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Pharyngeal Tonsil Cadmium Contamination in Children from Regions of Upper Silesia and Malopolska

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Humans are constantly exposed to cadmium as a result of the increase in air pollution and cigarette use (Swiatczak and Cimander, 1995; Kwapulinski et al., 2004; Mortada et al., 2004). Cadmium is one of the main environmental pollutants, also in Poland. The main source of cadmium in the environment is the non-ferrous metals industry, and pesticides and fertilizers used in agriculture. It is mainly used in production of stabilizers and dyes of plastics, glass, metal alloys and electrodes used in cadmium-nickel batteries (Rydzewski et al., 1999). People are also exposed to cadmium from cigarette smoking (Mortada et al., 2004; Orlowski et al., 1999).

In recent years the amount of cadmium in the external layer of the Earth, in water and in air has increased significantly due to technological developments. Cadmium is easily dissolvable, hence plants collect it well. It contaminates the biosphere as well as food, which has a major influence on its presence in the human body (Rydzewski et al., 1992). Cigarettes are another source of cadmium acquisition in the body. Lungs are the main way of cadmium absorption in the industrial regions. It induces DNA damage so, even in small concentrations, it could be toxic. Usually cadmium concentration is estimated post mortem in kidney, liver and lungs in patients from polluted regions. There is no particular organ acknowledged as the best indicator of cadmium in human body.

The goals of this study were to determine whether the pharyngeal tonsil is a useful tissue for monitoring exposure to cadmium in children living in industrial regions; to investigate the relationship between the level of cadmium accumulation in removed adenoids and age and gender; and to analyze the cadmium co-occurrence with other elements.

Materials and Methods

Pharyngeal tonsils, which were removed by adenotomy due to hypertrophy from 96 children, 40 girls (42%) and 56 boys (58%) aged 2 to 15 years (mean 6.80), underwent chemical analysis.

Children were divided into 3 groups according to age: I, 2–5 years old, 35 (36%); II, 6–7 years old, 29 (30%); III, 8–15 years old, 32 (33%).

According to the place of residence, three regions were distinguished: Silesian agglomeration - 55 children (57%), Krakow agglomeration - 25 children (26%), village - 16 children (17%). All of them underwent adenotomy under general anesthesia in ENT Departments. Material was frozen in –20°C. After collection, the whole material was transported to the Department of Analytical Chemistry, Silesian University in Katowice, where the analysis was performed. The tonsils were initially dried at 100 ± 2°C. Approximately one gram dry weight was diluted with 2 cm^3 supra pure spectrally 65% HNO_3 (V) from Merck (Germany). The resulting solution was transferred into

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Table 1 The comparison of cadmium contents (μg/g) in different samples

Species of sample	Average range	Geometric mean	Arithmetic mean	Percentiles		References
				10	90	
Pharyngeal tonsil	0.04–0.53	0.14	0.17	0.06	0.28	This work
Femoral artery	0.13–19.91	4.74	8.61	0.61	19.91	Nogaj et al. 2003
Femur capitulum	0.01–1.09	0.06	0.17	0.01	0.73	Brodziak-Dopierala et al. 2003
Gallstones	0.00–0.54	0.11	0.17	0.01	0.26	Kwapulinski et al. 2003
Teeth	0.01–1.97	0.23	0.27	0.12	0.37	Kwapulinski et al. 2004

Table 2 Cadmium occurrence in adenoids of girls and boys (μg/g)

Gender of children	*n*	Arithmetic mean	Geometric mean	Value of 10th percentile	Median	Value of 90th percentile
Whole group	96	0.17 ± 0.09	0.14	0.06	0.15	0.28
Girls	40	**0.14 ± 0.08**	**0.12**	**0.06**	**0.12**	**0.26**
Boys	56	**0.18 ± 0.10**	**0.16**	**0.07**	**0.17**	**0.31**

Cadmium concentration in adenoids was significantly higher for boys than for girls, $p < 0.05$

10 cm^3 volumetric flasks and filled up to the mark with doubly distilled water. The concentration of cadmium and other metals was determined by emission spectrometry (ICP-AES). The accuracy of determining investigated elements was 0.01 μg/g. The procedure was validated by determination of cadmium in reference standards NIST-1400 and NIST-1486 (ash bone tissue), and BRW-1648 (urban dust). The results differed by 2.4–4.8%. Moreover, the procedure also was validated in cooperation with certified laboratory of the Department of Environmental Monitoring of the Central Mining Institute – AB 145 (Polish central accreditation symbol). The recovery of cadmium from the reference material was equal to 97–99%. Cadmium content in samples was established as an average of six repetitions. The data concerning emission of cadmium proceeded from Wojewodzka Stacja Sanitarno - Epidemiologiczna (Sanitary and Epidemiology Agency) in Katowice and in Krakow.

Results and Discussion

In many published studies, the association between cadmiumexposure with its content in different human tissues was analyzed. The evaluation of cadmium concentration was conducted in blood, urine, hair and nails (Huzior-Balajewicz et al., 2001; Orlowski et al., 1999; Rydzewski et al., 1992; Rydzewski et al., 1999).

Many studies estimated the cadmium deposition in kidneys, liver and in airways in workers exposed to the harmful action of cadmium. There is no doubt that excessive levels of cadmium impair renal function and are also the reason for respiratory system disorders (Mortada et al., 2004). Orlowski et al. (1999) proved that pulmonary cadmium may be used as a marker of smoking habit of individuals. Based on the samples collected in autopsies, they showed that the ratio of cadmium levels in smokers/nonsmokers is approximately 9 in the lungs (Orlowski et al., 1999).

The highest values of cadmium concentration were found in children from the Silesian Region, but the differences were not significant.

Cadmium concentration was the lowest in adenoids of 2–5 years old children and it was significantly lower than in second and third age groups, $p < 0.05$. The differences in cadmium contents between second and third groups were not significant.

Since 1993 (IARC), cadmium has been recognized as a carcinogen, which may be responsible for the development of carcinoma of the lungs, testicles and prostate (Swiatczak and Cimander, 1995; Jakubowski et al., 1995). In the literature, there is a very little data concerning adenoid cadmium contamination. The methodology of cadmium analysis in blood is difficult due to a very low concentration (about 100 times lower than lead) and high chance of contamination during the blood collection (Environmental Health Criteria, 1992; Razniewska and Trzcinska-Cichocka, 1995). Therefore, adenoids seem to be useful material for monitoring levels of cadmium and other elements in children. Firstly, the material is easy to get by adenotomy. Adenotomy is one of the most frequently performed operations in children due to pharyngeal hypertrophy. Monitoring can be done via adenotomy, and not by exposing the child to additional complications.

Table 3 Cadmium concentration in adenoids of children from different sites (μg/g)

Region	*n*	Arithmetic mean	Geometric mean	Value of 10th percentile	Median	Value of 90th percentile
Whole group	96	0.17 ± 0.09	0.14	0.06	0.15	0.28
Krakow	25	0.14 ± 0.07	0.12	0.07	0.11	0.23
Silesian Region	55	0.18 ± 0.11	0.15	0.06	0.16	0.32
Village	16	0.15 ± 0.05	0.14	0.09	0.16	0.21

Table 4 The changes of cadmium concentration in adenoids for given age groups (μg/g)

Age of children	*n*	Arithmetic mean	Geometric mean	Value of 10th percentile	Median	Value of 90th percentile
Whole group	96	0.17 ± 0.09	0.14	0.06	0.15	0.28
2 – 5 years	35	**0.12 ± 0.09**	**0.10**	**0.06**	**0.10**	**0.21**
6 – 7 years	29	**0.19 ± 0.08**	**0.18**	**0.10**	**0.17**	**0.32**
8 – 15 years	32	**0.19 ± 0.10**	**0.17**	**0.08**	**0.18**	**0.30**

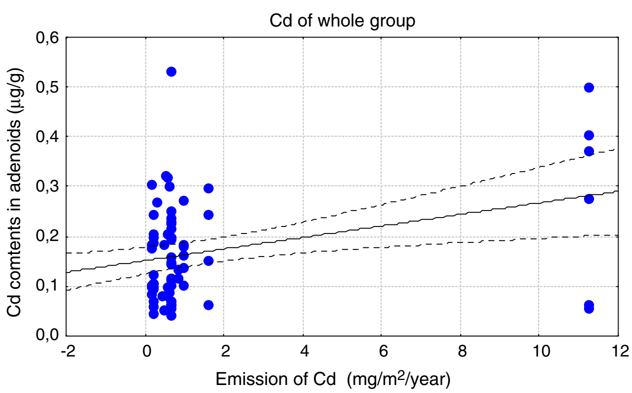

Fig. 1 The change of cadmium content in adenoids with relation to different cadmium emission levels

Table 5 The correlations between cadmium concentrations in adenoids and the emission of cadmium

	Pearson's *r*
Whole group of children	**0.33**
Krakow	–0.21
Silesian Region	**0.32**
Sex:	
Girls	0.26
Boys	**0.52**
Age:	
2 – 5 years	–0.18
6 – 7 years	**0.50**
8 – 15 years	**0.74**

Thus the aim of this study was to answer the question whether adenoids are a good biomarker of exposure for cadmium, according to differently polluted places of residence. Children were divided into three groups: from Upper Silesia region, the center of heavy industry in Poland; Krakow; and the village region. The data concerning the fallout of cadmium were taken from the Wojewodzka Stacja Sanitarno-Epidemiologiczna studies from Katowice and Krakow. The range of cadmium was 0.04–0.53 μg/g, the arithmetic mean in adenoids was 0.17 ± 0.09– (Table 2). The cadmium concentration in the adenoids of boys was significantly higher than in girls, $p < 0.05$ (Table 2). Huzior-Balajewicz et al., (2001) showed, that girls accumulate more cadmium in blood, whereas the boys absorb more lead. They did not find a correlation between cadmium blood concentration and body mass and height of children, however smaller head circumferences, independent of gender, were associated with a higher cadmium level (Huzior-Balajewicz et al., 2001; Environmental Health Criteria 134 1992; Razniewska and Trzcinska-Cichocka, 1995). By age groups, the lowest cadmium concentration was found in the youngest group (2–5 years old) in comparison to the elder groups (6–7 and 8–15 years old). The difference was significant, $p < 0.05$. This is probably a result from a longer period of exposure (Table 4). In comparison to results given in Table 1 for different biological samples, adenoids were a very good biomarker for cadmium exposure by specific ventilation of polluted air by nose. Thus, pharyngeal tonsils of children as biomarker of exposure can be a useful tool in the specific monitoring of cadmium.

The relationship between cadmium concentration in adenoids and fallout cadmium in the place of residence is possible (p =0.05).

The degree of accumulation of cadmium by the adenoid tissue depends on age and gender. The higher cadmium concentration was observed in boys and in elder groups of children. The relationship between cadmium content and other analyzed elements was significant for Cu, Mn and Fe.

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