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Toxic Effect of Hexavalent chromium on the Workers Employed in Chrome plating

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Abstract
Chromium has been considered corrosive, cytotoxic, and carcinogenic for humans and occupational exposure to chromium compounds may result in various health hazards. In this study, 200 chrome plating workers from Lahore industrial area with age ranging from 20 to 50 were selected for the assessment of health risks. A control group of 100 individuals from the same age without chromium exposure was selected. A total of 100 chrome plating workers with age ranging 20-35, were included. Hexavalent chromium was significantly higher among all the workers as compared to controls. Alkaline phosphatase (ALP) and Alanine transaminase (ALT) were significantly (p<0.001) higher in exposed groups I and II than control while albumin (Alb) level was significantly (p>0.001) lower in both the groups as compared to controls.

Keywords: Chrome plating, white blood cells, red blood cells, hexavalent chromium, haemoglobin

1. Introduction
Chrome plating workers are exposed to many physical and chemical hazards. Chrome plating includes many processes with different exposures, which can be hazardous for the health of the workers [1].

Chromium (VI) is one of the toxic heavy metals, which is extensively used in many industries including chrome plating [2]. Chromium is found in two valence states, the most stable and common forms is hexavalent chromium [Cr (VI)] and trivalent chromium [Cr (III)] [3]. Hexavalent chromium is highly toxic, whereas trivalent chromium is an essential micronutrient for living organisms. Chromium may enter the body by breathing and by direct skin contact; therefore, workers are exposed to this element, mainly in Cr (VI) form. These exposures may result hematological, biochemical defects and acute and chronic lung cancers [4]. As chromium is an irritant, it can cause perforations in the nasal septum, respiratory problems, dermatitis, gastrointestinal, hepatic and renal impairments [5]. Several toxic effects are associated with exposure to hexavalent chromium compounds, including increased incidence of certain cancers, toxic towards living cells, tissue and organisms [6-7].

2. Materials and Methods
In this study of 200 electroplating workers from the Lahore industrial area, Punjab province, Pakistan with age ranging from 20 to 50 were selected for the assessment of health risks. Hexavalent chromium was determined by graphite furnace atomic absorption spectrophotometer Perkin Elmer model 700 (Perkin Elmer, CA, USA). Biochemical parameters were determined at the department of Biochemistry, Fatima Jinnah medical college, Lahore by using the Sysmex model KX-21 automated hematology analyzer.

3. Results
About 200 individuals were included in this study along with the prior consent. All the individuals were grouped into different age groups ranging from 20 to 50 years old. All the workers are exposed to hexavalent chromium, which is considered major health hazard. The levels of hexavalent chromium in erythrocytes of the exposed and control groups are shown in table 1. Chrome workers in group I (aged 20-35, 1-10 years exposure) and group II (aged 36-50, 11-20 years exposure) showed significantly higher blood Cr levels than that of controls. Chrome plating workers in age group II were more effected and showed higher chromium

concentration as compared to group I and control. From the results it is clear that no definite pattern has been observed in different biochemical parameters. The difference observed in various parameters is mostly insignificant. Alkaline phosphatase (ALP) and Alanine transaminase (ALT) were significantly (p<0.001) higher in exposed groups I and II than control while albumin (Alb) level was significantly (p>0.001) lower in both the groups as compared to controls.

Electroplating workers in group II with longer duration of chromium exposure were more affected and showed higher ALP and ALT levels than that of group I and unexposed population. This showed that duration of exposure has significant effect on biochemical parameters of workers (table 1).

In Pearson correlation table 2, albumin level showed significant negative correlation with Cr concentration (r = -0.728, p< 0.05) (r = -0.983, p< 0.001) in exposed groups I and II respectively. There was no significant correlation (r =-0.474, p> 0.05) (r =-0.052, p> 0.05) observed between albumin and Cr concentration in control groups I and II respectively.

ALP concentration showed significant positive correlation with Cr concentration (r =0.725, p< 0.001) (r =0.967, p< 0.05) in exposed groups I and II respectively. While, no significant correlation (r =-0.036, p> 0.05) (r =0.228, p> 0.05) was observed between ALP and Cr concentration in control groups I and II respectively.

ALT showed no significant correlation with Cr concentration (r = 0.110, p> 0.05) (r = -0.016, p> 0.05) in both exposed groups I and II respectively. AST concentration also showed no significant correlation with Cr concentration (r = 0.201, p> 0.05) (r = 0.142, p> 0.05) in exposed groups I and II respectively.

There was no significant correlation observed between D. Bilirubin and Cr concentration (r = 0.233, p>0.05) (r = 0.287, p>0.05) in exposed groups I and II respectively.

T. Bilirubin showed no significant correlation with Cr concentration (r = 0.161, p> 0.05) (r = 0.200, p> 0.05) in both exposed groups I and II respectively.

T. Protein concentration showed no significant correlation with Cr concentration (r = 0.353, p> 0.05) (r = 0.386, p> 0.05) in exposed groups I and II respectively. There was also no significant correlation observed between the level of glucose and Cr concentration (r = 0.343, p>0.05) (r = 0.158, p>0.05) in exposed groups I and II respectively.

Table 1: The biochemical parameters in blood samples of chrome plating workers and control

	20-35 years age group			36-50 years age group		
	Controls	**Workers (exposed group I)**	**t-statistic**	**Controls**	**Workers (exposed group II)**	**t-statistic**
ALP (U/l)	95.79±4.76	117.27±8.84	-1.51*	98.35±6.52	121.28±8.371	0.28*
ALT (U/l)	33.91±2.35	36.20±2.20	-0.69*	37.51±4.81	40.05±4.60	-0.64*
AST (U/l)	32.89±2.60	33.53±3.49	-1.15	35.61±2.61	36.05±2.31	-0.98
Alb g/dl	5.20±0.33	3.81±0.288	24.42*	5.08±0.38	3.75±0.282	21.69*
T. Protein g/dl	7.84±0.380	7.92±0.443	-0.98	7.59±0.44	7.70±0.496	-1.37
D. Bilirubin (mg/dl)	0.21±0.01	0.22±0.018	-1.19	0.24±0.02	0.25±0.017	-0.51
T. Bilirubin (mg/dl)	0.52±0.10	0.55±0.148	-1.21	0.54±0.16	0.56±0.187	-0.69
Glucose (mg/dl)	86.59±2.86	85.82±3.14	-1.4	89.48±3.32	88.92±3.28	-0.94

*Values are significance at p<0.05 n = 200

Table 2: Pearson correlation coefficient between the levels of blood chromium and biochemical parameters in chrome plating workers and controls

Biochemical Parameter	20-35 years age group		36-50 years age group	
	Controls	**Tanners (exposed group I)**	**Controls**	**Tanners (exposed group II)**
Alb	-0.474	-0.728*	-0.052	-0.983**
Alp	0.036	0.725**	0.228	0.967**
ALT	0.404	0.110**	0.012	-0.016**
AST	0.416	0.201	-0.067	0.142
D.Billuribin	0.456	0.233	0.215	0.287
T.Billuribin	0.392	0.161	0.199	0.200
T. Protein	0.298	0.353	0.471	0.386
Glucose	0.284	0.343	0.129	0.158

* p<0.05 ** p<0.001

4. Discussion

Hexavalent chromium compound is a strong oxidizing agent and can lead to health hazards. In chrome plating, workers are occupationally exposed to hexavalent chromium, which has shown toxic effect on health [8].

Chromium is reported to cause severe elevation in liver enzyme levels, hepatic effects, hepatic failure and hepatomegaly in four of the five workers exposed to chromium in chrome plating industry [9]. Elevated activity of AP without bone disease is a sign of biliary disturbance [10]. Elevated level of AP has been associated with bile duct obstruction, primary biliary cirrhosis, primary sclerosing cholangiti, metastatic liver disease and bone disease [11]. The concentration of AP may be raised in malignancies without liver or bone involvement [12]. ALT, a cytosolic enzyme is located in its highest concentration in the liver and is considered more specific to the liver. Hepatocellular injury is the trigger to release of these aminotransferases into the circulation [13]. Elevated levels of aminotransferases cause chronic hepatitis B and C, haemochromatosis, autoimmune liver disease, Wilson's disease, α - antitrypsin deficiency, alcoholic liver disease, and coeliac disease [14].

Albumin synthesis is an important function and characteristic feature of the liver. 10g albumin is synthesized and secreted daily from the human body. The low level of albumin is an indication of liver disease [15]. Low albumin concentration has been associated with prognosis in chronic liver disease [16]. According to Schillinger *et al*., low albumin level is a powerful predictor of cardiovascular adverse events in humans [17]. Low serum albumin concentration has also been

associated with a 2-fold increased risk of cardiovascular disease [18]. The correlation results show that ALP, ALT and Alb strongly correlated with Cr concentration in blood samples.

With the protection of gloves, apron and boots, respiratory system is the main way through which hexavalent chromium are absorbed into the body. Therefore, chromium compounds may be the main source of metal exposure for chrome plating workers and the major contributor to biochemical defects.

5. Conclusion

Our data demonstrated the fact that occupational exposure to hexavalent chromium induces biochemical defects in chrome plating workers. Furthermore, ALP, ALT and ALB showed significant correlation with Cr concentration in blood. The workers should be encouraged to follow the health protection procedures and strictly observe workplace safety rules to minimize the toxic effect of hexavalent chromium.

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