CADMIUM CONCENTRATIONS IN THE ORGANS AND TISSUES OF CADAVERS FROM ACCIDENTAL DEATHS

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ABSTRACT

In this study cadmium concentrations in several organs of more than 100 cadavers were measured in order to estimate the total body burden of cadmium by age. Six hundred urine samples from inhabitants of Tokyo of various age groups were collected in order to measure cadmium concentrations to observe if urinary cadmium concentration reflects the total body burden. The average renal cadmium concentration in the age group 40-49 years reached about 200 µg/g (20 mg net weight in the kidneys). However, individual variation was very great. The total body burden of cadmium was calculated to be about 45 mg in the age groups 30-59 years. In general, cadmium concentrations in the organs and the total body increased with age, leveling off at about 60 years of age. The average cadmium concentration in urine was 1.7 µg/l in all age groups, increasing by age and showing a pattern similar to that of cadmium concentrations in the total body according to age, and it was shown that on a group basis, cadmium in urine of the Japanese people reflected the total body burden of cadmium.

INTRODUCTION

The purpose of this study was to estimate cadmium contents in several organs and in the total body, and to evaluate the relationship of cadmium concentration in urine to the total body burden.

There is a report concerning cadmium concentrations in tissues and organs of the Japanese people, but this report was not sufficient in its statistical and systematic evaluation. The present study aimed to collect more exact data on cadmium concentrations in tissues and organs by analyzing sufficient numbers of samples for statistical evaluation and for calculating biological half-times.

Tsuchiya presented this paper as well as the second part of this study on biological half-time at the XVIIth International Congress on Occupational Health.
Subcommittee Meeting on the Toxicology of Metals in Buenos Aires, held in September 1972.2

MATERIALS AND METHODS

The materials used for the cadmium analyses were collected from cadavers on which autopsies were performed in the Department of Legal Medicine, Keio University School of Medicine, during the period October 1970 to March 1972. One hundred sixty cadavers were autopsied. The autopsies were performed on those persons with no known disease or poisoning who had lived in the Tokyo area and had died accidental deaths. Cadavers without recognized autolysis were used for the study. The organs and tissues subjected to the study were the renal cortex, renal medulla, liver, pancreas, heart muscle, aorta. Bile was also examined.

The method of analysis for cadmium was as follows. After wet ashing with dithizone extraction, atomic absorption spectrophotometry was used for calibration. For cross checking purposes, each sample was analyzed by two laboratories. Since information concerning sex, age, occupational history, height, body weight, organ weight, etc. was recorded for each cadaver, it was possible to compute not only the concentration of cadmium in a given organ, but the net content of cadmium in the organ. Cadmium content in the total kidney was calculated using the following equation: Cd content in kidney = Weight of both kidneys (g) × Cd concentration in the cortex (µg/g) × 0.722 + Weight of both kidneys (g) × Cd concentration in the medulla (µg/g) × 0.278.3 The total body burden was calculated by multiplying the cadmium content in the kidneys and liver by two.4 In addition to the organ study, about 600 specimens of urine were collected from inhabitants in Tokyo.

RESULTS

Cadmium concentrations in the renal cortex according to age group are shown in Table 1. A sharp increase in cadmium concentration with age was observed. It is important to note that the cadmium concentration in the 40–49 year-old group was 204 µg/g, in 99% level of significance, and also that the variation was great even within the same age group. In Figure 1, the net contents of cadmium in the kidneys by age are shown. The amount of cadmium in kidneys in the age group of 40–49 years and 50–59 years was about 20 mg with great standard deviation. As shown in Figure 2, the age group with the highest content of cadmium in the liver (about 7 mg) was located between 30 and 40 years of age. Again the variation was so great that the mean cadmium content of the three samples from the
Cadmium Concentration in the Organs

Table 1

Cadmium concentration in renal cortex by age
—Means and 99% level of significance—

<table>
<thead>
<tr>
<th>Age</th>
<th>Mean</th>
<th>S.D.</th>
<th>M+S.D.×2.5</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 ~ 9</td>
<td>4.75</td>
<td>5.07</td>
<td>17.43</td>
<td>13</td>
</tr>
<tr>
<td>10 ~ 19</td>
<td>33.2</td>
<td>31.48</td>
<td>—</td>
<td>5</td>
</tr>
<tr>
<td>20 ~ 29</td>
<td>46.25</td>
<td>21.53</td>
<td>100.09</td>
<td>38</td>
</tr>
<tr>
<td>30 ~ 39</td>
<td>69.21</td>
<td>29.31</td>
<td>142.49</td>
<td>27</td>
</tr>
<tr>
<td>40 ~ 49</td>
<td>85.07</td>
<td>47.49</td>
<td>203.8</td>
<td>11</td>
</tr>
<tr>
<td>50 ~ 59</td>
<td>125.3</td>
<td>56.74</td>
<td>—</td>
<td>6</td>
</tr>
<tr>
<td>60 ~ 69</td>
<td>125.88</td>
<td>14.20</td>
<td>—</td>
<td>3</td>
</tr>
<tr>
<td>70 ~ 79</td>
<td>37.9</td>
<td>—</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>80 ~</td>
<td>94.68</td>
<td>18.7</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>57.99</td>
<td>41.85</td>
<td>162.62</td>
<td>106</td>
</tr>
</tbody>
</table>

age group over 60 years showed more than 15 mg. In Figure 3, the correlation between concentrations of cadmium in the liver and renal cortex is shown. The correlation was significant within 0.54 of the correlation coefficient, although some samples showed very high cadmium in the renal cortex with very low liver cadmium, and vice versa. The cadmium concentration in the aorta was 0.15 µg/g in the age group 0 to 9 years and about 0.5–0.6 µg/g in the age groups 40–60 years. The cadmium content in the pancreas was very low in the age group 0–9 years, and the highest was found in the age group 40–49 years, showing about 350 µg, again with great variation. Cadmium content in the renal medulla was rather low, showing about 1.5 mg between the ages 40 to 49 years. Cadmium content in the heart muscle increased gradually with age, showing up to 100 µg at the age 50 to 59 years.

As shown in Figure 4, the total body burden of cadmium was about 30 mg in the age group 10–30 years, about 45 mg in those 30–50 years of age, and about 55 mg in those 50 to 59 years. However, since there were only 7 samples for the last age group, it may be unwise to state that this age group had the highest total body burden.

In Figure 5, the cadmium concentrations in urine from 609 Tokyo inhabitants by age is shown. The observed cadmium concentrations in urine by age fitted very well the theoretical curve calculated by an equation which included caloric intake and observed values as variables. Tsuchiya has discussed this equation in a paper entitled, “Mathematical Derivation of the Biological Half-time of Cadmium in Some Organs,” presented at the above-mentioned Subcommittee Meeting in Buenos
Fig. 1  Cadmium Content in Kidneys.

Fig. 2  Cadmium Content in Liver.
Cadmium Concentration in the Organs

Fig. 3 Cd Concentrations in Liver and Renal Cortex by Age.

Fig. 4 Total Body Burden of Cadmium by Age.
The theoretical curve shown in Figure 5 indicates a pattern similar to that of the total body burden by age. The mean values of urinary cadmium in the age group 30–59 years of age were about 1.7 ± 1.5 µg/l. The highest was about 10 µg/l.

DISCUSSION

Some studies concerning cadmium concentrations of organs and tissues of human bodies have been reported by Kitamura and Ishizaki in Japan. However, in the studies, the number of samples used was not statistically sufficient for evaluating the distribution curve by age. A report by Tipton et al. mentions higher cadmium concentrations in the organs of the people of Far East Asia, but they used cadavers from pathological autopsies and the sample number from Far East Asia was not sufficient for statistical analysis. As shown clearly in this report, standard deviations of the organs and tissues were so great that it is dangerous to draw conclusions from the analysis of only a small number of samples. It is particularly important to note that the cadmium concentration varied greatly even within the same age group, and at least 20 or 30 samples are re-
quired in order to derive biological half-times or to evaluate the critical body burden of cadmium. The reason why the observed curve of cadmium concentration in urine by age fitted the theoretical curve very well is that a sufficient number of samples, a total of 609 with over 40 samples for most age groups, was used for the urine study.

This urine study showed the same result as that of Imbus. From these two observations as well as from the observation on the relationship between urinary cadmium concentration and total body burden, there is no reason to conclude that the Japanese people are exposed to higher levels of cadmium than are Americans.

CONCLUSION

One hundred sixty cadavers from autopsies and 609 urine samples from Tokyo inhabitants were used for the cadmium analyses. The principal results obtained were as follow:

1. The net renal cadmium content in persons between the ages of 40 to 59 years was about 20 mg, with great standard deviation.
2. The maximum concentration of cadmium in the renal cortex in those between the ages of 40 to 49 years was 204 µg/g in 99% level of significance.
3. The total body burden was about 45 mg in those between the ages 30 to 59 years.
4. The curve of urinary cadmium concentrations according to age showed a pattern similar to that of the total body burden. The cadmium level in urine was 1.7 µg/l on the average in those between the ages of 30 to 59 years, with a standard deviation of about 1.5 µg/l.
5. As the cadmium concentration or content in organs or tissues in general varied greatly by individual even within the same age group, it is important to analyze as many samples as possible—more than 20 or 30 samples from groups of the same age and sex—in order to derive biological half-times or to evaluate the critical body burden of cadmium.

ACKNOWLEDGEMENT

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REFERENCES

Note: Since this study was presented at the XVIIth International Congress on Occupational Health in Buenos Aires, September 17–23, 1972, reports which have
appeared since that time have not been included in the references.