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FEATURES OF THE INFLUENCE OF *S*-ETHYL-4-AMINOBENZENE THIOSULFONATE ON SOME BIOCHEMICAL PARAMETERS OF RAT BLOOD UNDER THE CONDITION OF Cr(VI) INTOXICATION

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Background. The main pathway of Cr(VI) cytotoxicity is activation of oxidative stress in cells of living organisms, resulting in an imbalance of blood biochemical parameters. Our recent studies indicate that *S*-ethyl-4-aminobenzenethiosulfonate (ETS), which belongs to thiosulfonate compounds, is able to reduce intensity of Cr(VI)-induced oxidative stress in liver tissue of rats. It is known that oxidative stress induced by Cr(VI) causes liver and kidney tissue damage with a subsequent imbalance of blood biochemical parameters. Therefore, the aim of this study was to evaluate the potential ability of ETS to prevent Cr(VI)-induced disorders of some biochemical blood parameters, which are important biomarkers of Cr(VI) intoxication.

Materials and Methods. The object of the research was the separate biochemical parameters of the blood of rats with Cr(VI)-induced oxidative stress after prior exposure to ETS. Two experimental groups of male *Wistar* rats were intoxicated once per day intraperitoneally with $K_2Cr_2O_7$ dissolved in physiological saline solution for 7 or 14 days. Two other experimental groups were pretreated once per day intragastrically with ETS dissolved in oil before the period of 7 or 14-day $K_2Cr_2O_7$ intoxication. We measured total protein, creatinine and urea level, as well as determined the activity of aminotransferases in the blood plasma of rats.

Results. Intraperitoneal injection of $K_2Cr_2O_7$ (dissolved in physiological saline solution at a dose of 2.5 mg Cr(VI)/kg body weight) for 7 and 14 days causes a decrease in

total protein level and leads to elevation of plasma creatinine level and urea concentration. The activity of blood aminotransferases increases due to Cr(VI) toxicity. The 14-day exposure to ETS (dissolved in oil at a dose 100 mg/kg body weight) prior to the period of Cr(VI) intoxication is characterized by a smaller percentage increase in the level of creatinine, urea and activity of alanine aminotransferase (ALT) in the blood plasma of rats.

Conclusion. Cr(VI)-induced toxicity causes an imbalance in biochemical blood parameters. Cr(VI) induces a total protein decrease and leads to an increase in the level of the studied biochemical parameters of blood plasma, which are markers of damage to the liver (aminotransferases) and kidneys (creatinine, urea). In contrast, exposure to ETS for 14 days prior to the period of Cr(VI) intoxication causes percentage decrease in creatinine, urea accumulation and percentage reduction of ALT hyper-activation in the blood of rats. However, the levels of creatinine, urea and ALT activity in this case remained significantly higher than those in the control group. In conclusion, pretreatment with ETS (100 mg/kg) for 2 weeks helps to reduce the level of Cr(VI)-induced disturbances of some blood biochemical parameters, but does not normalize them.

Keywords: thiosulfonates, hexavalent chromium, potassium dichromate, creatinine, urea, aminotransferases

INTRODUCTION

Chromium (Cr) is a grayish-white shiny metal and one of the most common chemical elements in the Earth's crust. Cr ranks seventh in the group of the most common chemical elements in the environment and naturally occurs in two valence states – hexavalent (Cr(VI)) and trivalent (Cr(III)). Cr(VI) compounds exhibit potent toxicological, carcinogenic and prooxidant properties (Wise *et al*., 2022).

Active use of Cr(VI) compounds for industrial purposes is the main cause of environmental pollution by these compounds. In particular, Cr(VI) is an integral component in such industrial processes as paint, and magnetic tape production, hydrocarbons production (as a catalyst), leather tanning, metal processing, production of chromite ore, and welding of stainless steel (Wise *et al*., 2022; Boşgelmez, 2021). Cr(VI) compounds accumulate in the cells of living organisms that inhabit contaminated soils and water bodies and are thus included in the food chain. Toxic Cr(VI) can also enter the body along with drinking water. Industry, in addition to groundwater pollution, releases Cr(VI) compounds into the atmosphere, which leads to poisoning of organisms by inhalation of polluted air (DesMarais & Costa, 2019).

Cr(VI) from natural and industrial sources mostly occurs in the form of oxyanion chromate (CrO_4^{2-}), which is very close to anion sulfate by its chemical structure. Cr(VI) uses sulfate anion transporters to penetrate into the cell. The main pathways of Cr(VI)-induced toxicity are the activation of oxidative stress mechanisms, damage to DNA structure, epigenetic mechanisms of changes in gene expression. All these changes in turn lead to cytotoxicity, cell mutagenesis, carcinogenesis and apoptosis (Saidi *et al.,* 2019).

Cr(VI) intoxication causes an imbalance in biochemical blood parameters, which reflect the degree of metabolic disorders under the conditions of intoxication with Cr(VI) compounds (Buchko *et al*., 2021; Kandpal *et al*., 2019). Enzymatic activity disbalance of aminotransferases of blood indicate the degree of Cr(VI)-induced hepatotoxicity

(Buchko *et al.,* 2021). In turn, the accumulation level of creatinine and urea in blood is a stable indicator of Cr(VI)-induced nephrotoxicity (Kayode *et al.,* 2022).

S-ethyl-4-aminobenzenethiosulfonate is a sulfur organic synthetic representative of the class of thiosulfonate compounds. Thiosulfonates are synthetic analogues of natural organosulfur compounds isolated from garlic (*Allium sativum*), onion (*Allium cepa*), various types of cabbage (including cauliflower) and deep-sea hedgehog (*Echinocardium cordatum*) (Liubas *et al*., 2022). Our previous studies have shown positive effects of ETS under Cr(VI)-induced toxicity. In particular, ETS caused a decrease in lipid peroxidation intensity, prevented a decrease in catalase activity and restored the total GSH pool in liver of rats under a 14-day Cr(VI) intoxication (Kotyk *et al.,* 2020). Given that ETS is able to partially compensate for Cr(VI)-induced oxidative stress, it is important to understand whether ETS-induced compensation of the prooxidant effect of Cr(VI) is sufficient to prevent disorders of some biochemical blood parameters under the influence of this heavy metal.

Therefore, the aim of our study was to determine the effect of ETS, as a synthetic analogue of natural biologically active substances, on some biochemical parameters in the blood of laboratory rats exposed to toxic Cr(VI).

MATERIALS AND METHODS

Experimental details. The section “Experimental details” was prepared by analogy with our previous publication (Kotyk et al., 2020). The research was conducted on the basis of the Laboratory of biochemistry adaptation and ontogenesis of animals of the Institute of Animal Biology of NAAS. All procedures were made to minimize animal suffering and the guidelines of European Convention “For the Protection of Vertebrate Animals Used for Experimental and Other Scientific Purposes” (Strasbourg, 1986) and “Common Ethical Principles for Animal Experiments” (Ukraine, 2001) were followed. A permission to conduct the research was obtained from the Committee on Bioethics of Institute of Animal Biology NAAS of Lviv (Protocol No. 124; from 20 December, 2022).

White laboratory male *Wistar rats* (130–140 g) were randomly divided into 7 groups with 5 animals in each group. Animals of all groups were fed with standard compound feed for laboratory rats with free access to drinking water and feed. Group I (intact control) was daily intraperitoneally injected with 150 μL of physiological saline solution for 7 days. Groups III and Group IV intraperitoneally received potassium dichromate ($K_2Cr_2O_7$) dissolved in physiological saline solution (150 μL) at a dose 2.5 mg Cr(VI)/kg body weight per day for 7 and 14 days, respectively. Group II was daily intragastrically injected with 1000 μL of oil for 14 days (“Oleina” oil, traditional: refined, deodorized, frozen; Producer of PJSC with II “DOEP”; certified according to State Standard of Ukraine 4492: 2017, complies with ISO 14024) and from the next day after oil treatment, the animals were daily intraperitoneally injected with 150 μL of physiological saline solution for 7 days. Group V was daily intragastrically injected with ETS (*S*-ethyl-4-aminobenzenethiosulfonate) dissolved in oil (1000 μL) at a dose of 100 mg/kg body weight for 14 days and from the next day after ETS treatment, the animals were daily intraperitoneally injected with 150 μL of physiological saline solution for 7 days. Group VI/Group VII received intragastrically an oil solution of ETS at a dose 100 mg/kg body weight daily for 14 days and from the next day after ETS treatment, the animals daily intraperitoneally received $K_2Cr_2O_7$ at a dose of 2.5 mg Cr(VI)/kg body weight per day

for 7 days/14 days. In our work, we used *S*-ethyl-4-aminobenzenethiosulfonate (ETS). This compound was synthesized at the department of technology of biologically active compounds, pharmacy and biotechnology of National University "Lviv Polytechnic" according to the protocol as described previously (Lubenets *et al.*, 2018). The chemical formula of the synthesized *S*-ethyl-4-aminobenzenethiosulfonate is shown in **Fig. 1**; its physical and chemical properties were described in detail by Lubenets *et al.,* 2018.

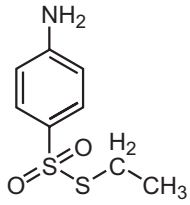

Fig. 1. Chemical structure of *S*-ethyl-4-aminobenzenethiosulfonate
Note: molecular weight 217.30

After decapitation of the animals, which occurred under thiopental anesthesia, the blood was collected**.** In blood plasma we measured total protein, creatinine and urea level, as well as determined the activity of aminotransferases.

Comparison of animal groups. Groups of animals were compared according to the scheme in **Fig. 2**. Group I is an intact control in relation to experimental groups III and IV which did not receive an oil solution. Group II is a control in relation to experimental

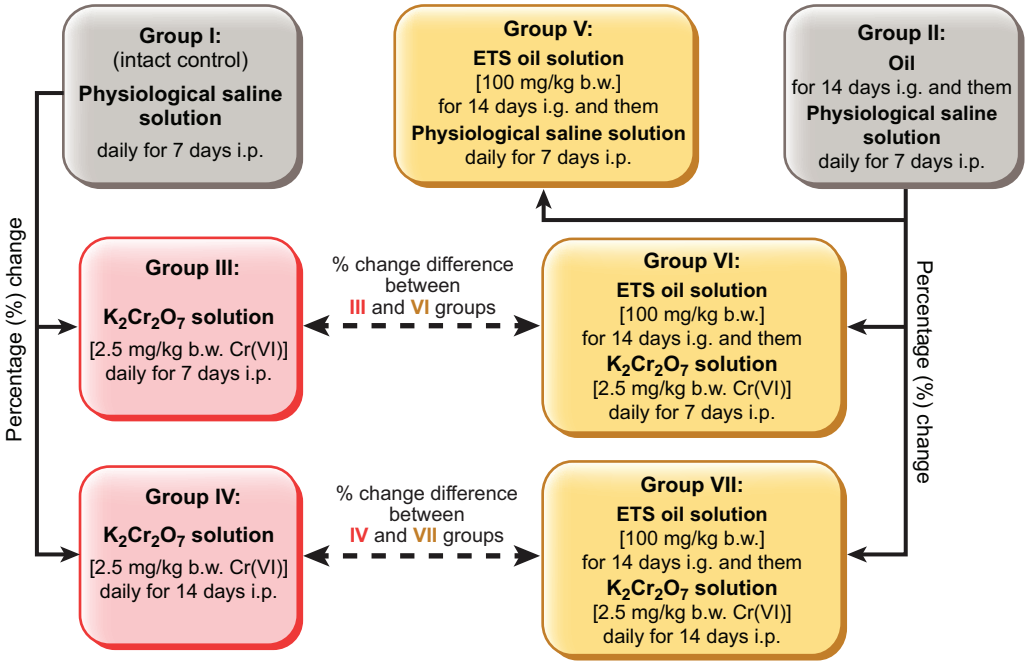

Fig. 2. Comparison of animal groups
Note: ETS – *S*-ethyl-4-aminobenzenethiosulfonate; i.p. – intraperitoneally; i.g. – intragastrically; b.w. – body weight

groups V, VI and VII, which received an oil solution. We recorded the percentage (%) change in indicators for experimental groups III and IV relative to group I (intact control). We also recorded the % change in indicators for experimental groups V, VI and VII relative to group II (oil control). At the final stage, we analyzed the % change in indicators of experimental groups III/IV relative to group I (intact control) and compared it with the % change in indicators of experimental groups VI/VII relative to group II (oil control).

Determination of aminotransferases activity. Alanine aminotransferase (ALT, EC 2.6.1.2), aspartate aminotransferase (AST, EC 2.6.1.1) enzymatic activity were determined by "Simko LTD" Biochemical Kit (Ukraine, Lviv). All absorbance values were measured using spectrophotometer "Unico" 1205 (USA).

Determination of total protein content. Total plasma protein content was measured by the Lowry Method (Lowry *et al.*, 1951) using the "Simko LTD" kit (Ukraine, Lviv). All absorbance values were measured by spectrophotometer "Unico" 1205 (USA).

Determination of creatinine and urea. The content of creatinine and urea in blood plasma was determined using a biochemical analyzer HUMALYZER 2000 (brand: HUMAN; analizator type: automatic) and biochemical kits "Creatinine liquicolor (REF 10051)" (Germany, Wiesbaden), "Urea liquicolor (REF 10505)" (Germany, Wiesbaden). The content of creatinine and urea was expressed in μmol/L and mmol/L, respectively.

Statistical analysis. Experimental data from different groups were expressed as mean values (M) ± standard error (S.E.M.). Statistical comparison between groups was calculated through ANOVA (followed by Tukey's post hoc test) using Microsoft Excel statistical package. Confidence level of P values ≤0.05 was statistically significant in all cases.

RESULTS AND DISCUSSION

We observed that exposure to Cr(VI) for 7 (group III) and 14 days (group IV) led to statistically significant decrease in total protein content (P ≤0.05) in the blood plasma of rats compared with group I by 33% and 30% respectively (**Table 1**). According to the literature, Cr(VI)-toxicity is also accompanied by damage to kidney tissue with the subsequent development of proteinuria. These negative changes can also lead to a decrease in the concentration of total protein in the blood due to its accumulation in the urine (Saidi *et al.*, 2019). The toxic action of Cr(VI) activates the processes of free radicals formation, which in turn stimulates the processes of protein oxidation (Hassan *et al.,* 2019). There were no statistically significant differences in blood plasma total protein level between animals intoxicated with Cr(VI) for 7 (group III) and 14 days (group IV).

We also observed statistically significant elevation of plasma creatinine content in rats under the action of Cr(VI) for 7 (group III) and 14 days (group IV) relative to group I by 52 and 110% respectively (P ≤0.05). The level of creatinine was significantly higher by 37% in the blood of rats intoxicated with Cr(VI) for 14 days compared to the animals injected with Cr(VI) for 7 days (P≤0.05). The literature data report that the increase in creatinine level is more pronounced in blood serum under a higher dose of Cr(VI) and the elevated creatinine indicates that Cr(VI) has toxic effects on the kidneys of rats (Zheng *et al.,* 2020).

The urea content in the rat blood plasma of experimental groups III and IV significantly increased compared with group I by 89% and 106% respectively (P ≤0.05). Literature data indicate that plasma urea and creatinine content increases in response to Cr(VI)-induced kidney tissue damage and are unique parameters of glomerular functional status (Saidi *et al.*, 2019; Estévez-Carmona *et al.*, 2020). We only observed a tendency to urea level increase in blood plasma of rats of group IV relative to group III.

Researchers point out that the increase in the content of relevant indicators in blood plasma under the action of Cr(VI) occurs against the background of violations of the structure of the renal tubules, the development of histopathological lesions and an increased renal mass (Orabi & Shawky, 2020). According to literature sources, Cr(VI) also activates the mechanisms of oxidative stress, inflammation, fibrosis, tubular necrosis, hyperplasia and apoptosis of renal epithelial tubular cells, which in turn may cause increased creatinine and urea in plasma (Orabi & Shawky, 2020).

Table 1. **The content of total protein and end products of proteins breakdown in blood plasma (M ± S.E.M., n = 5)**

Groups of animals	Biochemical parameters		
	Total protein, g/L	Creatinine, μmol/L	Urea, mmol/L
I – Control	45.33 ± 4.23	50.01 ± 4.35	6.15 ± 0.65
II – Oil	43.92 ± 2.58	56.74 ± 4.95	5.95 ± 0.72
III – Cr(VI) 7 days	30.57 ± 2.57 *	76.4 ± 7.01 *	11.6 ± 1.45 *
IV – Cr(VI) 14 days	31.74 ± 3.69 *	104.81 ± 6.0 * §	12.67 ± 1.40 *
V – ETS	41.88 ± 2.46	52.66 ± 2.14	5.55 ± 0.48
VI – ETS + Cr(VI) 7 days	37.90 ± 0.51	64.14 ± 4.26	9.39 ± 0.72 #
VII – ETS + Cr(VI) 14 days	39.50 ± 0.88	90.52 ± 8.68 * #	10.54 ± 0.71 * #

Note: ETS – *S*-ethyl-4-aminobenzenethiosulfonate; statistically significant difference II, III, IV, V, VI, VII groups compared to group I (control): * − (P ≤0.05); statistically significant difference V, VI, VII groups compared to group II: # − (P ≤0.05); statistically significant difference between groups III and IV: § − (P≤0.05)

Animals of experimental groups V, VI, VII received an oil solution of ETS (100 mg/kg) intragastrically. Therefore, we also included group II, which was treated only with oil, into the experiment. Group II was a control in relation to experimental groups V, VI and VII, which received an oil solution. ETS administration followed by a 14-day exposure to Cr(VI) also caused an increase in the total creatinine level by 60% in the blood of animals of group VII compared to group II (P ≤0.05). However, the percentage increase

in plasma creatinine in rats of group VII (60%) compared to group II was by 50% lower than the percentage increase in blood creatinine level in animals of group IV (110%) compared to group I (P ≤0.05).

Pretreatment with ETS before the 7-day period of Cr(VI) intoxication led to a statistically significant increase of blood urea content by 58% (P≤0.05) and the urea content in this case was by 31% lower compared to the rats with a 7-day period of Cr(VI) intoxication without ETS pretreatment. Similarly, ETS pretreatment followed by a 14-day intoxication with Cr(VI) caused a statistically significant elevation of blood urea content by 58% (P ≤0.05) and the urea content in this case was by 29% lower compared to the rats with a 14-day period of Cr(VI) intoxication without ETS pretreatment. The organosulfur natural analog of thiosulfonates, diallyl thiosulfonate, exhibits a nephroprotective effect and reduces the level of creatinine and urea in the blood plasma of rats. Authors suggest that diallyl thiosulfonate-induced activation of antioxidant pathways in rat kidneys is the main reason for the stabilization of creatinine and urea content in the blood of animals under oxidative stress (Abdel-Daim *et al.*, 2019). The results of our previous studies indicate that ETS reduces the level of lipid peroxidation products in rat liver tissue, as well as normalizes the GSH content under Cr(VI)-induced oxidative stress (Kotyk *et al.*, 2020). It is possible that the antioxidant properties of ETS help to lower the level of creatinine and urea under Cr(VI)-induced toxicity. However, the content of these metabolites in this case still remains significantly higher than in the control.

ALT activity was statistically significantly increased (P ≤0.05) in the blood plasma of rats under the action of Cr(VI) for 7 (group III) and 14 days (group IV) relative to group I by 94% and 115% respectively (**Table 2**). We also observed a statistically significant activation of AST after 7 days (group III) and 14 days (group IV) of exposure to $K_2Cr_2O_7$ in comparison with group I by 34% and 53%, respectively (P ≤0.05). The increase in the activity of ALT and AST is due to the high hepatotoxicity of $K_2Cr_2O_7$. Cr(VI)-induced oxidative stress is accompanied by damage to hepatocyte cell membranes, after which aminotransferases enter the blood plasma (Hassan *et al.,* 2019). Therefore, changes in blood aminotransferases activity are an important indicator of the structural and functional state of the liver (Ma *et al.,* 2022). We only observed a tendency to increase in ALT, AST activity in the blood plasma of rats of group IV relative to group III. However, no statistically significant changes were found in this case.

The ratio of AST/ALT enzymatic activity (de Ritis ratio) was reduced after Cr(VI) intoxication in the blood plasma of rats of group III (0.86) and group IV (0.89) relative to group I (1.25) (P ≤0.05). Literature sources also indicate that Cr(VI)-induced inflammatory processes in the liver and kidneys leads to a decrease in De Ritis ratio due to accumulation of ALT in blood plasma. Experimental data indicate that moderate and severe liver damage is characterized by de Ritis coefficients <1.0 (Ma *et al.*, 2022; Buchko *et al.*, 2021).

We did not observe statistically significant changes in the activity of AST in the blood of animals of all experimental groups that received ETS intragastrically for 14 days (V, VI, VII groups) relative to group II.

Pretreatment with ETS before the 7-day period of Cr(VI) intoxication caused a statistically significant elevation of blood ALT activity by 38% (P ≤0.05). However, the ALT activity in this case was by 56% lower compared to the rats with a 7-day period of Cr(VI) intoxication without ETS pretreatment.

Literature sources indicate that natural organosulfur biologically active compounds can act as effective hepatoprotectors by regulating the activity of ALT and AST in the blood plasma of mice under oxidative stress. In particular, diallyl thiosulfonate, a natural analog of synthetic thiosulfonates, exhibits hepatoprotective properties against induced oxidative stress by reducing the level of lipid peroxidation products, attenuating pro-inflammatory signaling, destructive changes, necrosis, apoptosis in liver tissue through activation of Bcl-2 and Ki- 67 pathways (Samra *et al.,* 2020). It is possible that the anti-oxidant properties of ETS help to lower the ALT activity under **C**r(VI)-induced toxicity by reducing the intensity of oxidative damage to liver tissue of rats. However, the ALT activity in this case still remains significantly higher than in the control.

Table 2. **The indicators of aminotransferases activity in blood plasma (M ± S.E.M., n = 5)**

Groups of animals	Biochemical parameters		
	ALT, U/L	AST, U/L	De Ritis ratio
I – Control	39.9 ± 1.15	49.9 ± 3.23	1.25
II – Oil	39.3 ± 1.86	48.7 ± 1.57	1.24
III – Cr(VI) 7 days	77.6 ± 3.75*	66.7 ± 2.23*	0.86*
IV – Cr(VI) 14 days	85.6 ± 2.77*	76.4 ± 1.46*	0.89*
V – ETS	38.3 ± 2.81	46.3 ± 1.61	1.21
VI – ETS + Cr(VI) 7 days	54.3 ± 2.94 * #	55.8 ± 5.67	1.03
VII – ETS + Cr(VI) 14 days	42.9 ± 2.73	50.3 ± 1.45	1.17

Note: ETS – *S*-ethyl-4-aminobenzenethiosulfonate; statistically significant difference groups II, III, IV, V, VI, VII compared to group I (control): * – (P ≤0.05); statistically significant difference groups V, VI, VII compared to group II: # − (P ≤0.05)

CONCLUSION

Generalization of the obtained results indicates that Cr(VI)-induced toxicity causes an imbalance in biochemical blood parameters. Cr(VI) causes decrease of total protein content in blood plasma. $K_2Cr_2O_7$ intoxication leads also to an increase in the activity of ALT, AST and the content of creatinine and urea in plasma. In turn, ETS pretreatment leads to percentage decrease of creatinine and urea accumulation and causes percentage lowering of ATL hyperactivation in plasma under Cr(VI) intoxication. However, the levels of these blood biochemical parameters in this case still remain significantly higher than in the control. The corresponding effects of ETS may indicate some protective properties in relation to Cr(VI)-induced toxicity, but the 14-day pretreatment with 100 mg/kg ETS did not contribute to the normalization of the studied biochemical blood parameters under Cr(VI) intoxication. For a better and in-depth substantiation of the

protective properties of ETS, it is necessary to conduct additional studies with different variants of concentrations and periods of ETS administration. An important step may be the study of the combined action of ETS and other antioxidant compounds as Cr(VI)-protectors. We hope that the results of our research will help speed up the solution of the problem of intoxication of living organisms with Cr(VI) compounds.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest: The authors received no specific funding for this work and declare no conflict of interest.

Human Rights: The article does not contain any experiments with humans.

Animal Rights: All international, national and institutional guidelines for the care and use of laboratory animals were followed.

AUTHOR CONTRIBUTIONS

Conceptualization, [I.R.Ya.]; methodology, [I.R.Ya.; K.B.I.]; investigation, [K.B.I.]; resources, [K.B.I.; M.V.M.]; data curation, [I.R.Ya.]; writing – original draft preparation, [K.B.I., M.V.M]; writing – review and editing, [K.B.I.; M.V.M.]; visualization, [K.B.I.] supervision, [I.R.Ya.; M.V.M.]; project administration, [I.R.Ya., M.V.M.]; funding acquisition, [–].

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ОСОБЛИВОСТІ ВПЛИВУ *S*-ЕТИЛ-4-АМІНОБЕНЗЕН-ТІОСУЛЬФОНАТУ НА ОКРЕМІ БІОХІМІЧНІ ПОКАЗНИКИ КРОВІ ЩУРІВ У РАЗІ ІНТОКСИКАЦІЇ Cr(VI)

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Вступ. Одним з основних механізмів цитотоксичності Cr(VI) є активація оксидативного стресу у клітинах живих організмів, внаслідок чого виникає дисбаланс біохімічних показників крові. В результаті наших попередніх досліджень встановлено, що *S*-етил-4-амінобензентіосульфонат (ЕТС), який належить до класу сполук тіосульфонатів, здатний знижувати інтенсивність Cr(VI)-індукованого окисидативного стресу у тканині печінки щурів. Відомо, що оксидативний стрес за дії Cr(VI) спричиняє ушкодження тканини печінки та нирок з подальшим порушенням балансу біохімічних параметрів крові. Тому метою наших досліджень було оцінити потенційну здатність ЕТС запобігати Cr(VI)-індукованим порушенням окремих біохімічних параметрів крові, які є важливими біомаркерами інтоксикації Cr(VI).

Матеріали та методи. Об'єктом досліджень були окремі біохімічні параметри крові щурів за умов інтоксикації Cr(VI) та попереднього впливу ЕТС. Двом дослідним групам щурів самців лінії *Wistar* проводили інтоксикацію $K_2Cr_2O_7$ (розчинений у фізіологічному розчині) один раз на день протягом 7 або 14 діб внутрішньоочеревинно. Двом іншим дослідним групам протягом 2-х тижнів вводили ЕТС (розчинений в олії) внутрішньошлунково один раз на день попередньо до 7- або 14-добового періоду інтоксикації $K_2Cr_2O_7$. У плазмі крові щурів вимірювали рівень загального протеїну, креатиніну та сечовини, а також визначали активність амінотрансфераз.

Результати. Внутрішньоочеревинне введення $K_2Cr_2O_7$ (розчинений у фізіологічному розчині в дозі 2,5 мг Cr(VI)/кг маси тіла) протягом 7 та 14 діб призводить до зниження рівня загального протеїну, спричиняє підвищення концентрації креатиніну та сечовини у плазмі крові. Активність амінотрансфераз крові зростає внаслідок токсичності Cr(VI). Період 14-добового введення ЕТС (розчинений в олії у дозі 100 мг/кг маси тіла) у разі подальшої інтоксикації Cr(VI) характеризується нижчим відсотковим накопичення креатиніну, сечовини й активації аланінамінотрансферази (АЛТ) у плазмі крові щурів.

Висновки. Cr(VI)-індукована токсичність спричиняє дисбаланс біохімічних показників крові. Cr(VI) індукує зниження рівня загального протеїну та призводить до підвищення рівня досліджуваних біохімічних показників плазми крові, які є мар-

керами ушкодження печінки (амінотрансферази) та нирок (креатинін, сечовина). У свою чергу, вплив ЕТС протягом 14 діб у разі подальшої інтоксикації Cr(VI) сприяє відсотковому зниженню гіперактивації АЛТ, вмісту креатиніну та сечовини у крові щурів. Однак показники АЛТ, креатиніну та сечовини у цьому разі залишаються значно вищими, ніж у контрольній групі. Отже, вплив ЕТС (100 мг/кг) протягом 2 тижнів сприяє зниженню рівня Cr(VI)-індукованих порушень деяких біохімічних показників крові, проте нормалізації відповідних показників не спостерігали.

Ключові слова: тіосульфонати, шестивалентинй хром, дихромат калію, креатинін, сечовина, амінотрансферази

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