Effect of cigarette smoking on copper, lead, and cadmium accumulation in human lens

Osman Cekic

Abstract

Aim—To identify cigarette smoking as a risk factor for development of cataract, to determine the importance of copper, lead, and cadmium in cataractogenesis, and to learn about any relation between these elements.

Methods—Copper, lead, and cadmium concentrations were measured by atomic absorption spectrophotometry in 37 cataractous and nine normal human lenses.

Results—All three element accumulations in lenses with cataract were statistically meaningful. Lenticular copper, lead, and cadmium were increased significantly with cigarette smoking. Cadmium had a positive correlation both with lead and copper in cataractous lenses.

Conclusion—The accumulation of copper, lead, and cadmium occurs in cataract. The probable source of cadmium in humans is cigarettes. Lenticular cadmium accumulation also increases copper and lead precipitation in the lens. Cigarette smoking might be cataractogenic.


Cataract is responsible for visual impairment in 30 million to 45 million people and is the largest single cause of blindness worldwide. At least 5 million to 10 million new, visually disabling cataracts occur yearly around the world. From a clinical standpoint, cataract is defined as visual impairment as a result of a disturbance of lens transparency. However, although small opacities which do not fall within the visual axis have little effect on visual acuity, any source of light scattering can be considered a cataractogenic lesion from a biochemical standpoint. Senile cataracts probably result from many, possibly compound, obscure causes. Race, altitude, dietary habits, aging, diabetes, cardiovascular disease, cigarette smoking, use of topically applied ophthalmic drugs, environmental factors, occupation, exposure to sunlight, low socioeconomic status are some that have been suggested. Overall, comparing copper, lead, and cadmium levels of normal and cataractous lenses, it could not be detected in normal lenses, it could not be detected in normal human lenses copper, lead, cadmium, and calcium contents were measured with an atomic absorption spectrophotometer. The ages of the cataractous group ranged from 46 to 73 years (mean 54.7 (SD 5.4)) while the control group ranged in age from 51 to 67 (57.7 (3.2)) years. Normal lenses were removed from cadaver eyes within 10 hours after death. The cataractous lens material was obtained by extracapsular lens extraction in patients with a visual acuity of 10/100 or worse. Lenses from cadaver eyes were examined visually and the nuclear parts of the clear ones were included in the study. The lenses were placed into scrupulously cleaned glass pots, and they were kept frozen at temperatures below −20 °C until analysis of the elements. Then they were dried in an oven at 90 °C until a constant weight was reached. Dry weights of all the samples were measured, then they were burned till all their organic parts had been lost. Residual inorganic parts were diluted with distilled water up to a known volume. The copper, lead, and cadmium levels were measured by atomic absorption spectrophotometry (Hitachi 180/80 AAS) by using a standard addition technique and a graphite furnace system. All the measurements were taken twice. Results were calculated in terms of µg/g dry tissue weight (ppm).

The results were analysed by Student’s t test, and correlation analysis.

All the lens samples were taken from patients who had no metabolic or systemic disease, and who were not taking medication that could interfere with their blood element level.

Results

The mean concentrations of copper (Cu), lead (Pb), and cadmium (Cd) of normal and cataractous female and male lenses, as determined by the methods described above, are presented in Table 1. For the cataractous lenses, no meaningful difference was noted in the accumulation of copper or lead levels according to the sex differences. The mean concentration of cadmium was significantly higher in males (1.05 (SD 0.18) ppm) than in females (0.88 (0.22) ppm) (p<0.01). While there was no significant difference for normal human lenticular mean copper content, normal lenses also showed higher levels of cadmium in males (0.055 (0.004) ppm) than in females (0.032 (0.003) ppm) (p<0.05). Although there was some lead in cataractous lenses, it could not be detected in normal lenses.

Overall, comparing copper, lead, and cadmium levels of normal and cataractous group,
Table 1  The mean (SD) Cu, Cd, and Pb levels in cataractous and normal human lenses (µg/g dry tissue weight = ppm)

<table>
<thead>
<tr>
<th>Lenses</th>
<th>Cu</th>
<th>No</th>
<th>Cd</th>
<th>Pb</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cataractous</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>overall</td>
<td>2.11</td>
<td>(0.47)</td>
<td>0.99</td>
<td>(0.21)</td>
<td>37</td>
</tr>
<tr>
<td>males</td>
<td>2.13</td>
<td>(0.44)</td>
<td>1.05</td>
<td>(0.18)</td>
<td>25</td>
</tr>
<tr>
<td>females</td>
<td>2.04</td>
<td>(0.53)</td>
<td>0.88</td>
<td>(0.22)</td>
<td>12</td>
</tr>
<tr>
<td>p Values</td>
<td>&gt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>overall</td>
<td>0.69</td>
<td>(0.15)</td>
<td>0.05</td>
<td>(0.04)</td>
<td>9</td>
</tr>
<tr>
<td>males</td>
<td>0.66</td>
<td>(0.16)</td>
<td>0.88</td>
<td>(0.22)</td>
<td>12</td>
</tr>
<tr>
<td>females</td>
<td>0.72</td>
<td>(0.12)</td>
<td>0.03</td>
<td>(0.03)</td>
<td>4</td>
</tr>
<tr>
<td>p Values</td>
<td>&gt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

Table 3  Correlation coefficient values between the elements studied in cataractous and normal human lenses

<table>
<thead>
<tr>
<th>Lenses</th>
<th>Cu-Cd</th>
<th>Cu-Pb</th>
<th>Cd-Pb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cataractous</td>
<td>0.65</td>
<td>0.41</td>
<td>0.63</td>
</tr>
<tr>
<td>Normal</td>
<td>-0.38</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Many studies have linked cataract with smoking, but there is speculation about the mechanism. Smoking appears to induce oxidative stress, in that smokers have diminished level of antioxidants such as vitamin C, vitamin E, and carotenoids. Cyanide and thiocyanide levels are raised in the blood of smokers, and cigarette smoke is rich in free radicals and aldehydes. Highly reactive radicals are unlikely to reach the lens, but some aldehydes might find their way to the lens to attack enzymes and other proteins in the same way as isocyanate. The constituent aromatic compounds and trace metals in smoke condensates generate long lived reactive oxygen species which eventually might cause oxidative damage to the lens and produce cataracts. Finally, the changes in the cadmium and some other trace metals in the blood might be responsible for cataractogenesis in smokers. Additionally, cadmium possibly interacts with various components of the lens during the process of cataractogenesis.

Smoking as a source of exposure to cadmium has been recognised for at least 25 years. Investigators found cadmium at 1.56 to 1.96 µg per cigarette. Data showed that 0.1–1.2 µg of cadmium might have been inhaled by smoking one cigarette. In this study, the cadmium concentration was found to be higher in cataractous than in normal lenses, as had previously been reported. Ramarkrishnan et al found a significant accumulation of cadmium in both the blood and the lens of smokers. It is likely that the major source of cadmium is tobacco smoke and the high concentration of cadmium in tobacco leaves probably results from the widespread use of chemical fertilisers. We found significantly higher cadmium level in cataractous smokers in our study. Data showed an increasing cadmium concentration in the lens with increasing numbers of cigarettes per day.

Cadmium may hasten cataractogenesis by various mechanisms. It is known to compete with copper in the body and could affect the copper homeostasis of blood and copper containing proteins. Copper is necessary for the normal physiological activity of numerous enzymes such as cytochrome oxidase, superoxide dismutase, and uricase. Derangements in copper metabolism and resulting changes in its concentration within tissues and body fluids have been associated with pathological states.
Numerous investigators have reported alterations in trace metal components of the lens occurring in cataractogenesis. While some reported no correlation between copper and cataract, some had shown raised, and some decreased levels of copper in cataractous lenses. In the present study, we observed raised copper level in the cataractous lenses. There was no significant difference in copper values in relation to both normal and cataractous groups.

Cadmium may directly interact with lens proteins and denature them in cataractogenesis. It is known that heavy metal ions such as lead can precipitate blood and body proteins. Lead accumulation in the body is also a result of pollution. We could not detect lead in normal lenses while it was found in cataractous lenses. This also confirms previous studies.

Lenticular copper and lead was also observed to be significantly higher in smokers. Cadmium accumulation possibly increased the absorption of the other two elements. There were positive correlations between copper and lead with cadmium content in the cataractous lenses. So, it can be hypothesised that raised concentrations of cadmium in smokers might trigger copper and lead accumulation in the lens, or the precipitation of copper and/or lead might also cause the precipitation of cadmium.

Copper, lead, and cadmium accumulation occurs in the cataractous lenses. Current smoking or number of cigarettes smoked per day might be a significant risk factor in cataractogenesis.

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