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Original Research Paper

An Analytical Study of Lead in Blood Serum and Urine in Relation to Health of Silver Jewellery Workers of Ajmer City, Rajasthan

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ABSTRACT

Lead is a naturally-occurring element that can be harmful to humans when ingested or inhaled. The determination of lead in blood serum and urine is a very important clinical investigation procedure. The aim of this investigation was to determine the concentration of lead (Pb) in blood serum and urine samples of silver jewellery workers (SJW), because of their exposure to lead fumes and lead oxide dust during their routine activities of silver jewellery processing affecting many systems in their body. The relationship between serum lead levels and urinary lead levels with health effects were also assessed in a cross sectional study of the SJW group of Ajmer city. Blood and urine samples were collected from 40 SJW. Lead concentration in the samples was determined by atomic absorption spectrophotometer (AAS). The results indicate that the level of serum lead concentrations ranging from 0.4 to 142.65 µg/dl and the urinary lead level concentrations ranging from 0.66 to 134.98 µg /dl. The prominent findings among the lead exposed SJW group were impaired concentration, encephalopathy, fatigue, abdominal colic, spontaneous abortion, abnormal sperm, anaemia, kidney failure, etc. Such results might point that lead exposure increases the serum and urinary lead levels of SJW group. Lead poisoning affects multiple organ systems and can cause permanent damage.

INTRODUCTION

Lead has been used by human for many years (Zenz et al. 1994). It is highly resistant to corrosion having high density, low elasticity, high thermal expansion, low melting point, easy workability, excellent antifriction metal and inexpensive. Due to its excellent properties it is used in silver jewellery making, printing press, acid battery manufacture, soldering cans, traditional practices such folk remedies, cable sheating in colour pigments, petrol additives, soldering water distributing pipes, ceramic glazes and paper industries. Lead and its compounds can enter the environment at any point during mining, smelting, processing, recycling or disposal (Klaassen 2008, ATSDR 2005, WHO 1995).

In developed countries due to better identification, monitoring and improvement in industrial safety methods, occupational lead exposure has been significantly reduced. However, in developing countries, lead toxicity is a persistent health problem for occupational workers (Khan et al. 2009). High prevalence of lead toxicity has been reported in construction workers in Poland and lead smelters in South Korea (Kim et al. 2002). The blood lead level was significantly raised in the battery manufacturing workers, silver jewellery workers and spray painters in Western Maharashtra, India (Patil et al. 2007). Recently, significantly elevated blood and urinary lead levels have been reported in Pakistani steel mill workers (Afridi et al. 2006).

The inhalation and ingestion are the primary roots of absorption of lead compounds. Approximately, 40% of lead oxide fumes are absorbed through the respiratory tract and 5-10% absorbed from the gastro-intestinal tract. In blood, 98% lead is mainly bound to erythrocytes and 2% present in plasma, which can be distributed to brain, kidney, liver, skin and skeletal muscle where it is readily exchangeable (Dongre et al. 2010). The study of the relationship between lead exposure and metal levels in blood serum and bone showed that Pb in the serum is a better indicator of chronic contamination (endogenous exposure) and is toxicologically very significant. Lead can cause several harms to health. It interferes with the production of haemoglobin, causes renal neurological disturbances and affects the encephalon. These effects can be evidenced and can be correlated to several levels of its concentration in blood (Cake et al. 1996).

The biological monitoring of lead in blood serum and urine has become a matter of wide interest owing to the toxicity of these metals and their influence in controlling the course of biological processes. Therefore, our aim of this study was to assess the effects of lead exposure and its toxicity in blood serum and urine of silver jewellery workers from Ajmer city, Rajasthan (India).

THE STUDY AREA

Ajmer city is the geographical centre of Rajasthan and its area is 8481 sq. km. Ajmer is famous for silver processing

work. The old silver ornaments and jewellers waste is smelted with lead scraps at high temperature in congested workshops 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 damages their organ systems. That is why lead analysis in blood serum and urine is a useful diagnostic tool.

MATERIALS AND METHODS

Study group consisted of 40 occupationally lead exposed males and females from silver jewellery processing workshops in Ajmer city. For convenience, SJW were divided into different age groups to assess the degree of exposure to lead. The blood and urine sampling was done properly among the selected groups of SJW. Analysis was carried out by atomic absorption technique.

Instrumentation: On the basis of high sensitivity and simplicity, atomic absorption spectrophotometer model 4141 was used for these determinations. The optical parameters of the atomic absorption spectrophotometer are given in Fig. 1.

Reagents and solutions: Analytical reagent grade HCl, HNO_3, $HClO_4$ and H_2O_2 were procured from E. Merck Germany. Certified standard stock solution of Pb was obtained from CDH India for calibration purpose. Fresh standard solutions were prepared from stock solutions on each day of analysis by dilution with 5% HNO_3 solution in distilled water. Blank solutions were treated and prepared exactly in the same way as the samples. All glassware and apparatus used were cleaned by soaking in 5% HNO_3 followed by rinses with distilled water before use. All working solutions were also prepared in double distilled water.

Preparation of blood serum samples and their digestion: Human blood samples were collected from 40 SJW suffering from lead poisoning 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.

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. Heat was supplied to maintain gentle boiling of the solution. The reaction was carried out in a 100 mL beaker covered with a watch glass to prevent the loss of the sample. Further 10 mL of HNO_3 was added and heating was continued for a further 30 min. A 2 mL portion of 70% perchloric acid was subsequently added and the contents were gently heated on a hot plate until the solution became colourless, and the white fumes of $HClO_4$ were evolved. When the solution was cooled to room temperature, the contents were brought to volume with double distilled water and the solutions were kept mixed with a magnetic stirrer (Mamtha 2011).

Preparation of urine samples and their digestion: The urine samples were collected using 30 mL sealed plastic containers. The containers were washed thoroughly with detergent and distilled water to avoid any contamination. Fresh urine tends to decompose to become alkaline due to the breakdown of urea to ammonium carbonate; but can be stored in a refrigerator. Because of lack of storage facilities, the samples were collected and digested the same day and kept in a refrigerator for a few days before analysis.

10 mL each of urine samples were measured with a measuring cylinder into a 150 mL beaker and 10 mL of 1:1 nitric acid was added. Each of the mixture was covered with a watch glass and heated using an adjustable hot plate and was allowed to reflux for 10-15 minutes without boiling. It was then allowed to cool and 15 mL of concentrated nitric acid was added and allowed to reflux for 30 minutes. The last step was repeated and the mixtures were allowed to evaporate to about 5 mL without boiling. They were allowed to cool and 2 mL of water and 3 mL of 30% hydrogen peroxide was added. Each beaker was covered with a watch glass and placed on a hot plate and allowed to heat until the effervescence was minimal. It was then allowed to cool and 5 mL of concentrated HCl and 10 mL of water was added and heated and refluxed for 15 minutes without boiling. The samples were finally diluted to 100 mL volume with distilled water after cooling and were then filtered using suction filtration to remove any particulate matter (Adotey et al. 2011).

RESULTS AND DISCUSSION

Forty silver jewellery workers (SJW) who are exposed to lead for long duration, ranging from 15 to 45 years participated in the study. It was found that at least 33 out of 40 workers, involved in silver processing, were suffering from lead toxicity. The mean ± SD values of lead in blood serum in SJW were 6.77±3.6 mg/dl (15-20 year), 34.73±9.8 mg/dl (21.25 years), 48.64±3.5 mg/dl (26-30 year), 65.41±1.1 mg/dl (31-35 year), 86.73±6.3 mg/dl (36-40 year) and 122.61±11.6 mg/dl (41-45 year) (Fig. 1). The mean urinary lead levels of SJW were 7.29±3.7 mg/dl (15-20 year), 35.85±8.8 mg/dl (21-25 year), 49.81±3.1 mg/dl (26-30 year), 65.59±1.8 mg/dl (31-35 year), 86.11±4.1 mg/dl (36-40 year) and 110.28±12.5 mg/dl (41-45 year) respectively (Fig. 2). Urinary and serum lead concentrations are also given in Fig. 3. In the age groups between 36-40 and 41-45 year, the serum lead level was higher than urinary lead level. As the age of SJW increases, the lead concentrations in blood serum and urine increases (Tables 2 & 3).

The mean ± SD values of lead in blood serum and urine in SJW were significantly higher in the age group between 41 to 45 years. 31 out of 40 SJW with high serum lead levels (range 41.61-142.65 mg/dl) and urinary lead levels 42.44-134.98 mg/dl, were affected from severe lead toxicity. Most of these SJW have shown clinical symptoms such as impaired concentration, fatigue, encephalopathy, nausea, dyspepsia, abdominal colic, sperm abnormalities, spontaneous abortion, kidney dysfunction, anaemia and muscular wasting suggestive of lead poisoning. The remaining 7 SJW (age group between 15 to 20 years) showed lower lead concentrations in blood serum and urine (0.4-12.44 and 0.66-13 mg/dl) and less clinical symptoms. However, they seem to have a risk of developing lead poisoning. Thus, increased lead concentration in serum and urine was found in 33 lead exposed SJW. Thirty three lead exposed SJW had blood serum and urinary lead levels more than the WHO recommended levels (>30 mg/dl) and OSHA permissible limits (>40 mg/dl) and they were affected with severe lead toxicity.

Lead is a cumulative toxic metal and industrial workers are easily exposed to the dust or fumes of lead at their work place. This study represents the health effects of lead poisoning and its relationship with serum and urinary lead levels in the SJW. The old silver ornaments and jeweller's waste are smelted with lead scrapes at high temperature in congested workshop without adequate exhaust system, ventilation and protective measures where workers are exposed to lead fumes and lead oxide dust. Their clothing, hair, nail and food also get contaminated. Lead exposed SJW above the recommended limits of OSHA and WHO, require periodic medical examination. Age group between 41 to 45 years was severely affected from lead poisoning while age group between 15 to 20 years was less affected from lead toxicity. The different health effects of lead poisoning in SJW group are 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 exposure has been consistently associated with increase in blood pressure (Staessen et al.1984). Ten SJW (age group between 21-30 year) whose serum lead levels were 23.25-48.03 mg/dl and urinary lead levels 25.25-55.27 mg/dl were associated with increase in blood pressure.

Renal system: Kidney damage occurs with exposure of higher levels of lead (Weaver et al. 2003). In our finding seven SJW age groups between 36 to 40 year and 41 to 45 year were highly affected by kidney dysfunction.

Cardiovascular system: Higher lead exposure causes cardiovascular effect (Navas-Acien et al. 2007). In our study, a significant relationship was found between higher lead levels in blood serum and urine, which causes coronary heart disease. Age group between 41 and 45 years of SJW having lead 105.83-142.65 mg/dl in blood serum and 108.07-134.98 mg/dl in urine, were severely affected from cardiac autonomic dysfunction.

Reproductive system: Lead is a reproductive toxicant for human males at exposure levels of Pb > 40 µg/dl and low-to-moderate lead exposures may increase the risk of sponta-

Table 1: Optical Parameters for lead (Pb) determination.

Instrument	ECIL, AAS
Wavelength	217.00 nm
Slit setting	1.0 nm
Light source	Hollow cathode lamp
Flame type	Air-acetylene flame oxidizing (lead, blue)
Operating current	5mA

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

Age (years)					
0.4 (F)	23.25 (F)	43.91 (F)	64.22 (M)	80.51 (M)	105.83 (M)
5.17 (M)	24.88 (F)	47.86 (M)	65.56 (M)	80.55 (M)	107.78 (M)
5.9 (M)	41.61 (F)	49.77 (F)	66.45 (M)	83.06 (M)	110.16 (M)
7.34 (M)	41.82 (M)	53.62 (F)	-	83.7 (M)	121.44 (M)
8.05 (F)	42.07(F)	48.03 (F)	-	87.59 (M)	122.79 (M)
8.07 (M)	-	-	-	89.44 (M)	120.49 (M)
12.44 (M)	-	-	-	99.56 (M)	124.03 (M)
-	-	-	-	89.46 (M)	124.26 (M)
-	-	-	-	-	124.55 (M)
-	-	-	-	-	124.76 (M)
-	-	-	-	-	142.62 (M)
-	-	-	-	-	142.65 (M)

M = Male and F = Female

Table 3: Urinary lead concentrations (mg/dl) of SJW according to age.

Age (years)					
15-20	**21-25**	**26-30**	**31-35**	**36-40**	**41-45**
0.66 (F)	25.25 (F)	47.61 (F)	64.59 (M)	82.6 (M)	108.07 (M)
6.19 (M)	27.32 (F)	48.86 (M)	67.08 (M)	81.15 (M)	108.69 (M)
5.96 (M)	42.44 (F)	48.44 (F)	68.11 (M)	84.88 (M)	109.73 (M)
8.26 (M)	41.82 (M)	48.86 (F)	-	82.81 (M)	103.72 (M)
8.53 (F)	42.44 (F)	55.27 (F)	-	89.02 (M)	101.86 (M)
8.44 (M)	-	-	-	91.92 (M)	103.93 (M)
13 (M)	-	-	-	91.3 (M)	101.03 (M)
-	-	-	-	85.3 (M)	89.44 (M)
-	-	-	-	-	114.9 (M)
-	-	-	-	-	118.21 (M)
-	-	-	-	-	128.77 (M)
-	-	-	-	-	134.98 (M)

M = Male and F = Female

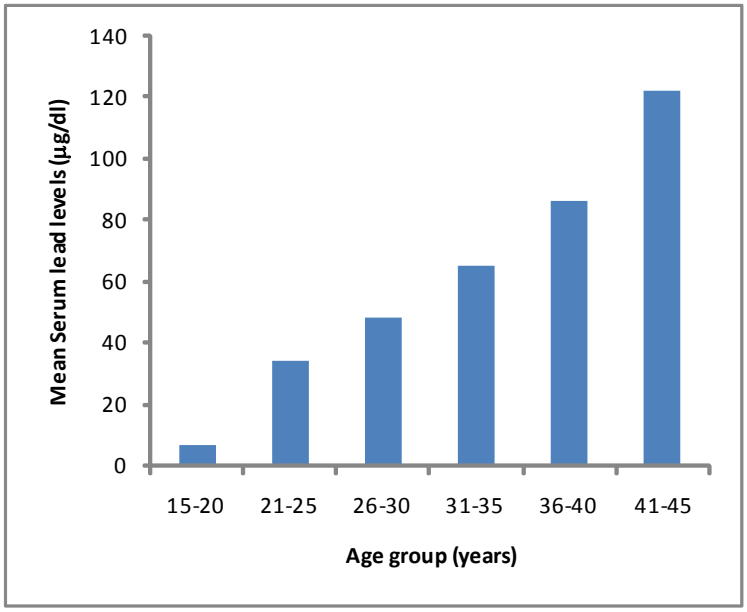

Fig. 1: Mean values of serum lead levels of SJW according to age.

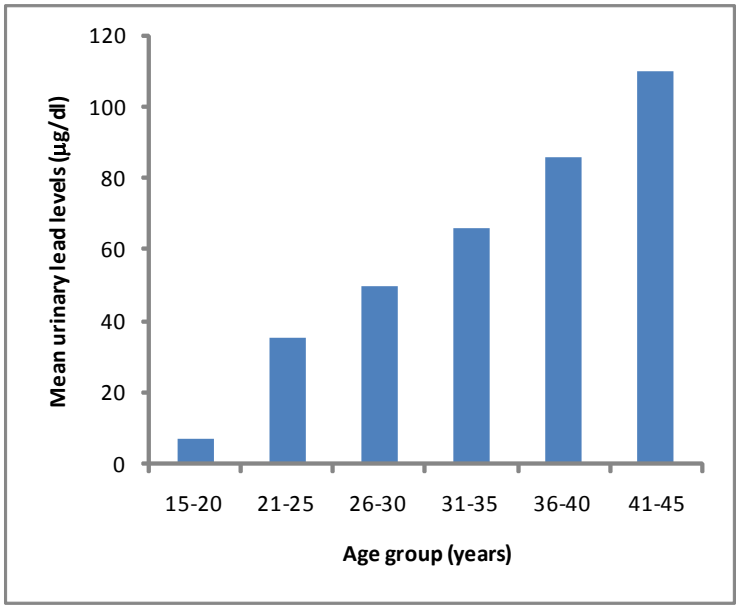

Fig. 2: Mean values of urinary lead levels of SJW according to age.

neous abortion (Sallmen 2001; Hertz-Picciotto 2000). In our study, SJW age group between 21 to 25 and 26 to 30 years were affected with sperm abnormalities and eight females were highly affected from spontaneous abortion.

Neurological system: Lead affects the peripheral nervous system (especially motor nerves) and the central nervous system. Blood lead level of 40-79 mg/dl causes neurocognitive deficits (Kosnett et al. 2007). In our study, out of 40 SJW 33 had serum lead concentration ranging between 23.25-142.65 mg/dl, and urinary lead concentration ranging between 25.25-134.98 mg/dl associated with lead exposure causing neurocognitive defects. High lead levels in blood serum and urine of SJW also cause psychiatric symptoms such as depression and anxiety.

Gastrointestinal system: Abdominal pain, constipation, cramps, nausea, vomiting, anorexia and weight loss, collec-

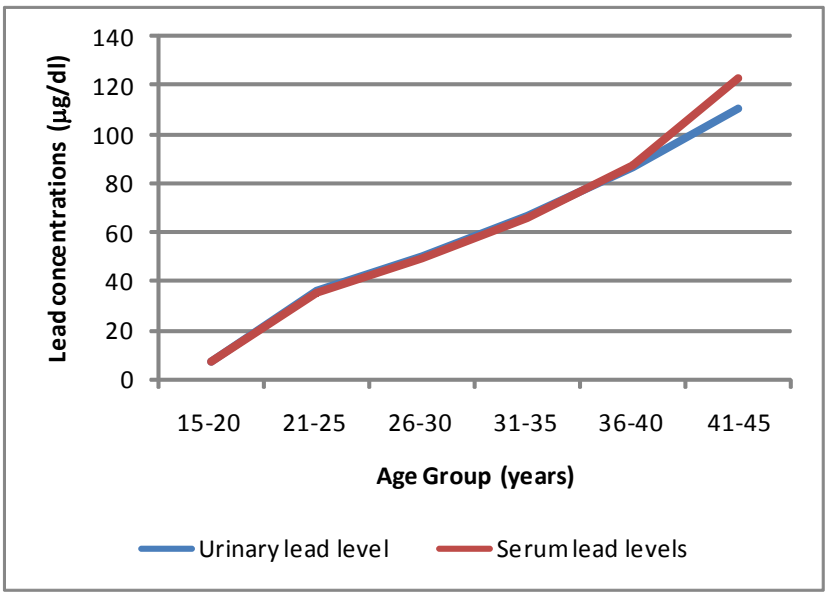

Fig. 3: Serum and urinary lead levels of SJW according to age.

tively known as colic, are early symptoms of lead poisoning. Blood lead level ≥ 80 mg/dl cause colic (Kosnett et al. 2007). In our study, a significant relationship was found between lead levels in blood serum and urine with gastrointestinal effects. We examined that age group between 36 and 40 year (86.73±6.3 and 86.12±4.1 mg/dl) and 41 to 45 year (122.61±11.6 and 110.28±12.5 mg/dl) were hardly affected by abdominal colic.

Anaemia: Blood lead level ≥ 10 mg/dl was significantly associated with anaemia, i.e. decreased iron absorption and effects on haematological parameters (Hegazy et al. 2010). In our study, we found that lead concentration in serum and urine of SJW age group of 31 to 35 year (65.41±1.1 and 65.59±1.8 mg/dl) and 36 to 40 year (86.73±6.3 and 86.12±4.1 mg/dl) were affected by low haemoglobin causing anaemia. We concluded that strong relationship occurs between high serum and urinary lead concentration with decreased haemoglobin in SJW .

Other health effects: Immediate health effects of high level exposure to lead resulting in blood lead values of 70-100 mg/dl or above are clinical emergencies and may cause encephalopathy (NHMRC 2009). In our finding five SJW of age group between 41 to 45 years were affected by lumber pains and leg myalgia. Three SJW age groups between 36 to 40 years showed the symptoms of encephalopathy and one SJW was affected from Hodgkin's lymphoma.

CONCLUSION

The study shows that SJWs 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, neurological system and may lead to damage to various organs. Blood serum and urine are the most reliable tools 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 the establishment of regulations for the precautionary measures to be taken amongst SJW exposed to lead.

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