle" disorders of vision	1/22	
13	Vertigo	1/22	
14	Lack of complaints	6/22	(27.3%)
15	Rash and erythema on both hands	2/22	
16	Irritation of eye conjunctiva	1/22	

on the body and erythema on both hands were observed. Additionally, in one of these patients irritation and reddening of eye conjunctiva occurred. Six people did not report any complaints. They were members of the families that immediately called specialist services to remove mercury and 1 adult person in family No. 1, who was rarely home due to work (Table 2).

The examined group exposed to metallic mercury vapor included 5 children at aged 18 months to 15 years, among which two babies were breastfed. One of them, a 22-month-old baby was out of the contaminated flat for the first 4 days, and then the family came back home before the professional decontamination had been performed. The main reported symptom was increased sleepiness of the child. After a single visit to the clinic, this family did not come back to perform further psychological and neurological diagnostics.

In the second case, an 18-month-old baby stayed out of the contaminated flat from the day of the incident, but his mother came back to the contaminated flat for several times and participated in the cleaning procedure. This family did not report any alarming symptoms regarding the children, and no abnormalities in additional diagnostic tests were recorded. The U-Hg levels are presented in Table 3. Among the older children (5-15 years), complaints and abnormalities in additional examinations were found only in the 5-year-old girl in family No. 7. Her parents reported excessive fatigue and nervousness in the girl. In the physical examination of the child, throat reddening and reactive enlargement of the upper cervical lymph nodes were observed. Additional laboratory tests (blood count, liver enzymes, urea, creatinine) did not reveal any abnormalities. The level of β_2-M was 148 μg/l (normal value =300 μg/l). The Terman-Merrill test was used during a psychological examination: intelligence age was 7 years and 2 months, at the biological age of 5 years and 2 months IQ = 119 (above average). It was noticeable that the child easily resigned from performed tasks. A neurological consultation showed negative for meningeal signs, slight nystagmus when looking to the right, which disappearing after a few seconds, without lateralization of symptoms. A vivid mandibular reflex and deliberation signs as well as ataxia were present. EEG – on the irregular background activity 7-8 c/sec, in the temporo-occipital region, at a periodical prevalence on the right side, a high-voltage, slow theta waves were recorded as well as sharp waves and complexes comprising sharp wave-slow wave. During hyperventilation, a tendency to generalize mentioned changes was observed. Changes within the hindbrain and paroxysmal activity were recorded.

The control U-Hg level, performed 2 months after the incident of intoxication, still showed an increased mercury concentration in urine (Table 3). U-Hg levels in adults ranged between 14.8 and 50 μg/g of creatinine, except family No. 7, where U-Hg levels were from 114.6 to 222.8 μg/g of creatinine.

This family stayed in the flat for 22 days after the mercury incident. At that time they tried to remove mercury with a vacuum cleaner, whose drops were present between the wooden floor boards. The flat was small and comprised a kitchen and room. A 26-year-old mother complained of fatigue, irritability, headache, and, 2 months after the incident, pain in the epigastrium and occasional trembling of hands. U-Hg levels were as follows (in order according to the period from accident):

I. (23rd day) – 190 μg/g of creatinine,
II. (1 month) – 132.2 μg/g of creatinine, and
III. (3 months) – 67.7 μg/g of creatinine.

Table 3. Mercury levels in urine of examined children.

Family No.	Child's age	U-Hg [μg/g of creatinine]	Time of first examination U-Hg since exposure
1	22 months	I. 18.6	13th day
2	18 months	I. 14.5 II. 3.0 (after 2 months)	31st day
3	6 years	I. 22.4 II. 9.8 (after 2 months)	31st day
6	11 years	I. 25.1	4th day
	15 years	I. 18.0	4th day
7	5 years	I. 222.8 II 62.2 (after 40 days) III. 27.2 (after 2 months)	23rd day

No abnormalities in blood count and liver enzymes were found. No features of renal damage were observed (urea, creatinine, urine test-normal, β_2-M concentration was 151 μg/L).

A neurological examination was performed three times (in month 1, 4, and 5 after the incident). During the neurological assessment there were two episodes of right-hand trembling. In the examination, positive deliberation signs and pathological signs in the left upper limb were observed. In the right lower limb a policlonic knee reflex was present. The EEG showed slight diffuse changes within the temporal region.

With regard to gastric complaints, panendoscopy was performed (2 months after the incident), which revealed hyperemia of the lower part of the oesophagus, gastric mucosa, and duodenal bulb. Single erosions were observed below the cardia. The test for Helicobacter pylori was positive.

A 28-year-old father complained of fatigue, irritability, trembling of hands, a burning sensation within eye conjunctiva, and a rash on hands. The symptoms caused a visit to the family doctor's surgery 22 days after the incident. With regard to medical history, the patient was referred to the Environmental Medicine Outpatient Clinic. U-Hg levels were as follows (in order according to the period from accident):

I. (24 days) - 114.6 μg/g of creatinine,
II. (1 month) - 75.2 μg/g of creatinine,
III. (3 months) - 42.9 μg/g of creatinine.

No abnormalities in blood count and liver function enzymes were found. The urine analysis, urea, and creatinine were normal: β_2-M concentration = 191 μg/L. The neurological examination revealed positive deliberate signs, more vivid reflexes in the left upper and lower limb. The EEG record included slight diffuse changes within the temporal regions. In both mother and father as well as in the child the treatment involved Penicillamine 25 mg/kg at 4 doses a day, without any side effects.

Discussion

Metallic mercury vapor intoxication cases are mainly related to occupational exposure [1, 7, 8, 11]. Exposure to metallic mercury vapors in children result from environmental accidents. Examples of metallic mercury vapor sources include spills of metallic mercury in indoor environment, domestic processing of ore that contains mercury, suicide attempts, use of mercury-containing cosmetics, and use of metallic mercury in ritual celebrations in some religious groups [3, 6, 12-14]. Among described cases, we did not find any symptoms in respiratory system, which might be present in acute exposure to metallic mercury vapor, suggesting a chronic character at low levels of exposure [2, 3]. We did not observe any signs of renal damage in our patients, although there were such cases described in literature [1, 4, 15]. There are also publications presenting harmful effects of metallic mercury on the gastrointestinal tract. In patients under study the following symptoms were described: stomachache, nausea, burning in the oesophagus, and diarrhea with admixture of blood [7, 13]. In our study gastric complaints occurred in one patient 2 months after the incident, when the family lived in another temporary flat, whilst their own flat was being cleaned. The panendoscopic examination revealed inflammatory lesions and erosions in the stomach, which most probably were associated with *Helicobacter pylori* infection and stress resulting from the stressful situation. In two patients exposed to metallic mercury vapor, allergic symptoms occurred in the form of contact dermatitis; other authors have indicated a possible allergy-inducing activity of metallic mercury [16]. According to other authors, we have been observing nonspecific symptoms along with mercury vapor intoxication, such as: fatigue, weariness, headache, vertigo, hyperexcitability, defective memory, and irritability, especially visible in a child, and confirmed by psychological examination [1, 3, 5, 17]. A family that is exposed to mercury vapor for a long time reveals some neurological symptoms. In spite of the complexity of mercury's toxic effect on the nervous system and emphasis put on difficulties to interpret such a relationship between complaints/symptoms and exposure, it seems that observed neurological symptoms, justified by neurological examination, indicate the presence of chronic intoxication with mercury vapor [5, 11, 17]. Alarming findings, especially high mercury levels, and abnormalities in psychological and neurological examination, were observed in the 5-year-old girl, but Hg values in her urine were higher than in other studies describing health disturbances in mercury-exposed children [4, 5, 12, 18, 19].

Pediatric elemental mercury intoxication is a growing concern because children may be exposed to metallic mercury from household items, some religious practices or occupational practices of parents [20, 21]. The hazards of occupational exposure to mercury vapor have been well-documented in adults, but little toxicological information about children is available, especially with respect to developmental neurotoxicity. Some study investigated not only the neurophysiological effects of metallic mercury intoxication, but such other substances as cadmium, lead, and arsenic, which may affect neurophysiological responses [19, 22, 23].

Children are more sensitive to mercury than adults. The respiratory rate of children is higher than for adults, and they inhaled more mercury vapor of the same concentration than adults. The nervous system of children is developing and the blood-brain barrier is less able to keep mercury out of the brain [5, 13, 15]. In literature, the high toxicity of mercury, especially in children's nervous system, is emphasized [5, 11, 13, 17]. In the case of the remaining children, where early environmental action was taken or when the children stayed out of place of exposure, mercury concentrations were definitely lower.

In breastfed babies mercury levels in urine were considerably higher in comparison with values in the general population of children, according to studies in the Czech Republic (0.32 μg/g of creatinine) and Germany (0.36 μg/g of creatinine) [24, 25]. In Poland, recommended mercury concentration in urine is below 5 μg/g of creatinine [26], similar to recommendations in the Czech Republic (5.5

μg/g of creatinine) [27]. However, in Germany the most recently introduced referential values for mercury in urine in children are 0.7-1.4 μg/L [28].

The source of mercury, in the case of breastfed infants, could be mother's milk or mother's clothes because she did not change clothing or shoes after visiting the contaminated flat (unfortunately, mercury concentration in milk wasn't determined) [29]. Such behavior indicates a mother's ignorance of harmful effects of mercury and the rules of proper behavior in a situation of environmental pollution.

Despite environmental mercury contamination, medical effects associated with exposure may be limited due to quick identification of the source and its decontamination, which was achieved for the families that quickly left the contaminated flats and received professional attention from the chemical emergency response service. The decision to allow tenants to return was based on the measurement of mercury vapor in the air. In Poland mercury problems are regulated by a 1996 directive issued by the minister of health and social welfare, according to which, in a room of "A" category dwelling houses the permissible concentration of mercury vapors is 1 $\mu g/m^3$, and 3 $\mu g/m^3$ in other rooms.

Our cases reveal a lack of knowledge, both in families and teams performing measurements, considering necessary measures to clean up mercury. The following uncomplicated precautions should be taken after a mercury spill: people and children not involved in the cleaning should leave the contaminated flat, minimize tracking by removing clothes and shoes, windows should be opened to ventilate the flat, small amounts of visible mercury should be collected with a syringe or an eye dropper and stored in a plastic container, and an elemental sulphur can be used in the spill area before the arrival of the chemical emergency service [30, 31]. Removing mercury by means of improper "domestic methods," and lack of knowledge of medical effects of mercury vapors, were reasons for delayed environmental action. Intoxication by metallic mercury vapors was observed in cases of delayed environmental action. The most pronounced symptoms were observed in the family who repeatedly tried to remove mercury with a vacuum cleaner; the small area of the flat and the presence of deposits of mercury between floor boards caused increased scattering and evaporation of mercury, and, as a result, a longer period of exposure.

Environmental exposure to metallic mercury vapors gradually decreases, but mercury in already existing devices can still be found. This fact is extremely important because the European Parliament (directive No. 2002/95/EC) has put a total ban on the introduction of new equipment containing mercury [32]. The above also creates the need to educate the general public as well as professionals engaged in health care, including emergency services.

Conclusions

1. Delayed or improper environmental emergency action can cause nervous system problems in patients exposed to metallic mercury vapor over a long period of time.
2. There is a need for continuous education of different groups of the population regarding rules of proper handling in cases of environmental exposure to metallic mercury vapor.
3. The algorithm of immediate reaction in cases of accidental exposure to metallic mercury vapor should be elaborated on and easily available to medical professionals and emergency services.

References

1. MARQUARDT H. Toxicology, Academic Press, London, pp. 784-786, **1999**.
2. MOROMISTATO D.Y., ANAS N.G., GOODMAN G. Mercury Inhalation Poisoning and Acute Lung Injury in a Child. Use of High-Frequency Oscillatory Ventilation. Chest, **105**, (2), 613, **1994**.
3. NATELSON E.A., BLUMENTHAL B.J., FRED H.L. Acute mercury vapor poisoning in the home. Chest, **59**, (6), 677, **1971**.
4. AQUADO S., DE QUIROS I.F., MARIN R. Acute mercury vapor intoxication: report of six cases. Nephrol. Dial. Transplant. **4**, (2), 133, **1998**.
5. ATSDR. Medical Management Guidelines (MMGs) for Mercury (Hg). Atlanta, GA: Agency for Toxic Substances and Disease Registry. **2004**. http: // www. atsdr.cdc.gov/MHMI/mmg46.html
6. RILEY D.M., NEWBY C. A., LEAL-ALMERAZ T.O, THOMAS V.M. Assessing Elemental Mercury Vapor Exposure from Cultural and Religious Practices. Environ. Health Perspect., **109**, (8), 779, **2001**.
7. LANGAUER-LEWOWICKA H., ZAJĄC–NĘDZA M. Mercury and Occupational Diseases. In: Marek K, Eds. Occupational Diseases. PZWL, Warsaw, pp. 184-189, **2001** [In Polish].
8. ZŁOTKOWSKA R., ZAJĄC-NĘDZA M. Occupational acute mercury intoxication. A case report; Med. Pracy, **53**, (4), 315, **2002** [In Polish].
9. BOSE-O'REILLY S., LETTMEIR B., GOTHE R.M., BEINHOFF C., SIEBERT U., DRASCH G. Mercury as a serious health hazard for children in gold mining areas. Environ.Res. **107**, (1), 89, **2008**.
10. BURDA P. Intoxications with xenobiotics in children [In Polish]. www.dzieckokrzywdzone.pl
11. LANGAUER-LEWOWICKA H. Neurotoxicity of metallic mercury vapors: diagnostic difficulties. Med. Pracy, **54**, (4), 377, **2003** [In Polish].
12. AZZIZ-BAUMGARTNER E., LUBER G., SCHURZ-ROGERS H., BACKER L., BELSON M., KIESZAK S., CALDWELL K., LEE B., JONES R., TODD R., RUBIN C. Exposure assessment of mercury spilled in a Nevada school-2004. Clin. Toxicol. (Phila), **45**, (4), 391, **2007**.
13. BAUGHAM T.A. Elemental Mercury Spills. Environ. Health Perspect., **114**, (2), 147, **2006**.
14. KASZNIA-KOCOT J., DĄBKOWSKA B., MUSZYŃSKA-GRACA M., BREWCZYŃSKI P.Z., ZŁOTOWSKA R. Domestic accidental mercury vapor intoxication in families. J. Public Health, doc10.1093/pubmed/fdm088, pp. 1, **2008**.
15. FRANCO A., ANTOLIN A., TRIQUEROS M., MUÑOZ C., NAVAS J., PERDIQUERO M., OLIVARES J. Two consecutive episodes of acute renal failure following mercury poisoning. Case Report. Nephrol. Dial. Transplant., **12**, (2), 328, **1997**.

16. SCHRALLHAMMER- BENKLER K., RING J., PRZYBILLA B., MEURER M., LANDTHALER M. Acute mercury intoxication with lichenoid drug eruption followed by mercury contact allergy and development of antinuclear antibodies. Acta Derm. Venereol., **72**, (4), 294, **1992**.
17. LAUWERYS R., BONNIER CH., EVRARD PH, GENNART J.PH., BERNARD A. Prenatal and Early Postnatal Intoxication by Inorganic Mercury Resulting from Maternal Use of Mercury Containing Soap. Human Toxicol., **6**, (3), 253, **1987**.
18. COUNTER S.A. Neurophysiological Anomalies in Brainstem Responses of Mercury-Exposed Children of Andean Gold Miners. J. Occup.Environ.Med. **45**, (1), 87, **2003**.
19. DESPRES C., BEUTER A., RICHER F., POITRAS K., VEILLEUX A., AYOTTE P., DEWAILLY E., SAINT-AMOUR D., MUCKLE G. Neuromotor functioning in Inuit preschool children exposed to Pb, PCBs, and Hg. Neurotoxicol.Teratol. **27**, (2), 245, **2005**.
20. COUNTER S.A., BUCHANAN L.H.: Mercury exposure in children: a review. Toxicol.Appl.Pharmacol. **198**, (2), 209, **2004**.
21. GOLDMAN L.R., SHANON M.W. Technical report: mercury in the environment: implications for pediatricians. Pediatrics, **108**, (1), 197, **2001**.
22. COUNTER S.A., BUCHANAN L.H., ORTEGA F., LAURELL G. Elevated blood mercury and neuro-otological observations in children of the Ecuadorian gold mines. J.Toxicol.Environ.Health **65**, (2), 149, **2002**.
23. DE BURBURE C., BUCHET J. P., LEROYER A., NISSE C., HAGUENOER J.M., MUTTI A., SMERHOVSKY Z., CIKRT M., TRZCIONKA-OCHOCKA M., RAZNIEWSKA G., JAKUBOWSKI M., BERNARD A. Renal and neurologic effects of cadmium, lead, mercury, and arsenic in children: evidence of early effects and multiple interactions at environmental exposure levels. Environ. Health Perspect. **114**, (4), 584, **2006**.
24. BENES B., SPEVACKOVA V., SMID J., CEJCHANOVA M., KAPLANOVA E., CERNA M., GAJEWSKA V., BLATNY J. Determination of normal concentration levels of Cd, Pb, Hg, Cu, Zn and Se in urine in the Czech Republic. Centr. Eur. J. Public Health, **10**, (1-2), 3, **2002**.
25. TREPKA M.J., HEINRICH J., KRAUSE C., SCHULTZ C., WJST M., POPESCU M., WICHMANN H.E. Factors affecting internal mercury burden among eastern German children. Arch Environ Health, **52**, (2), 134, **1997**.
26. SEŃCZUK W. Toxicology (iv Eds), PZWL, Warsaw, pp. 771, **2002** [In Polish].
27. BATARIOVA A., SPEVACKOVA V., BENES B., CEJCHANOVA M., SMID J., CERNA M. Blood and urine levels of Pb, Cd and Hg in the general population. Int. J. Hyg. Environ. Health, **209**, (4), 359, **2006**.
28. WILHELM M., SCHULZ C., SCHWENK M. Revised and new reference values for arsenic, cadmium, lead and mercury in blood or urine of children: basis for validation of human biomonitoring data in environmental medicine. Int. J. Hyg. Environ. Health, **209**, (4), 301, **2006**.
29. DOREA J.G. Mercury and lead during breast-feeding. Review article. Brit. J. Nutrit., **92**, (1), 21, **2004**.
30. HRYHORCZUK D., PERSKY V., PIOTROWSKI J., DAVIS J., MOOMEY C.M.,KRANTZ A., RUNKLE K.D., SAXER T., BAUGHAM T., MC CANN K. Residential mercury spills from gas regulators. Environ. Health Perspect. **114**, (6), 848, **2006**.
31. ILLINOIS DEPARTMENT OF PUBLIC HEALTH. A Facts Sheet for Health Professionals - ElementalMercury. http://www.idph.state.il.us/health/factsheets/mercuryhlthprof.htm.
32. DIRECTIVE 2002/95/EC EUROPEAN PARLIAMENT AND COUNCIL, 27 January **2003**. www.tme.pl/pliki/rohs/rohs_pl.pdf.