Original Article

Necrotic Changes in the Kidney of Albino Rat Due to the Toxic Effects of Chromium Consumption and the Protective Role of Vitamin E

Nahid Yasmin[1], Rati Tandon[1], Manali Arora[2], M Yousuf Sarwar[3], Wali Akram[4]

[1]Associate Professor, Department of Anatomy, Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan, India. [2]Associate Professor, Department of Anatomy, Arya Medical College and Hospital, Jaipur, Rajasthan, India. [3]Professor, Department of Anatomy, Medinirai Medical College and Hospital, Palamu, Jharkhand, India. [4]Tutor, Department of Anatomy, Narayan Medical College and Hospital, Sasaram, Bihar, India

Abstract

Background: Hexavalent chromium Cr (VI) molecules are extremely toxic and have been demonstrated to harm kidneys in both people and animals through oxidative stress. The widespread presence of these compounds in the environment has sparked growing interest in understanding how to prevent their harmful effects. The present study was aimed to evaluate the histopathological changes in kidney due to Cr (VI) induced toxicity and the possible protective role of vitamin E in preventing renal damage in albino rats. **Material and Methods:** The research was done on 36 albino rats, aged about 60 days with an average weight of 140 g. All the rats were equally divided into four groups (n=9). Group I was the control group. Depending on how long the medicines were administered, animals in Groups II and III were further split into three subgroups (n=3). Group II and III received a single oral dose of potassium dichromate ($K_2Cr_2O_7$) at 10 mg/kg body weight for duration of 1 day, 2 weeks and 6 weeks. Group III also received α-tocopherol at 125 mg/kg body weight daily. Group IV served as the α-tocopherol treated group, receiving α-tocopherol daily for 6 weeks. Upon completion of the experiment, the rats were euthanized. To evaluate histopathological changes among various groups, 30 non-overlapping fields per slides were analyzed. The Z-proportion test was used to assess the significance of changes. Statistical significance was defined as a p-value of less than 0.05. **Results:** Rats treated with Cr (VI) exhibited histopathological changes, in the form of glomerular and tubular necrosis. However, the administration of vitamin E counteracted the morphological alterations induced by Cr (VI), showcasing its protective properties against Cr (VI) induced kidney damage. **Conclusion:** The finding implies that vitamin E may offer a protection to the rat kidney against oxidative stress caused by Cr (VI) exposure.

Keywords: Glomerular necrosis, Tubular necrosis, Chromium toxicity, Vitamin E, Oxidative damage.

Received: 26 April 2025 **Revised: 16 July 2025** **Accepted: 26 August 2025** **Published: 04 September 2025**

Introduction

With rapid industrialization throughout the globe, the risk associated with the use of heavy metals in these industries including chromium is of grave concern. Industries such as chrome plating, metal refining, stainless-steel, leather and chemical dye all use chromium.[1] These industries largely produce chromium particularly its hexavalent form Cr (VI), which is toxic and can contaminate water, air, soil and food chain. It is possible for these airborne chromium particles to enter the lungs and stay there for years. The digestive system or skin contact can allow a trace amount of chromium to enter the body.[1]

Cr (VI) compounds containing hexavalent chromium are extremely harmful and carcinogenic. Environmental and occupational exposure to chromium compounds, especially Cr (VI), is commonly recognized as a possible cause of nephrotoxicity in both humans and animals.[2-4]

Research suggests that prolonged exposure to Cr (VI) has led to chronic kidney damage and change in renal function among workers involved in ferrochromium production.[2] The conversion of Cr (VI) to Cr (III) generates reactive oxygen species (ROS), leading to oxidative damage contributing to impaired hematopoiesis and triggering a series of cellular events.[5,6] These include the modulation of the p53 gene, which regulates apoptosis, and ultimately contribute to cytotoxicity, genotoxicity and carcinogenicity.[7]

Vitamin E is a vital nutrient that functions as a fat-soluble antioxidant, safeguarding the integrity of cellular membranes and the proper functioning of intracellular organelles by neutralizing free radicals, thereby preventing lipid peroxidation and maintaining cellular health.[8] It is a crucial part of human diet and is regarded as the most effective liposoluble antioxidant in biological systems. Vitamin E has several subgroups, with tocotrienols and tocopherols being the most extensively researched. It could be a useful therapeutic agent for treating various disorders related to oxidative damage.[9] It may reduce lipid peroxidation (LPO) caused by heavy metals like dichromate

Address for correspondence: Dr. Nahid Yasmin, Associate Professor, Department of Anatomy, Mahatma Gandhi Medical College and Hospital, Jaipur, Rajasthan, India
E-mail: nahid.sabir05@gmail.com

DOI:
10.21276/amit.2025.v12.i3.31

How to cite this article: Yasmin N, Tandon R, Arora M, Sarwar MY, Akram W. Necrotic Changes in the Kidney of Albino Rat Due to the Toxic Effects of Chromium Consumption and the Protective Role of Vitamin E Acta Med Int. 2025;12:40-43.

and protects the body's biological systems.[10] Researchers have reported that vitamin E has protective effects against the harmful effects of metals in both humans and laboratory animals.[11,12]

The objective of this study was to enhance the understanding of histopathological changes in kidney due to chromium mediated toxicity. Furthermore, it also investigated the protective role of vitamin E against the toxic effects of hexavalent chromium, administered as potassium dichromate ($K_2Cr_2O_7$).

Materials and Methods

The current experimental study was carried out in the Subharti Medical College, Anatomy department in Meerut, Uttar Pradesh. The Institutional Animal Ethical Committee (IAEC) and the Committee for Purpose of Control and Supervision of Experiments on Animals, registration number 1204/PO/Re/S/2008/CPSEA, were among the ethics committees that approved the study.

Experimental Animals: The study involved 36 healthy albino rats, both male and female, aged about 60 days with an average body weight of about 140 grams. The rats were housed in a suitable polypropylene cage, with three rats per cage. The cages were maintained under a controlled environment with a 12-hour light-dark cycle and a controlled temperature of 25±2°C. These rats were fed with 200 grams of black gram soaked in water daily as food and water ad libitum.

Chemicals: Potassium dichromate ($K_2Cr_2O_7$) diluted in sterile distilled water at a single dose of 10 mg/kg body weight is the source of Chromium. 10 millilitres of distilled water were used to dissolve 100 milligrams of potassium dichromate to create the solution. Vitamin E (α-tocopherol) is used in concentration of 125 mg/kg body weight daily orally. Dosages of potassium dichromate ($K_2Cr_2O_7$) and α-tocopherol were determined based on earlier studies conducted by Biber TU et al.[13] and Arreola Mendoza L et al.[10]

Experimental Design: Thirty-six albino rats were allocated into four groups of equal size, with nine rats in each group [Table 1].

Table - 1: Different experimental groups and drug doses in each group.

Group I	Control	No drug was given	No drug was given
Group II	Cr VI- toxicity	Received Cr VI	10mg/kg body wt.
Group III	Cr VI- toxicity + α-tocopherol	Received both Cr VI + α-tocopherol	10mg/kg body wt. + 125mg/kg body wt.
Group IV	α-tocopherol treated	Received α-tocopherol	125mg/kg body wt.

Group II and III were further subdivided into three sub-groups, based on the duration of drugs given, with 3 albino rats in each sub-group:

- Sub-group A: Received drug for 1 day
- Sub-group B: Received drug for 2 weeks
- Sub-group C: Received drug for 6 weeks

Group IV rats received α-tocopherol for 6 weeks. α-tocopherol and Cr VI were both given orally using a canula fitted with an insulin syringe after proper calculation of doses. After the administration period, the animals were sacrificed, and their kidneys were removed and processed for histopathological examination. The kidney tissues were fixed in 10% buffered formalin and paraffin blocks were prepared. Thin sections (5-7 microns) were cut and stained with Haematoxylin and Eosin (H&E). Motic imaging software was used to record images. Thirty non-overlapping fields on each slide were analysed for histopathological changes.

Statistical Analysis: The data collected during the research was analysed statistically using Statistical Package for the Social Sciences (SPSS) software, version 21.0. The analysis involved examining 30 non-overlapping fields per stained slide and a Z-proportion test was conducted to determine statistical significance, with a p-value of less than 0.05.

Results

For histopathological observation, haematoxylin and eosin (H&E) stained section of kidney from all groups were examined under a light microscope. The microscopic examination of kidney tissues of control group and α-tocopherol treated group showed the normal histological structures with normal glomeruli and renal tubules [Figure 1].

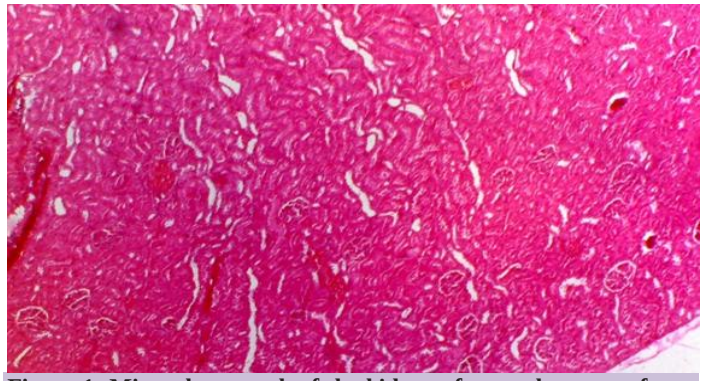

Figure 1: Microphotograph of the kidney of control groups of rats showing normal architecture of glomeruli and tubules. (H and E, X 100).

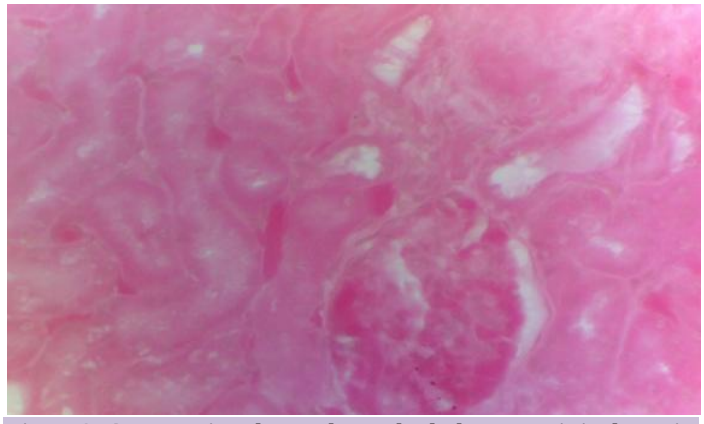

Figure 2: An extensive glomerular and tubular necrosis is shown in the kidney microphotograph of rats in the Cr (VI) toxicity groups (H and E, X 400).

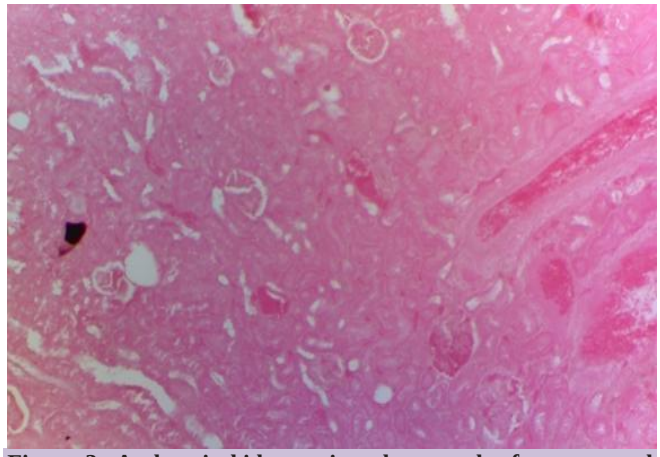

Figure 3: A chronic kidney microphotograph of rats treated with Cr (VI) + α-tocopherol reveals tubular and glomerular necrosis (H and E, X 100).

Kidneys was monitored for histological changes induced by chromium administration after day 1, 2 weeks and 6 weeks. In Cr VI treated group, the sections showed substantial loss of normal renal architecture with glomerular and tubular necrosis after 6 weeks in almost all the fields which was examined. While, after day 1 and 2 weeks of treatment both glomerular and tubular necrosis was found but in few numbers of field [Figure 2].

Following the administration of α-tocopherol and Cr VI, the histological sections of kidney were examined after day 1, 2 weeks and 6 weeks. There was apparent restoration of renal architecture in the form of a smaller number of fields affected as compared to Cr VI treated group [Figure 3].

Z- proportion test was done to assess the level of significance between Cr VI treated group and Cr VI along with α-tocopherol treated group. Glomerular necrosis was observed in 55.92 % in Cr VI treated group while, it was 45.18 % in Cr VI + α-tocopherol treated group, with a p-value of < 0.012. Tubular necrosis was found in 60.37 % in Cr VI treated group while, it was 48.52 % in Cr VI + α-tocopherol treated group, with a p-value of < 0.1006 [Table 2, Figure 4 & 5].

Table 2: Comparison of histopathological findings of kidney in different groups, by Z- proportion test.

Histopathological changes	Group II: Cr VI-toxicity (%)	Group III: Cr VI-toxicity + α-tocopherol (%)	Difference	p-value
Glomerular necrosis	55.92	45.18	10.74	< 0.012
Tubular necrosis	60.37	48.52	11.85	< 0.1006

p-value < 0.05 - statistically significant

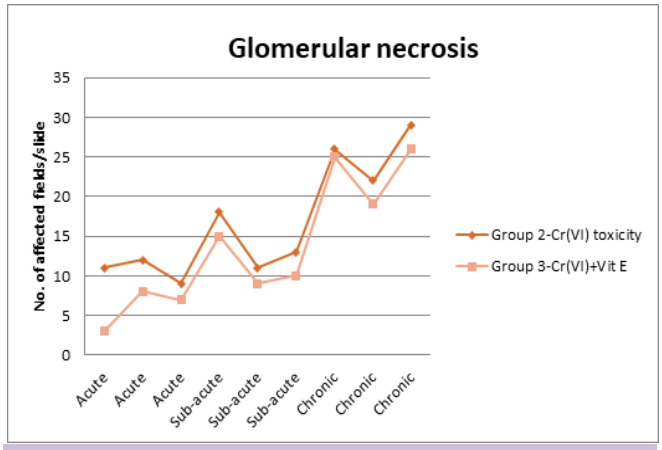

Figure 4: Shows comparison of glomerular necrosis between two groups.

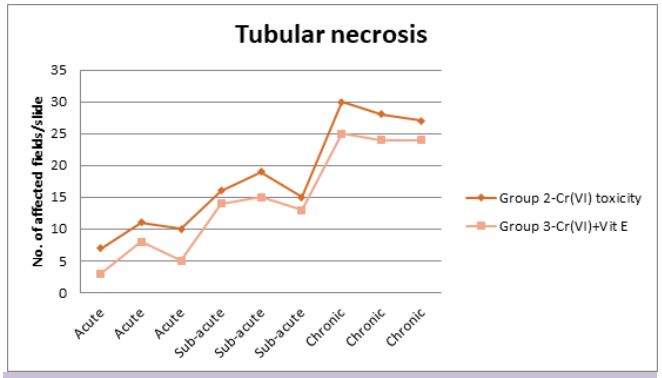

Figure 5: Shows comparison of tubular necrosis between two groups.

Discussion

Chromium (Cr VI) is a well-known nephrotoxic agent in humans as well as experimental animals.[14] It does not directly generate free radicals but triggers the generation of various radicals such as superoxide, peroxynitrite, nitric oxide and hydroxyl leading to the damage associated with oxidative stress.[15] The role of oxidative stress in dichromate-induced kidney damage has been supported by the present study and previous studies.[16]

Chromium (Cr VI) compounds are considered a known human carcinogen.[17] Epidemiological study indicates that hexavalent chromium increases the risk of cancers involving bone, prostate, lymph nodes etc. suggesting that hexavalent chromium may infiltrate various body tissues.[18] Several mechanisms have been proposed to explain how chromium carcinogenesis occur. These include generation of free radicals, formation of stable Cr-DNA adducts and cross linkage between DNA and proteins.[19] Cr toxicity has also resulted in apoptosis, which may be likely due to the generation of reactive oxygen species (ROS).[20] ROS may further provoke the oxidative damage to kidney.[21] Vitamin E can be an effective treatment option for various disorders linked to oxidative stress and damage.[9] Therefore, the evaluation of toxic potentials of heavy metals, like chromium is important for the risk assessment of human beings exposed to these substances and the potential benefits associated with vitamin E. In the present study, administration of Cr VI to albino rats for 6 weeks resulted in oxidative stress in kidney which was manifested by altered histoarchitecture, such as glomerular and tubular necrosis whereas, less architectural derangement in kidney was observed after day 1 and 2 weeks. When Cr (VI) is absorbed through ingestion or skin contact, it predominantly accumulates in the kidneys, potentially leading to acute tubular necrosis in humans.[22] The study by Acharya S et al. done on male Wistar

rats fed with a combination of ethanol and chromium shown notable damage to the renal tubules and Bowman's capsule, which was characterized by vacuolation and degeneration of the basement membrane.[23]

α-tocopherol, is an antioxidant present in the cell membranes.[24] Its supplementation may help reduce and slow the progression of kidney diseases that are worsened by oxidative stress. It may also be effective in lowering cardiovascular disease risk in people with chronic renal failure and uremia. It removes harmful lipid peroxyl and alkoxyl radicals, inhibits the chain reaction of lipid peroxidation (LPO), and boosts the production of scavenger antioxidant enzymes.[25] The present study found a notable protective effect in most of the fields after giving α-tocopherol along with Cr VI as shown by reversal of histological changes. This capability may be linked to the fact that lipid peroxyl radicals react much faster with α-tocopherol than with membrane lipids as suggested by Halliwell and Gutteridge.[9]

Conclusion

The study found that high levels of hexavalent chromium produced structural damage in the kidney. Administering vitamin E led to an improvement in the histopathological changes caused by chromium in rat kidney. Thus, vitamin E appears to have a protective effect on the kidney due to its antioxidant properties. This effect reduces the production of toxic metabolites that contribute to chromium-induced kidney damage.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Wilbur S, Abadin H, Fay M, Yu D, Tencza B, Ingerman L, et al. Toxicological profile for Chromium. Atlanta (GA): Agency for Toxic Substances and Disease Registry (US); 2012.
2. Wang X, Qin Q, Xu X, Xu J, Wang J, Zhou J, et al. Chromium-induced early changes in renal function among ferrochromium-producing workers. Toxicology. 1994;90(1-2):93-101.
3. Sahu BD, Koneru M, Bijargi SR, Kota A, Sistla R. Chromium-induced nephrotoxicity and ameliorative effect of carvedilol in rats: Involvement of oxidative stress, apoptosis and inflammation. Chem Biol Interact. 2014;223C:69-79.
4. Balakrishnan R, Satish Kumar CS, Rani MU, Srikanth MK, Boobalan G, Reddy AG. An evaluation of the protective role of α-tocopherol on free radical induced hepatotoxicity and nephrotoxicity due to chromium in rats. Indian J Pharmacol. 2013;45(5):490-5.
5. Manerikar RS, Apte AA, Ghole VS. In vitro and in vivo genotoxicity assessment of Cr (VI) using comet assay in earthworm coelomocytes. Environ Toxicol Pharmacol. 2008;25:63-8.
6. Bainy AC, Saito E, Carvalho PS, Junqueira VB. Oxidative stress in gill, erythrocytes, liver and kidney of nile tilapia (orechromis miloticus) from a polluted site. Aquat Toxicol. 1996;34:151.
7. Bagchi D, Bagchi M, Stohs SJ. Chromium (VI)-induced oxidative stress, apoptotic cell death and modulation of p53 tumor suppressor gene. Mol Cell Biochem. 2001;222:149-58.
8. Dinka PJ, Langer EH, Vocks SK, Morrow FD. Nutritional correlates of atrophic glossitis. Possible role of vit E in papillary atrophy. J Am Coll Nutr. 1993;12(1):14-20.
9. Halliwell B, Gutteridge JM. Free radicals, other reactive species and disease. In: Free Radicals in Biology and Medicine. 3rd ed. Oxford: Clarendon Press; 1999. p.617-783.
10. Arreola Mendoza L, Reyes JL, Melendez E, Martin D, Namorado MC, Sanchez E, et al. Alpha-tocopherol protects against the renal damage caused by potassium dichromate. Toxicology. 2006;218:237-46.
11. Sokol RJ. Antioxidant defenses in metal-induced liver damage. Semin Liver Dis. 1996;16(1):39-46.
12. Appenroth D, Karge E, Kielssling G, Wechter WJ, Winnefeld K, Fleck C. LLU-alpha, an endogenous metabolite of gamma-tocopherol, is more effective against metal nephrotoxicity in rats than gamma-tocopherol. Toxicol Lett. 2001;122(3):255-65.
13. Biber TU, Mylle M, Baines AD, Gottschalk CW, Oliver JR, Mac Dowell MC. A study by micropuncture and microdissection of acute renal damage in rats. Am J Med. 1968;44:664-705.
14. Fatima S, Arivarasu NA, Banday AA, Yusufi AN, Mahmood R. Effect of potassium dichromate on renal brush border membrane enzymes and phosphate transport in rats. Hum Exp Toxicol. 2005;24(12):631-8.
15. Pritchard KA, Ackerman A, Kalyanaraman B. Chromium (VI) increases endothelial cell expression of ICAM-1 and decreases nitric oxide activity. J Environ Pathol Toxicol Oncol. 2000;19(3):251-60.
16. Pedraza-Chaverri J, Yam-Canul P, Chirino YI, Sanchez-Gonzalez DJ, Martinez-Martinez CM, Cruz C, et al. Protective effects of garlic powder against potassium dichromate-induced oxidative stress and nephrotoxicity. Food Chem Toxicol. 2008;46(2):619-27.
17. Gibb HJ, Lees PS, Pinsky PF, Rooney BC. Lung cancer among workers in chromium chemical production. Am J Ind Med. 2000;38:115-26.
18. Costa M. Toxicity and carcinogenicity of Cr (VI) in animal models and humans. Crit Rev Toxicol. 1997;27:431-42.
19. Kozlowski H, Kolkowska P, Watly J, Krzywoszynska K, Potocki S. General aspects of metal toxicity. Curr Med Chem. 2014;21(33):3721-40.
20. Son YO, Hiltron JA, Wang X, Chang Q, Pan J, Zhang Z, et.al. Cr (VI) induces mitochondrial-mediated and caspase-dependent apoptosis through reactive oxygen species-mediated p53 activation in JB6 C141 cells. Toxicol Appl Pharmacol. 2010;245(2):226-35.
21. Boşgelmez II, Güvendik G. Effects of taurine on oxidative stress parameters and chromium levels altered by acute hexavalent chromium exposure in mice kidney tissue. Biol Trace Elem Res. 2004;102:209-25.
22. Dartsch PC, Hildenbrand S, Kimmel R, Schmahl FW. Investigations on the nephrotoxicity and hepatotoxicity of trivalent and hexavalent chromium compounds. Int Arch Occup Environ Health. 1998;71:540-5.
23. Acharya S, Mehta K, Krishnan S, Rao CV. A subtoxic interactive toxicity study of ethanol and chromium in male Wistar rats. Alcohol. 2001;23:99-108.
24. Palamanda JR, Kehrer JP. Involvement of vitamin E and protein thiols in the inhibition of microsomal lipid peroxidation by glutathione. Lipids. 1993;28:427-31.
25. Ernster L, Forsmark P, Nordenbrand K. The mode of action of lipid-soluble antioxidants in biological membranes: Relationship between the effects of ubiquinol and vitamin E as inhibitors of lipid peroxidation in submitochondrial particles. Biofactors. 1992;3:241-8.