EFFECT OF LEAD ON THE HEALTH OF SILVER JEWELLERY WORKERS: A CASE STUDY OF AJMER CITY, RAJASTHAN, INDIA

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ABSTRACT

Lead accumulates slowly in the body and even low doses can eventually lead to poisoning. 95% of lead in body is deposited in the bones and teeth while 99% of lead in blood is associated with erythrocytes. Occupational exposure to lead is widespread problem in every region. In the occupational setting, exposure occurs both through inhalation of airborne lead and contaminated tobacco smoker and through ingestion of contaminated food, drink and sniff. The relationship between serum lead level and health effects were assessed in a pilot cross-sectional study of Silver Jewellery Workers (SJW) group in Ajmer city, India. Human blood samples were collected from 40 persons of SJW group. The level of serum lead concentration ranging from 0.4 to 142.65 µg/dl. The prominent findings among the lead-exposed SJW group were impaired concentration, encephalopathy, fatigue, abdominal colic, abnormal sperm, anemia, renal failure, muscular exhaustability, joint pain and myalgia. Such results might point that occupational exposure increases the serum lead levels of SJW group and lead adversely affects multiple organ systems and can cause permanent damage.

Key Words: Lead, Human blood, Silver Jewellery Worker (SJW), Serum lead level, Anemia

INTRODUCTION

Lead has been used by humans for at least 7000 years.1 It is highly resistant to corrosion, pliable, having high density, low elasticity, high thermal expansion, low melting point, easy workability, easily recycled and excellent antifriction metal and inexpensive, due to its excellent properties used in acid battery manufacture, printing press, silver jewellery making, soldering cans, traditional practices such as folk remedies, cable sheathing, in colour pigments, petrol additives, soldering water distribution pipes, ceramic glazes, paper industries. Lead and its compounds can enter the environment at any point during mining, smelting, processing, use, recycling or disposal.2-5 Health risks are increasingly associated with environmental exposures to lead emissions from the wide spread use of lead in industrial set up.6 Lead (Pb) is a heavy metal, one that is not needed by the human body. This element is found in the environmental naturally that can be harmful to humans. According to the World Health Organization (WHO) and Blood Lead Level (BLL) of more than 30 µg/dl is an indicator of significant lead exposure in the industrial workers.7 The Occupational Safety and Health Administration (OSHA) recommended 40 µg/dl as maximum acceptable BLL for the workers but the current OSHA standards fail to protect occupationally exposed males and females from all adverse affect of lead, hence the threshold of 25 µg/dl is the objective.8

In developed countries due to better identification, monitoring and improvement in industrial safety method, occupational lead exposure has been significantly reduced. However, in developing countries lead toxicity is a persistent health problem for occupational workers. High prevalence of lead toxicity has been reported in construction workers in Poland and lead smelters in South Korea.9 A human exposure to lead is mainly through the air, food, dust, soil and water. The inhalation and ingestion are the primary roots of absorption of lead compounds. Approximately 40% lead oxide fumes are absorbed through
respiratory tract and 5-10% absorbed from the gastro-intestinal tract. In blood 99% lead is mainly bound to erythrocytes and 2% in plasma, which can be distributed to brain, kidney, liver skin and skeletal muscles where it is readily exchangeable. The ingested and absorbed lead is mainly stored in soft tissues and bones. Lead-induced hypertension can occur in the absence of nephropathy. The mechanisms include vascular changes, increased sensitivity to catecholamines and an effect of lead on the renin-angiotensin system and on calcium signaling mechanisms, resulting in enhanced vasoconstriction and hypertension.

Ajmer is famous for silver processing work. The old silver ornament and jewellers waste are smelted with lead scraps at high temperatures in congested workshop without adequate exhaust system, ventilation and precaution but Silver Jewellery Workers (SJW) do not adopt proper protective measures. So SJW are directly exposed to lead oxide dust and lead fumes. As a result of this SJW get lead toxicity by ingestion, inhalation and direct skin contact which damaging their organ systems. That is why lead analysis in blood serum is a very useful diagnostic tool.

**AIMS AND OBJECTIVES**
1. Collection of blood samples from SJW of the Ajmer, Rajasthan, India
2. To Measure the levels of lead in the blood serum of SJW.
3. To find out the occupational health hazards prevailing in the SJW due to lead exposure.

**MATERIAL AND METHODS**

**Study area**
The study was carried out in Ajmer city in Rajasthan, India. The area under investigation, Ajmer is the geographical centre of Rajasthan lies between 26° 25’ and 26° 29’ North Latitudes and 74° 37’ and 74° 42’ East Longitude. Area of Ajmer is 8481 sq. km.

**Instrumentation**
Lead in blood serum was analyzed by Atomic Absorption Spectrophotometer (Model No. 4141). The operating parameters of Atomic absorption spectrophotometric (AAS) are shown in Table 1.

**Table 1 : Optical Parameters for lead determination**

<table>
<thead>
<tr>
<th>S/N</th>
<th>Parameters</th>
<th>ECIL, AAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Wave length</td>
<td>217.00</td>
</tr>
<tr>
<td>2.</td>
<td>Slit setting</td>
<td>1.0 nm</td>
</tr>
<tr>
<td>3.</td>
<td>Light source</td>
<td>Hollow cathode lamp</td>
</tr>
<tr>
<td>4.</td>
<td>Flame type</td>
<td>Air - A acetylene flame oxidizing (Lead, blue)</td>
</tr>
<tr>
<td>5.</td>
<td>Operating current</td>
<td>5mA</td>
</tr>
</tbody>
</table>

**Reagents and samples**
All reagents and standard were of analytical grade. Stock standard solutions of lead were 1000 μg mL⁻¹ solution. The working standard solutions were prepared weekly by appropriate dilution and keep refrigerated at 4°C. Nitric acid and perchloric acid were used. Double distilled water was also used in all operations. Human blood samples were collected from 40 SJW with a 10 ml polypropylene syringe equipped with silicon-coated glass tubes and centrifuged at 3000 rpm for 20 minutes. The supernatants were collected as the blood serum sample.

**Procedure**
0.5 ml of serum was initially heated on a hot plate with 10 ml of nitric acid for approximately 30 min. at 1100°C. Heating was supplied to maintain gentle boiling of the solution. The reaction was carried out in a 100 ml beaker covered with watch glass to the loss of the sample. Further 10 ml of HNO₃ was added and heating continue for a further 30 min. A 2 ml of portion of 70% per-chloric acid was subsequently added and the contents were gently heated on a hot plate until the solution becomes colorless and the white fumes of HClO₄ were evolved. When the solutions were cooled to room temperature the contents were brought to volume double distilled water and the solutions were kept mixed with a magnetic stirrer.
RESULTS AND DISCUSSION

Forty Silver Jewellery Workers (SJW) who were exposed to lead for long duration, ranging from 15 to 45 years participated in the study. As the age of SJW increases the lead concentrations in blood serum increases (Table 2). The mean and SD value of lead in blood serum in SJW were significantly higher in age group between 41 to 45 year. 31 out of 40 SJW with high serum lead levels 88.07±32.6 μg/dl (range 41.61-142.65 μg/dl) were affected of severe lead poisoning. Most of these SJW have shown clinical symptoms such as peripheral neuropathy, fatigue, impaired concentration, encephalo-pathy, nausea, dyspepsia, abdominal colic, sperm abnormalities, spontaneous abortion, kidney dysfunction, anemia and muscular wasting suggestive of lead poisoning. The remaining 7 SJW (15 to 20 year) have also shown significant alterations in lead sensitive parameters and shown separately (Table 3) because of far lower serum lead (6.77±3.6 μg/dl) and less clinical symptoms. However they seem to have a risk of developing lead poisoning. The mean of serum lead revealed that thirty one (78%) SJW had blood serum concentration above WHO recommended levels (>30 μg/dl). Thus increased lead body burden was found in 33 (82%) lead exposed SJW. Eleven (27.7%) lead exposed workers had serum lead levels more than the OSHA permissible limits (>40 μg/dl) and twenty (50%) SJW had greater than 80 μg/dl indicating severe lead toxicity (Fig. 1).

Table 2: Serum lead concentrations (μg/dl) of SJW according to age

<table>
<thead>
<tr>
<th>Age (year)</th>
<th>15-20</th>
<th>21-25</th>
<th>26-30</th>
<th>31-35</th>
<th>36-40</th>
<th>41-45</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4 (F)</td>
<td>23.25 (F)</td>
<td>43.91 (F)</td>
<td>64.22 (M)</td>
<td>80.51 (M)</td>
<td>105.83 (M)</td>
<td></td>
</tr>
<tr>
<td>5.17 (M)</td>
<td>24.88 (F)</td>
<td>47.86 (M)</td>
<td>65.56 (M)</td>
<td>80.55 (M)</td>
<td>107.78 (M)</td>
<td></td>
</tr>
<tr>
<td>5.9 (M)</td>
<td>41.61 (F)</td>
<td>49.77 (F)</td>
<td>66.45 (M)</td>
<td>83.06 (M)</td>
<td>110.16 (M)</td>
<td></td>
</tr>
<tr>
<td>7.34 (M)</td>
<td>41.82 (M)</td>
<td>53.62 (F)</td>
<td>-</td>
<td>83.7 (M)</td>
<td>121.44 (M)</td>
<td></td>
</tr>
<tr>
<td>8.05 (F)</td>
<td>42.07 (F)</td>
<td>48.03 (F)</td>
<td>-</td>
<td>87.59 (M)</td>
<td>122.79 (M)</td>
<td></td>
</tr>
<tr>
<td>8.07 (M)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>89.44 (M)</td>
<td>120.49 (M)</td>
<td></td>
</tr>
<tr>
<td>12.44 (M)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>99.56 (M)</td>
<td>124.03 (M)</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>89.46 (M)</td>
<td>124.26 (M)</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>124.55 (M)</td>
<td></td>
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<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>124.76 (M)</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>142.62 (M)</td>
<td></td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>142.65 (M)</td>
<td></td>
</tr>
</tbody>
</table>

M = Male, F = Female

Table 3: Mean values of serum lead levels of SJW according to age

<table>
<thead>
<tr>
<th>Age group (years)</th>
<th>No. of SJW</th>
<th>Serum lead levels (μg/dl)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15-20 (n=7)</td>
<td>7</td>
<td>6.77±3.6</td>
</tr>
<tr>
<td>21-25 (n=5)</td>
<td>5</td>
<td>34.73±9.8</td>
</tr>
<tr>
<td>26-30 (n=5)</td>
<td>5</td>
<td>48.64±3.5</td>
</tr>
<tr>
<td>31-35 (n=3)</td>
<td>3</td>
<td>65.41±1.1</td>
</tr>
<tr>
<td>36-40 (n=8)</td>
<td>8</td>
<td>86.73±6.3</td>
</tr>
<tr>
<td>41-45 (n=12)</td>
<td>12</td>
<td>122.61±11.6</td>
</tr>
</tbody>
</table>

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The present findings are consistent with our earlier surveys conducted among SJW and show that at least 33 out of 40 workers involved in silver processing were indeed suffering from lead poisoning. The old silver ornaments and jeweller's waste are smelted with lead scrapes out high temperatures in congested work shop without adequate exhaust system, ventilation and protective measures where workers are exposed to lead fumes and lead oxide dust. Their clothing, hair and food also get contaminated. Lead exposed SJW above the recommended limits of OSHA and WHO and require periodic medical examination. The mean level of lead in the blood serum of silver jewellery workers were 6.77±3.6 (15-20 years), 34.73±9.8 (21-25 years), 48.79±4.0 (26-30 years), 65.41±1.1 (31-35 years), 86.73±6.3 (36-40 years) and 122.61±11.6 (41-45 years) µg/dl. In which age group between 41 to 45 year was highly affected from lead poisoning while age group between 15 to 20 year was less affected from lead toxicity. The different health effects of lead poisoning in SJW group was presented in given below:

**Hypertension**
Hypertension is a major public health concern because it is a leading risk factor for heart disease, stroke and chronic kidney disease. Lead affect increases systolic and diastolic blood pressure. Some SJW whose serum lead levels were less than 20 µg/dl which was associated with increases in blood pressure.

**Renal effect**
Higher levels of lead exposure associated with worse clinical renal function. In our findings age group between 36 to 40 year (86.73±6.3 µg/dl) and 41 to 50 year (122.61±11.6) of SJW were highly affected to kidney dysfunction.

**Cardiovascular effect**
Higher lead exposure can cause cardiovascular disease. In our study, a significant relationship was found between higher serum lead levels causes coronary heart diseases. Age group of SJW between 41 to 50 (105.83-142.65 µg/dl) was severely affected from cardiac autonomic dysfunction.

**Reproductive effect**
Lead exposure and moderate lead absorption produced alteration in fertility with decreased production of spermatozoa, probability due to the direct toxic effect of lead on germinal epithelium of testis during spermatogenesis. In our study SJW, age group between 21 to 25 year (34.73±9.8 µg/dl) and 26 to 30 year (48.64±3.5 µg/dl) were affected sperm abnormalities. In which eight females were severely affected from spontaneous abortion.

**Gastrointestinal effect**
Blood lead level ≥ 80 µg/dl causing colic. Abdominal pain, constipation, cramps, nausea,
vomiting, anorexia and weight loss, collectively known as colic, are early symptoms of lead poisoning. In our study a significant relationship was found between lead levels in blood serum and gastrointestinal effects. In which SJW age group between 36 to 40 year (86.73±6.3 μg/dl) and 41 to 45 year (122.61±11.6 μg/dl) were hardly affected by abdominal colic.

Neurological effects
Lead affects the peripheral nervous system (especially motor nerves) and the central nervous system. Blood lead level 40-79 μg/dl causing neurocognitive deficits. In our studies we examined 40 SJW out of which 13 had serum lead concentration ranging between 33.25 to 66.45 μg/dl associated lead exposure causing neurocognitive deficits. A high lead level in blood serum of SJW also causes psychiatric symptoms such as depression and anxiety.

Anemia
Blood lead level ≥ 10 μg/dl was significantly associated with anemia decreased iron absorption and hematological parameters affection. In our study we found that serum lead concentrations in SJW age group between 31 to 35 year (65.41±1.1 μg/dl) and 36 to 40 year (86.73±6.3 μg/dl) were affected by low hemoglobin causing anemia. We concluded that strong relationship occur between high serum lead concentration and decreased hemoglobin in SJW.

Other health effects
Immediate health effects of high level exposure to lead resulting in blood lead values of 70-100 μg/dl or above are clinical emergencies and may cause encephalopathy. In our finding five SJW of age group between 41 to 45 year were affected by lumber pains and leg myalgia and Three SJW age group between 36 to 40 year were shown symptoms of encephalopathy.

CONCLUSION
The study shows that SJW are at a greater risk because of their exposure to lead fumes and lead oxide dust during their routine activities affecting many systems in their body like reproductive system, renal system, cardiovascular system, Gastrointestinal system, neurological system and may lead to damage to various organs. Serum lead levels are the most reliable tool for assessment of lead body burden and imminent health risks in SJW. The study helps to create awareness about the toxic effects of lead and may entail establishment of regulations for the precautionary measures to be taken amongst SJW exposed to lead.

REFERENCES
22. National Health and Medical research council, blood lead levels for Australians, NHMRC Information paper, 1-7, (2009).