Correlation between the concentration of lead in the blood of dogs and people living in the same environmental conditions

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Abstract

The studies, conducted between 2010 and 2012, involved 102 dogs and 505 people from Lower Silesia (LS), 104 dogs and 578 people from the Legnica-Głogów Copper Mining Region (LGCMR), and 101 dogs and 897 people from the Upper Silesian Industrial Region (USIR). A significant positive correlation between blood lead concentration (BLC) in dogs and people living in the same environment was found. Moreover, the data revealed an increase in BLC in dogs and people with the progressive aging of the body. The highest average BLC in dogs and humans were reported in the LGCMR followed by USIR and LS.

Keywords: people, dog, lead, blood, environment, contamination.

Introduction

Animals and people living in the environment contaminated with lead accumulate this metal in their body. Lead is mainly absorbed by ingestion of contaminated foods or feeds and drinking water, and by respiratory tissues (21). Sub-micron sized particles with lead may be accumulated in respiratory tissues; whereas, larger-sized particles may be transferred into the pharynx and then swallowed (5, 8, 10). Moreover, ingestion of soil and dust, and licking contaminated fur may also be important contributors in lead contamination (6, 9). Absorbed lead is associated with erythrocytes and transported to soft tissues, especially to the brain, spleen, liver, kidneys, and bone tissues, where it accumulates with age (16, 17). Foregoing studies suggest that the dog may serve as bioindicators of lead contamination because dogs have shared people’s environment, breathe the same air, drink the same water, and eat similar food for thousands of years. Moreover, reports indicate that the clinical symptoms of lead poisoning are very similar clinically and epidemiologically in humans and in dogs, especially in the childhood (1, 3, 4, 6, 7, 11, 16, 18–20). It is thought that dogs and children behave similarly by eating or chewing everything they can find. An increase in blood lead concentration (BLC) in companion dogs should correspond to a raise in BLC in people, thus suggesting a relationship between BLC in the two species sharing the same environment (24).

The aim of this study was to determine and compare BLC in people and dogs living in the same environmental conditions in three Polish regions at different risks of lead contamination. BLC was used because lead in blood is considered to be the criterion for potentially adverse health effects. The study also included calculation of the correlation coefficient R between BLC in dogs and people. The results enabled to evaluate whether BLC in dogs may predict BLC in people, and vice versa.

Material and Methods

The study was conducted from 2010 to 2012 and included three Polish areas with a different lead contamination: Lower Silesia (LS), the Legnica-Głogów Copper Mining Region (LGCMR), and Upper Silesian Industrial Region (USIR). Human blood lead
analysis was performed under supervision of the Department of Occupational Medicine and Department of Internal Medicine, (Wrocław Medical University). A total of 505, 578, and 897 blood specimens were collected in LS from the inhabitants of Wrocław and Olesnica, in LGCMR from the inhabitants of Głogów, Polkowice, and Lubin and in the USIR from the inhabitants of Katowice, Tarnowskie Góry, Miasteczko Śląskie respectively. The questions regarding the age of respondents were also included. Blood was sampled from the brachial vein of 102, 104, and 101 dogs living in the same towns of the LS, LGCMR, and USIR respectively to tubes containing EDTA, on the occasion of control examinations, vaccinations, or other treatments. The age of dogs was recorded. Tubes with blood were stored in the laboratory at 5°C. The analytical method used (flameless atomic absorption spectrophotometry, ET–AAS) was validated including quality assurance and control in Polish and international laboratories (FAPS) and in the EU reference laboratory in Rome (23). Lead in blood samples was determined after a 24-hour deproteinisation with 5% nitric acid at 4°C. After centrifugation, samples were placed in a graphite cuvette to measure lead concentrations at a wavelength of 283.30 nm with Zeeman background correction. The measurements were made using the Solaar M6 apparatus (Thermo Elemental, USA) equipped with a hollow cathode lamp (HCL) as a radiation source. A programme was adopted to divide the population into 12 age subgroups (Table 1) (15). Differences between selected age groups of people and dogs were analysed statistical methods (22).

Results

A total of 307 dogs and 1980 people were examined for BLC in the three regions selected. No apparent clinical signs of lead poisoning were found both in people and in dogs. In all regions, BLC were significantly higher in people compared to those in dogs living in the same region (Table 2). Among people the lowest BLC was found in children aged 0 - 15 years. BLCs in these children inhabiting the LS, LGCMR, and USIR were 30.03 µg/L ±11.90 µg/L, 34.80 µg/L ±7.20 µL, and 37.20 µg/L ±8.50 µg/L respectively, and then increased markedly with the age of the population examined. However, BLC was higher than 100 µg/L in adults ageing above 20 years in all regions examined.

Similar trends in BLC were found in dogs. The lowest BLC in dogs was attributed to young animals (0-1 year), and attained values of 3.31 g/L, 7.41 µg/L, and 12.90 µg/L in the LS, LGCMR, and USIR respectively (Table 1). The dogs belonging to the oldest age group (11-12 years) demonstrated a substantial increase in BLC up to 44.49 µg/L, 68.12 µg/L, and 64.10µg/L in the LS, LGCMR, and USIR respectively (Table 2).

Figs 1 to 3 reveal linear regression between people’s and dogs’ BLC from the three regions tested. The correlation coefficient R was calculated to evaluate the association between BLC recorded in dogs and people living in the same regions. The values of R were 0.928, 0.970, and 0.986 in the LS, LGCMR, and USIR respectively, indicating a high positive association between the variables examined.

This high positive correlation between BLC in dogs and humans living in the same region may enable estimating average BLC in humans at the corresponding age group, based on BLC in dogs living in the same environment. The conversion is based on a simple linear regression equation that includes the region examined. In the case of the USIR the equation of the linear regression is as follows:

\[ y = 4.82x - 19.04 \]

where \( y = \) BLC in humans µg/L
\( x = \) estimated BLC in dogs µg/L;

For example: to calculate LBC in the blood of people 36 to 40 years of age and living in the USIR, BLC from dogs 5 - 6 years old (Table 2) should be used as an x in the equation \( y = 4.82x - 19.04 \). The answer is 131.79 µg/L. This value is close to 129.90 µg/L that was found experimentally in the corresponding age group of people.

Similarly, a simple linear regression equation allows the calculation of BLC on the basis of the results found in people inhabiting the same region. In the present study the linear regression equation (LS: \( y = 3.84x + 64.45 \) and LGCMR: \( y = 3.98x + 39.61 \)) was calculated for each of the region tested.
Table 2. Blood lead concentrations (µg/L) in dog and human populations living in the regions examined

<table>
<thead>
<tr>
<th>Regions</th>
<th>Age of dogs</th>
<th>Age of people</th>
<th>Mean (Number of dogs)</th>
<th>Mean (Number of people)</th>
<th>Mean (Number of dogs)</th>
<th>Mean (Number of people)</th>
<th>Mean (Number of dogs)</th>
<th>Mean (Number of people)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LS</td>
<td>0–1</td>
<td>0–15</td>
<td>3.31 ± 0.92 (12)</td>
<td>30.03 ± 1.90* (55)</td>
<td>7.41 ± 2.36 (15)</td>
<td>34.80 ± 7.20* (64)</td>
<td>12.90 ± 3.95 (18)</td>
<td>37.20 ± 8.50* (89)</td>
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<td></td>
<td>1–2</td>
<td>16–24</td>
<td>5.60 ± 0.65 (11)</td>
<td>67.10 ± 17.50* (42)</td>
<td>12.05 ± 1.28 (9)</td>
<td>90.50 ± 22.10* (65)</td>
<td>20.10 ± 0.50 (6)</td>
<td>69.0 ± 16.30* (91)</td>
</tr>
<tr>
<td></td>
<td>2–3</td>
<td>25–28</td>
<td>7.33 ± 0.20 (5)</td>
<td>105.90 ± 1.60* (68)</td>
<td>15.88 ± 0.59 (6)</td>
<td>121.70 ± 4.70* (62)</td>
<td>22.63 ± 1.75 (6)</td>
<td>110.50 ± 2.90* (87)</td>
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<tr>
<td></td>
<td>3–4</td>
<td>29–32</td>
<td>8.39 ± 0.56 (14)</td>
<td>111.00 ± 1.70* (36)</td>
<td>17.61 ± 0.60 (6)</td>
<td>131.60 ± 1.60* (68)</td>
<td>26.97 ± 0.09 (12)</td>
<td>118.50 ± 1.60* (94)</td>
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<tr>
<td></td>
<td>4–5</td>
<td>33–36</td>
<td>10.02 ± 0.46 (8)</td>
<td>116.70 ± 2.80* (59)</td>
<td>20.63 ± 1.87 (10)</td>
<td>137.90 ± 1.70* (56)</td>
<td>28.03 ± 0.39 (4)</td>
<td>123.30 ± 1.80* (79)</td>
</tr>
<tr>
<td></td>
<td>5–6</td>
<td>37–40</td>
<td>11.26 ± 0.62 (6)</td>
<td>121.10 ± 0.30* (63)</td>
<td>24.96 ± 0.72 (6)</td>
<td>145.80 ± 2.90* (52)</td>
<td>31.32 ± 1.54 (8)</td>
<td>129.90 ± 1.60* (63)</td>
</tr>
<tr>
<td></td>
<td>6–7</td>
<td>41–44</td>
<td>12.74 ± 0.43 (6)</td>
<td>121.20 ± 0.70* (42)</td>
<td>28.83 ± 1.15 (12)</td>
<td>154.90 ± 3.30* (45)</td>
<td>35.22 ± 0.69 (6)</td>
<td>137.20 ± 2.40* (83)</td>
</tr>
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<td></td>
<td>7–8</td>
<td>45–48</td>
<td>13.56 ± 0.30 (5)</td>
<td>125.00 ± 2.50* (45)</td>
<td>35.10 ± 1.97 (10)</td>
<td>167.20 ± 4.50* (45)</td>
<td>37.92 ± 1.09 (8)</td>
<td>148.30 ± 3.70* (89)</td>
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<td></td>
<td>8–9</td>
<td>49–52</td>
<td>15.10 ± 0.69 (9)</td>
<td>133.50 ± 1.20* (54)</td>
<td>41.04 ± 1.30 (5)</td>
<td>188.0 ± 13.50* (39)</td>
<td>40.58 ± 0.01 (9)</td>
<td>168.30 ± 9.20* (99)</td>
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<td></td>
<td>9–10</td>
<td>53–56</td>
<td>20.49 ± 2.70 (8)</td>
<td>143.00 ± 6.20* (23)</td>
<td>50.88 ± 6.31 (13)</td>
<td>219.10 ± 13.50* (48)</td>
<td>45.84 ± 3.96 (10)</td>
<td>211.70 ± 15.90* (80)</td>
</tr>
<tr>
<td></td>
<td>10–11</td>
<td>57–60</td>
<td>32.19 ± 5.27 (9)</td>
<td>181.00 ± 1.40* (12)</td>
<td>61.62 ± 1.49 (5)</td>
<td>272.80 ± 19.50* (26)</td>
<td>54.61 ± 2.27 (9)</td>
<td>258.10 ± 9.40* (31)</td>
</tr>
<tr>
<td></td>
<td>11–12</td>
<td>61–64</td>
<td>44.49 ± 3.84 (9)</td>
<td>226.30 ± 29.50* (6)</td>
<td>68.12 ± 4.22* (7)</td>
<td>339.10 ± 28.90* (8)</td>
<td>64.10 ± 2.19 (5)</td>
<td>283.10 ± 5.40* (12)</td>
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</table>

The values are expressed as mean ± SD, * significant differences between BLC in humans and dogs from the same region at P<0.05. Values in parentheses indicate the number of blood samples.

Fig. 1. Simple linear regression of BLC in dogs and people living in LS (µg/L)
Discussion

People and domestic animals often share the same environmental conditions resulting in similar exposure to lead. Lead concentration in blood is a widely accepted and commonly used measure of lead exposure, and is considered to reflect recent, and to some extent past exposure to this metal (21). The order of lead concentration in the blood of urban dogs found in this study is similar to that reported by others (2, 12–14). Our findings also indicate that BLC in dogs was lower than the concentration reported for people living in the same environment, irrespective of the regions examined. These data are in contrast to a report indicating that dogs tend to have significantly higher blood lead concentration than people (5). On the other hand, it should be emphasised that the observed higher BLC in people in our study confirms the findings of Thomas et al. (24), who also reported a higher blood lead concentration in children than in dogs living in 83-low income suburbs families.

The present studies indicated that both in people and in dogs BLC grew with age. The tendency for BLC increases observed within the age subgroups tested was similar in the two species examined. This evidence that the ongoing process of aging may be a major factor in body lead burden in people and in dogs. Considering a comparable response of dogs and people to toxic action of lead, it is reasonable to use a cut-off value of 100µg/L regarded as the reference blood value level in humans (8). In all regions examined, the dogs tested had lead concentrations below the critical level of 100 µg/L; whereas, a high proportion of people (all above 20-year-old) had higher

Fig. 2. Simple linear regression of BLC in dogs and people living in the LGCMR (µg/L)

Fig. 3. Simple linear regression of BLC in dogs and people living in the USIR (µg/L)
BLC than the critical level. A high proportion of people with BLC > 100 µg/L demonstrated that people living in the three regions tested are more at risk of increased BLC than dogs living in the same environmental conditions. However, there is insufficient data to interpret these differences, but it is possible that the disparities between the two species resulted from behaviour patterns. Thus, it is suggested that higher BLC in people might be attributed to their outside activity where exposure to lead from environmental sources may be greater.

The findings, which involved a comparison of BLC between people and dogs in an age-dependent manner, indicate significant positive correlations between BLC in dogs and humans sharing similar environmental conditions. Moreover, the present study has confirmed that BLC in dogs provides supporting evidence to the reports of others on BLC in dogs living in the environment contaminated with lead (1, 5, 7), and may be a useful biomarker to assess the hazard of environmental lead to the health of people, because applying BLC in dogs enables the prediction of lead concentration in people and vice versa. Consequently, BLC in dog may be used, at least, for rough estimation of people’s exposure to lead from environmental sources. This relationship has an apparent advantage because it permits a non-invasive evaluation of BLC in people. It is not suggested that determination of BLC in dogs may replace BLC monitoring programme in people; however, the findings emphasise the fact that veterinarians are closely involved in protecting human health, and passing on information between medical and veterinary communities may be useful in estimation of lead body burden especially when clinical signs of lead poisoning are absent. It may be also concluded that increased BLC in dogs suggests an early warning to people living in the same environment.

References