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Hexavalent Chromium Effects on Hematological Indices in Rats

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Biological interest in chromium stems from its prominent role in industrial pollution and its toxicity to plants and animals (Browning 1969; Royle 1975). Large amounts of chromium are introduced in to the environment through sewage sludge, sewage water, tannery effluents and wastes from electroplating operations. Although chromium, in traces, is known to be essential for the growth and well being of men and animals (Mertz 1974), intakes at higher levels have been found to be toxic, mainly to the liver and kidney of experimental animals (Kumar and Rana 1982; Kumar et al. 1985). Exposure of humans to chromium (vi) is known to cause renal necrosis, hepatic damage and respiratory cancer (Enterline 1974). On the other hand, its deficiency caused impaired growth, disturbances in glucose, protein and lipid metabolism (Underwood 1971). Further, acute and chronic adverse effects of chromium are associated mainly with hexavalent chromium compounds, which are more toxic to humans than trivalent compounds (Tamino et al. 1981). In mammals, chromium (vi) caused more damage in liver, kidney and myocardium than did chromium (iii) after an i.p. administration of potassium dichromate or chromium (iii) nitrate (Tandon 1982). However, the information on its toxicity still warrants further study. Present study reports on the effects of chromium (vi) on hematological indices in rats.

MATERIALS AND METHODS

The present study was performed on 40 male, 90 days old albino rats (Rattus rattus albino), weighing 100 ± 10g, procured from the laboratory stock. Four groups were formed at random, each containing 10 rats. The rats were housed individually in plastic cages with galvanized iron wire bar tops in a room maintained at 23 ± 2°C and alternating 12 hr cycle of light and darkness. They were provided pellet diet (Lipton India Ltd., Bangalore) and tap water ad libitum. Rats in group I,II and III, in addition to receiving pellet diet, were fed by

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gavage with chromium (vi) in the form of potassium chromate at 0.05 g/kg body weight on each day for a period of 7, 15 and 30 days respectively. Rats from group IV were offered pellet diet alone and tap water ad libitum and served as controls.

After scheduled treatment, the rats were starved for 24 h and then sacrificed by decapitation. Blood samples were collected from the aorta and analysed for hemoglobin (Hb), total red blood corpuscles (RBC), white blood corpuscles (WBC) and plasma corpuscular volume (PCV) according to the method as described earlier (Kumar and Sharma 1987). To estimate other components, the blood was first allowed to clot, and was then centrifuged. The clear serum was collected and analysed for triglycerides and phospholipids as reported earlier (Kumar and Chandra 1989). Serum cholesterol, glucose, urea, total protein and the activities of serum enzymes viz. alkaline phosphatase (ALPase), acid phosphatase (ACPase), glutamic oxaloacetic transaminase (GOT), glutamic pyruvic transaminase (GPT), lactate dehydrogenase (LDH) and glutamate dehydrogenase (GDH) were determined adopting the methods as reported in previous paper (Kumar and Sharma 1987). The student 't' test described by Fisher (1950) was employed to calculate the statistical significance between control and experimental values.

RESULTS AND DISCUSSION

During the experiments the rats were active and there was no overt signs of toxicosis, although reduced weight gain was observed. Results presented in figures 1 to 4, exhibited chromium induced gross changes in hematological indices. Rats exposed to chromium for 30 days exhibited more conspicuous changes in the chemical composition of blood than those exposed for 7 and 15 days. Rats poisoned with chromium (vi) became anemic as evidenced by a significant reduction in percent Hb and total RBC in comparison to control rats (Fig. 1). Since there was a decrease in PCV also, hemorrhage was possibly inflicted by this metal which subsequently induced the anemia; this is supported by the observation of Tandon et al. (1978).

The level of serum triglycerides, phospholipids, cholesterol and glucose were elevated significantly in rats fed on chromium (vi) for 30 days (Fig. 2). The absorption of metals in excess disturbs the metabolism of lipids and cholesterol. Cobalt, cadmium and nickel are known to caused hyperlipaemia in experimental animals (Caplan and Block 1963). Whereas chromium has been implicated as a dietary component that can affect blood lipid levels with increased lipid levels in a chromium deficient state. A decrease in total cholesterol and lipids occurred after supplementation with 10.8 µg Cr/day from brewer's yeast in hypercholesterolemic subjects (Offenbacher and Pi-Sunyer 1980). However, at the present dose level chromium induced hypercholesterolaemia which may have been due either to animal's

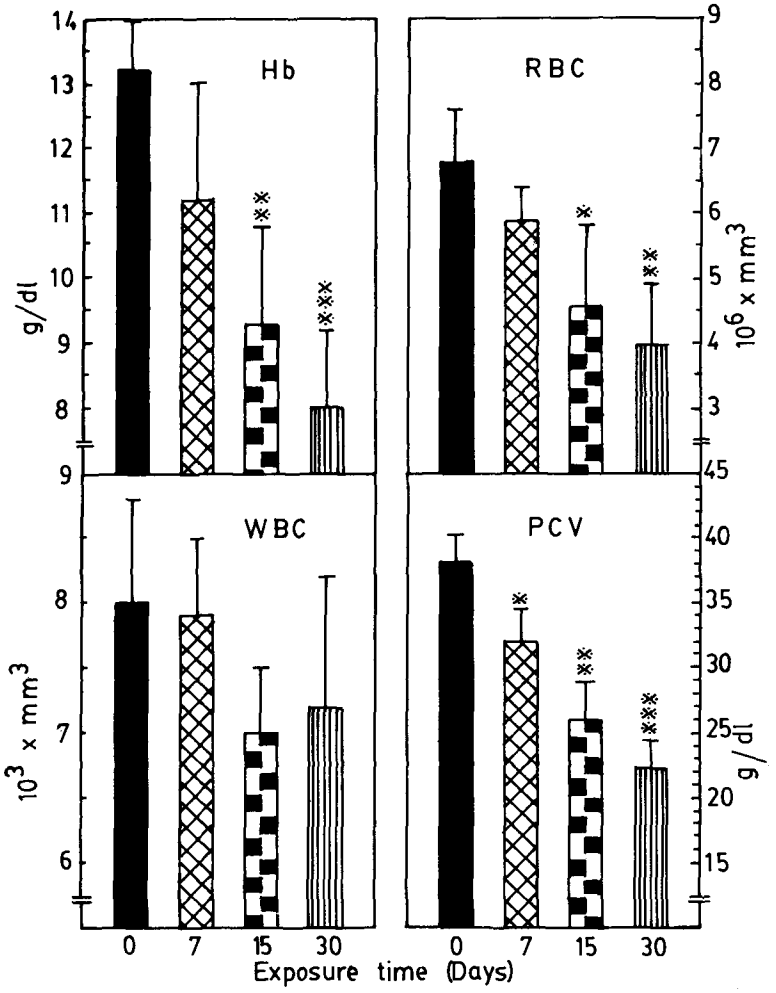

Figure-1-Effect of chromium (vi) on Hb,RBC,WBC and PCV in rats. Bars represent mean ± SE (n=5). Asterisks denote means significantly different from controls (0) at *P < 0.05; **P < 0.01; ***P < 0.001.

hypermetabolic state or to impaired liver function (Curran 1954). Kumar and Chandra (1989) found that oral administration of chromium did not produce any effect on hepatic cholesterol level, however, hepatic triglycerides and phospholipids were elevated in chromium poisoned rats. These results suggested a blockade in the process of oxidative phosphorylation. Since inhibition of oxidative phsophorylation is known to raise the accumulation of lipids (Hartmann1960). The increased blood glucose level in chromium poisoned rats supported the findings of Kumar and Sharma (1987) who observed significant variations in the blood sugar level of rats fed on copper. The condition of hyperglycaemia indicated disrupted carbohydrate metabolism

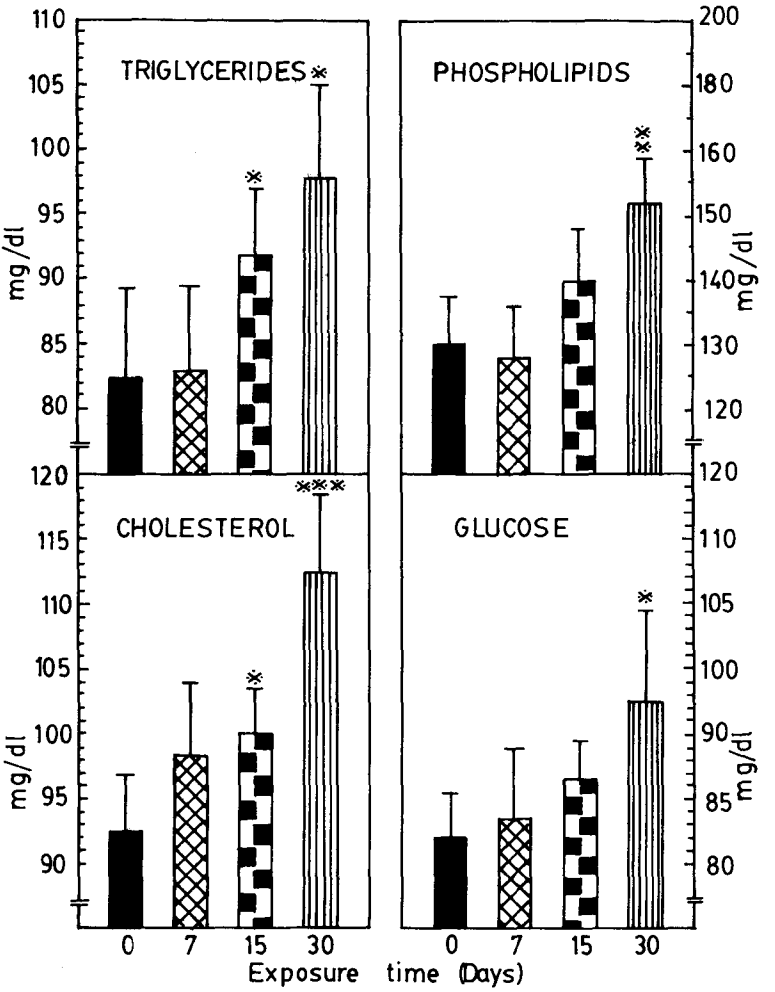

Figure-2-Serum triglycerides, phospholipids, cholesterol and glucose concentration in chromium (vi) poisoned rats. Bars represent mean ± SE (n=5). Asterisks indicate significant (*P < 0.05; **P < 0.01; ***P < 0.001) difference from control (0) rats.

Which might have been due to enhanced breakdown of liver glycogen, possibly mediated by adrenocorticotrophic (ACTH) and glucagon hormones and reduced insulin activity.

Exposure of chromium (vi) induced a significant rise in serum urea level in rats, is an indication of renal damage. Kumar and Rana (1984) observed considerable kidney damage in chromium poisoned rats resulting in significant functional impairment, necrosis and loss of enzyme activity from the renal tubules. The activity of lysosomal enzyme, i.e. acid phosphatase inhibited

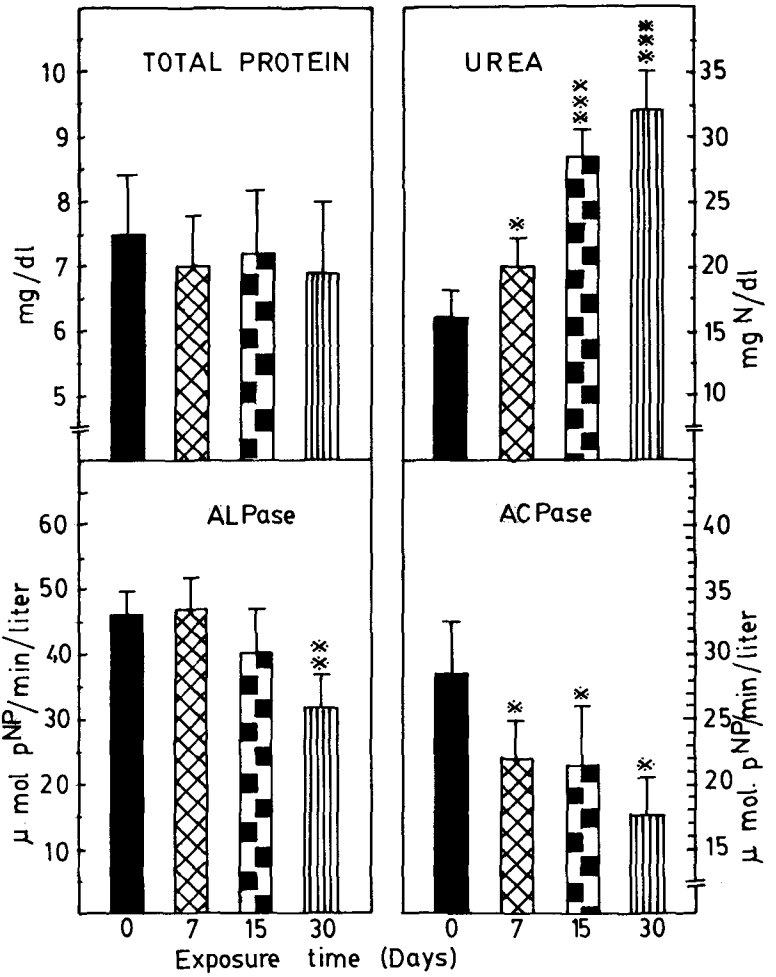

Figure-3-Effect of chromium (vi) on serum total protein, urea and alkaline and acid phosphatase activity in rats. Bars represent mean ± SE (n=5). Asterisks denote means significantly different from controls (0) at *P < 0.05; **P < 0.01; ***P < 0.001.

in rats exposed to chromium and the percentage of inhibition increased with the duration of exposure as shown in Figure 3. Whereas the alkaline phosphatase activity inhibited significantly only after 30 days of treatment with chromium, reflects damage to plasma membrane. The activities of these enzymes were also inhibited in hepato-renal tissues of rats (Kumar and Rana 1984; Kumar et al. 1985). The general mechanism of inhibition might involve (i) the removal of the essential metal ion leaving the apoenzyme alone and/or (ii) replacement of some of the amino-acid groups, resulting in a complex of enzyme and inhibitor metal.

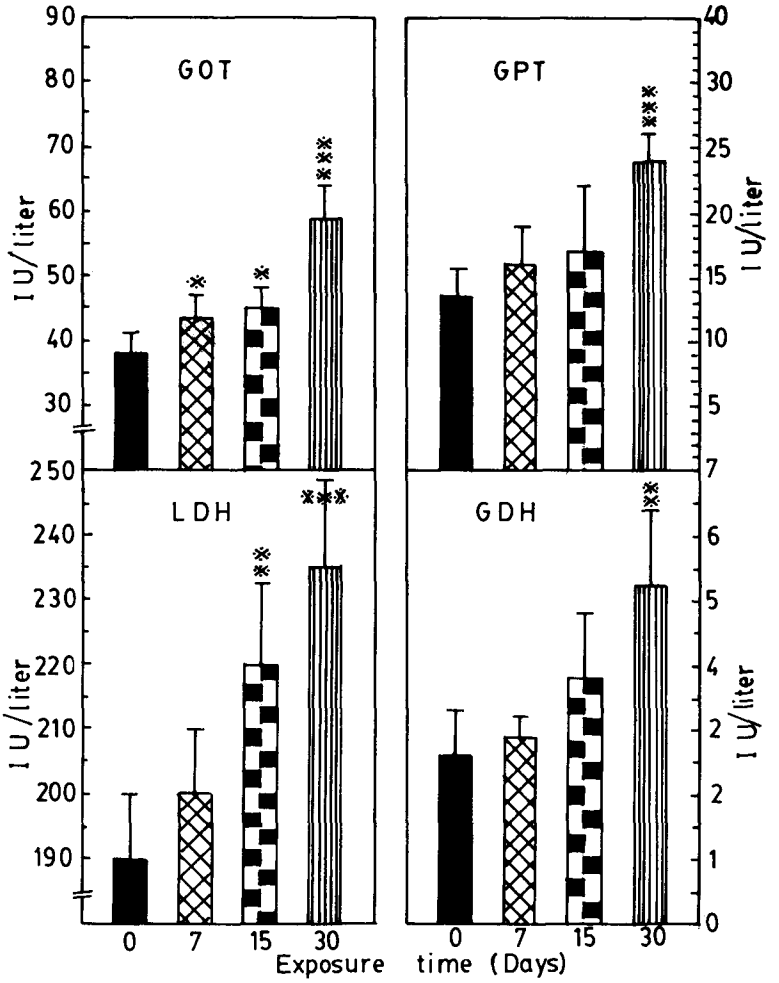

Figure-4-Serum GOT,GPT,LDH and GDH activity in rats exposed to chromium (vi). Bars represent mean ± SE(n=5). Asterisks denote means significantly different from controls (0) at *P < 0.05; **P < 0.01;***P<0.001.

A significant increase in the activity of glutamic oxaloacetic transaminase and glutamic pyruvic transaminase is indicative of liver dysfunction (Fig. 4). Elevated blood transaminases induced by heavy metals have also been reported (Rajanna et al. 1981). Plasma activity of glutamate dehydrogenase, an index of mitochondrial injury, was significantly elevated in rats exposed to chromium for 30 days. However, an insignificant stimulation was also reported after 7 and 15 days of treatment (Fig. 4). There was a marked increase in lactate dehydrogenase activity, which is a marker of tissue damage (Schmidt and Schmidt 1974). Altered dehydrogenase activity in rats induced

by tri and hexavalent chromium was also reported by Advic et al. (1986). Increased activity of serum enzymes was probably due to leakage of these enzymes from injured tissues in to the blood (Rees and Sinha 1960).

The causes of the observed enzymological changes are closely connected with the fact that these enzymes are the markers of particular cell organelles. The only possible conclusion is that each of the enzymes had its activity decreased or increased by a definite amount in its respective cell or organelle. As suggested by Holzer and Duntze (1971), the mechanisms behind the chemical modification of enzymes might include phosphorylation, adenylation, ADP-ribosylation, oxidation of thiol groups and the respective reverse reactions; all these reactions remain to be tested for the effect of chromium on them. However, the cause and significance of the change in enzyme activity are controlled by the level of enzyme protein and lipid with consequent involvement of the cellular arganelle, the highly dynamic structures.

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