

# The Effect of Carbon Monoxide on the Morphological Parameters of the Thymus

Qodirov Oybek O'ktam ugli<sup>1</sup>, Teshayev Shuxrat Jumayevich<sup>2</sup>

<sup>1</sup>PhD., Associate Professor, Department of Histology, Cytology and Embryology Bukhara State Medical Institute, Bukhara, Uzbekistan  
<sup>2</sup>Doctor of Medical Sciences, Professor, Department of Anatomy and Clinical Anatomy (OHTA), Bukhara State Medical Institute, Bukhara, Uzbekistan

---

**Abstract** Morphofunctional changes in the thymus were identified as a result of chronic exposure to an isocyanate isotope in laboratory animals under experimental conditions. Chronic exposure to the isocyanate isotope caused specific alterations in each part of the thymus, including the proliferation of connective tissue, cellular hypertrophy, signs of inflammation, and dilation of blood vessels.

**Keywords** Chronic carbon monoxide exposure, Oxidative stress, Apoptosis, Spleen, Morphological changes, Experimental study

---

## 1. Introduction

Carbon monoxide poisoning disrupts the metabolism of carbon and protein, resulting in symptoms of acidosis. The balance of potassium and calcium in the blood and the functioning of the central nervous system can be disrupted, which can lead to premature death [15,16,17]. The harmful effects of carbon monoxide include changes in the body, including the morphological characteristics of organs, and the development of therapeutic and preventive measures to reduce the harmful effects of carbon monoxide has not lost its relevance [1,2].

In practice, the morphometric changes in the thymus and the negative effects of carbon monoxide on the human body are very diverse, and many scientific studies are being conducted around the world to solve this urgent problem. These works were carried out at the world's leading research centers and universities (Western Kentucky University, Dominican University of California, Harvard University, University of Missouri-Columbia, University of Nebraska-Lincoln, Colby College (USA), Oxford University (Great Britain) [3,4,5]. Living organisms live under a huge number of external influences. It is no secret that carbon monoxide is constantly causing harm to humanity among such external influences. Carbon monoxide affects the body through the respiratory system [6,7,8,9]. According to researchers and scientists from leading scientific centers in the world today, the presence of 0.1% carbon monoxide in the composition of the inhaled air can lead to death [9,10]. This gas forms a compound with hemoglobin that is 300 times stronger than

oxygen - carboxyhemoglobin [11,12]. As a result, the ability of hemoglobin to transport oxygen to tissues decreases sharply, leading to hypoxia, and in severe cases, to anoxia. can lead to [13,14].

Objective of the study To identify the morphological and functional changes in spleen tissue under chronic inhalational exposure to carbon monoxide (CO), evaluate their severity and developmental stages, and scientifically substantiate the mechanism of CO influence on spleen immunological reactivity based on morphological, morphometric, histological, and biochemical parameters.

## 2. Material and Methods of Research

The experiments were conducted on 208 white female outbred rats born in vivarium conditions. Rats aged 3, 6, 9 and 12 months were involved. The experiments followed the ethical rules for the use of animals and the requirements of the Helsinki Congress. Before the start of the experiments, all sexually mature rats were quarantined for a week and, excluding somatic or infectious diseases, they were transferred to the usual vivarium regime under the same conditions. During the experiment, the behavior and physiological state of animals in the standard and experimental groups were monitored. Rats were divided into 4 groups (n = 208): I-control group (n = 40); II-IV-groups (n = 168) experimental animals were chronically poisoned with a dose of carbon monoxide in the air of 0.01-0.05 mg / l. During the experiment, 4 3-month-old, 1 6-month-old, and 1 12-month-old rats died as a result of chronic carbon monoxide poisoning. After that, we divided 162 outbred white female rats chronically poisoned with carbon monoxide into 3 more groups. Group 2 (n = 54) rats chronically poisoned with carbon monoxide in

the experiment; Group 3 (n = 54) rats chronically poisoned with carbon monoxide were administered intragastrically through a metal stomach tube for 14 days with 1 ml of infusion of the plant Gulimansar; In the 4th group (n = 54) experiment, rats chronically poisoned with carbon monoxide were administered intragastrically through a metal gastric tube for 14 days with a volume of 0.1 ml of an alcoholic solution of asparagus oil (in a ratio of 1:9). A total of 208 rats were used in the experiments, of which only 6 died during the experiments.

### 3. Results and Discussion

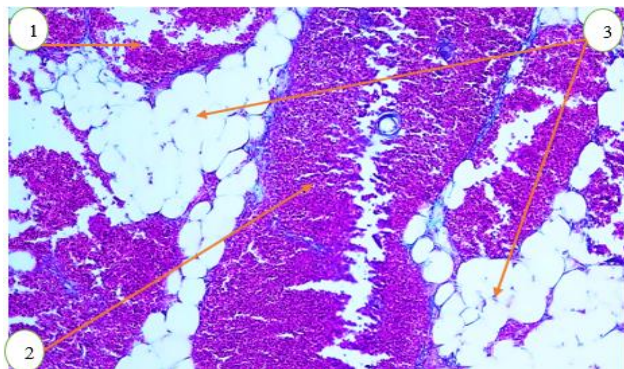
In 6-month-old rats, the mean thickness of the thymic capsule was  $4.6 \pm 0.21 \mu\text{m}$  at the hilum,  $7.0 \pm 0.10 \mu\text{m}$  at the anterior pole, and  $5.7 \pm 0.14 \mu\text{m}$  at the posterior pole. The mean diameter of the trabecula was  $11.1 \pm 0.19 \mu\text{m}$  in the proximal part and  $7.7 \pm 0.24 \mu\text{m}$  in the distal part. The average depth of the trabecula was  $12.7 \pm 0.31 \mu\text{m}$ .

In 6-month-old rats, the mean area of the thymic lobule was  $66.3 \pm 0.9\%$ . In the control group of 6-month-old rats, the mean area of the cortical region was  $64.9 \pm 1.3\%$ , the mean area of the medullary region was  $25.4 \pm 1.6\%$ , and the corticomedullary index was  $2.4 \pm 0.1\%$ .

In 6-month-old rats, the mean wall thickness of trabecular vessels was as follows: arteriole –  $16.8 \pm 0.32 \mu\text{m}$ , venule –  $15.9 \pm 0.24 \mu\text{m}$ , and capillary –  $4.2 \pm 0.10 \mu\text{m}$ . The mean internal diameter of the trabecular arteriole was  $18.2 \pm 0.15 \mu\text{m}$ ; the mean diameter of the accompanying arteriole was  $18.2 \pm 0.15 \mu\text{m}$ ; and the mean diameter of the venule was  $4.8 \pm 0.30 \mu\text{m}$ .

The mean wall thickness of cortical vessels was  $15.4 \pm 0.17 \mu\text{m}$  for arterioles,  $13.9 \pm 0.23 \mu\text{m}$  for venules, and  $3.4 \pm 0.10 \mu\text{m}$  for capillaries. The mean internal diameter of cortical arterioles was  $17.2 \pm 0.33 \mu\text{m}$ , venules –  $23.1 \pm 0.25 \mu\text{m}$ , and capillaries –  $4.5 \pm 0.30 \mu\text{m}$ .

In the medullary region, the mean wall thickness of arterioles was  $14.1 \pm 0.11 \mu\text{m}$ , venules –  $14.6 \pm 0.36 \mu\text{m}$ , and capillaries –  $2.6 \pm 0.10 \mu\text{m}$ . The mean internal diameter of medullary arterioles was  $15.8 \pm 0.17 \mu\text{m}$ , venules –  $15.1 \pm 0.21 \mu\text{m}$ , and capillaries –  $3.7 \pm 0.30 \mu\text{m}$ .

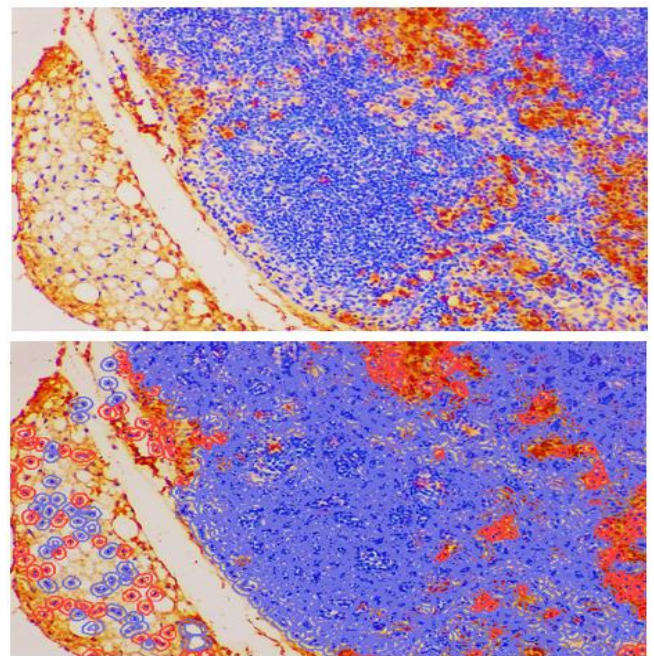


**Figure 1.** Microscopic appearance of the thymus of a 6-month-old outbred white rat following chronic exposure to carbon monoxide. Alcian blue staining. Objective 20 $\times$ , ocular 10 $\times$ . 1 – cortical zone; 2 – medullary zone; 3 – interlobular trabeculae

In this image, we can observe structural disruptions in both the cortical and medullary regions of the thymus. In a normal thymus, the cortex (darker/redder) and medulla (lighter) are clearly distinguishable. In this image, however, their boundaries appear blurred and disrupted. A decrease in the number of cells and their dispersed arrangement in the cortical region indicate signs of lymphoid atrophy.

The amount of adipose tissue in the thymus is normally very low, especially in young rats, whereas in our study group, the opposite pattern is clearly seen. In this image, numerous large, pale adipocytes are visible. Areas of intensified bluish staining around the thymic stroma represent mucoid degeneration or pathology of extracellular matrix components.

In 6-month-old rats, the average thickness of the thymic capsule was  $9.7 \pm 0.21 \mu\text{m}$  at the hilum,  $12.6 \pm 0.1 \mu\text{m}$  at the anterior pole, and  $11.1 \pm 0.14 \mu\text{m}$  at the posterior pole. The average diameter of the proximal trabecula was  $17.1 \pm 0.19 \mu\text{m}$ , and  $13.7 \pm 0.24 \mu\text{m}$  at its distal part. The average depth of the trabecula measured  $17.7 \pm 0.31 \mu\text{m}$ . The average area of the thymic lobule in 6-month-old rats was  $70.3 \pm 0.9\%$  (Figure 2).



**Total number of detected cells: 703**  
**Positive cells: 112**  
**Negative cells: 591**  
**Positive expression: 15.93%**  
**Total analyzed area: 195,444 px<sup>2</sup>**

**Figure 2.** Expression of the CD68 marker in thymic tissues of 6-month-old outbred white rats following chronic exposure to carbon monoxide. Staining was performed using the DAB chromogen method. Magnification  $\times 400$ . CD68-positive cells are shown in red

As a result of chronic carbon monoxide exposure, the cortical area in 6-month-old rats averaged  $70.9 \pm 1.3\%$ , while the medullary area comprised  $31.4 \pm 1.6\%$ , and the cortex-to-medulla index was  $6.5 \pm 0.1\%$ .

In 6-month-old rats, the average wall thickness of trabecular arterioles was  $25.8 \pm 0.32 \mu\text{m}$ , venules  $21.9 \pm 0.24 \mu\text{m}$ , and

capillaries  $10.2 \pm 0.1 \mu\text{m}$ ; the internal diameter of arterioles was  $24.2 \pm 0.15 \mu\text{m}$ , venules  $27.4 \pm 0.33 \mu\text{m}$ , and capillaries  $10.8 \pm 0.3 \mu\text{m}$ .

In the cortical layer, the average arteriole wall thickness was  $20.4 \pm 0.17 \mu\text{m}$ , venules  $18.9 \pm 0.23 \mu\text{m}$ , and capillaries  $9.4 \pm 0.1 \mu\text{m}$ ; the internal diameter of arterioles averaged  $23.2 \pm 0.33 \mu\text{m}$ , venules  $29.1 \pm 0.25 \mu\text{m}$ , and capillaries  $10.5 \pm 0.3 \mu\text{m}$ .

In the medullary region, the average arteriole wall thickness was  $20.1 \pm 0.11 \mu\text{m}$ , venules  $20.6 \pm 0.36 \mu\text{m}$ , and capillaries  $9.6 \pm 0.1 \mu\text{m}$ ; the internal diameter of arterioles averaged  $25.8 \pm 0.17 \mu\text{m}$ , venules  $23.1 \pm 0.21 \mu\text{m}$ , and capillaries  $10.7 \pm 0.3 \mu\text{m}$ .

The immunohistochemical changes in the thymus of 6-month-old albino rats subjected to chronic carbon monoxide exposure and treated with *Ephedra* (for therapeutic–preventive purposes) were investigated. For immunohistochemical evaluation of primary tumors and their metastases, a wide range of markers—antigens—was used. A marker is an indicator of normal biological processes, pathogenic processes, or pharmacologic response to therapeutic intervention that can be objectively measured and evaluated. Antigens may be cyto-specific or tissue-specific; they may reflect processes of cell proliferation or tumor-associated antigens and, finally, may include tumor markers such as oncofetal antigens, enzymes, protein products of cellular oncogenes, and others.

## 4. Discussion

Immunohistochemical changes in the thymus of 6-month-old outbred white rats exposed to chronic carbon monoxide and treated with citric acid for therapeutic and prophylactic purposes were investigated. In 6-month-old rats, the mean thickness of the thymic capsule was  $12.7 \pm 0.21 \mu\text{m}$  at the hilum,  $15.6 \pm 0.10 \mu\text{m}$  at the anterior pole, and  $14.1 \pm 0.14 \mu\text{m}$  at the posterior pole. The mean diameter of the trabecula was  $20.1 \pm 0.19 \mu\text{m}$  in the proximal part and  $16.7 \pm 0.24 \mu\text{m}$  in the distal part. The average depth of the trabecula was  $20.7 \pm 0.31 \mu\text{m}$ . The mean area of thymic lobules in 9-month-old rats was  $73.3 \pm 0.9\%$ .

In the control group of 6-month-old rats, the mean cortical area was  $73.9 \pm 1.3\%$ , the medullary area was  $34.4 \pm 1.6\%$ , and the corticomedullary index was  $10.5 \pm 0.1\%$ .

The mean wall thickness of trabecular vessels in 6-month-old rats was  $33.8 \pm 0.32 \mu\text{m}$  for arterioles,  $32.9 \pm 0.24 \mu\text{m}$  for venules, and  $21.2 \pm 0.10 \mu\text{m}$  for capillaries. The mean internal diameter was  $32.2 \pm 0.15 \mu\text{m}$  for arterioles,  $38.4 \pm 0.33 \mu\text{m}$  for venules, and  $21.8 \pm 0.30 \mu\text{m}$  for capillaries.

In the cortical layer, the mean wall thickness of arterioles was  $32.4 \pm 0.17 \mu\text{m}$ , venules  $30.9 \pm 0.23 \mu\text{m}$ , and capillaries  $20.4 \pm 0.10 \mu\text{m}$ . The mean internal diameter of cortical arterioles was  $34.2 \pm 0.33 \mu\text{m}$ , venules  $40.1 \pm 0.25 \mu\text{m}$ , and capillaries  $21.5 \pm 0.30 \mu\text{m}$ .

In the medullary region, the mean wall thickness of arterioles was  $31.1 \pm 0.11 \mu\text{m}$ , venules  $31.6 \pm 0.36 \mu\text{m}$ , and

capillaries  $20.6 \pm 0.10 \mu\text{m}$ . The mean internal diameter of medullary arterioles was  $25.8 \pm 0.17 \mu\text{m}$ , venules  $25.1 \pm 0.21 \mu\text{m}$ , and capillaries  $13.7 \pm 0.30 \mu\text{m}$ .

## 5. Conclusions

Immunohistochemical changes in the thymus of 6-month-old outbred white rats exposed to chronic carbon monoxide and treated with citric acid for therapeutic and prophylactic purposes were investigated. In 6-month-old rats, the mean thickness of the thymic capsule was  $12.7 \pm 0.21 \mu\text{m}$  at the hilum,  $15.6 \pm 0.10 \mu\text{m}$  at the anterior pole, and  $14.1 \pm 0.14 \mu\text{m}$  at the posterior pole. The mean diameter of the trabecula was  $20.1 \pm 0.19 \mu\text{m}$  in the proximal part and  $16.7 \pm 0.24 \mu\text{m}$  in the distal part. The average depth of the trabecula was  $20.7 \pm 0.31 \mu\text{m}$ . The mean area of thymic lobules in 9-month-old rats was  $73.3 \pm 0.9\%$ .

In the control group of 6-month-old rats, the mean cortical area was  $73.9 \pm 1.3\%$ , the medullary area was  $34.4 \pm 1.6\%$ , and the corticomedullary index was  $10.5 \pm 0.1\%$ .

The mean wall thickness of trabecular vessels in 6-month-old rats was  $33.8 \pm 0.32 \mu\text{m}$  for arterioles,  $32.9 \pm 0.24 \mu\text{m}$  for venules, and  $21.2 \pm 0.10 \mu\text{m}$  for capillaries. The mean internal diameter was  $32.2 \pm 0.15 \mu\text{m}$  for arterioles,  $38.4 \pm 0.33 \mu\text{m}$  for venules, and  $21.8 \pm 0.30 \mu\text{m}$  for capillaries.

In the cortical layer, the mean wall thickness of arterioles was  $32.4 \pm 0.17 \mu\text{m}$ , venules  $30.9 \pm 0.23 \mu\text{m}$ , and capillaries  $20.4 \pm 0.10 \mu\text{m}$ . The mean internal diameter of cortical arterioles was  $34.2 \pm 0.33 \mu\text{m}$ , venules  $40.1 \pm 0.25 \mu\text{m}$ , and capillaries  $21.5 \pm 0.30 \mu\text{m}$ .

In the medullary region, the mean wall thickness of arterioles was  $31.1 \pm 0.11 \mu\text{m}$ , venules  $31.6 \pm 0.36 \mu\text{m}$ , and capillaries  $20.6 \pm 0.10 \mu\text{m}$ . The mean internal diameter of medullary arterioles was  $25.8 \pm 0.17 \mu\text{m}$ , venules  $25.1 \pm 0.21 \mu\text{m}$ , and capillaries  $13.7 \pm 0.30 \mu\text{m}$ .

---

## REFERENCES

- [1] Abdrakhmanov, V.I., Dorogova, O.A., Kiryutkin, G.V. & Krasnov, V.L., 2005. Comparison of quality indicators of ASD-2F produced by Areal-Medical LLC and Armavir Biopharmaceutical Factory. *Zoindustry*, (1), p. 5.
- [2] Abdrakhmanov, V.I., Sakhpov, V.R. & Krasnov, V.L., 2015. Study of the chemical composition of ASD-2F. *Problems of Modern Science and Education*, (11(41)), pp. 58–64.
- [3] Abdrakhmanov, V.I., Sakhpov, V.R., Krasnov, V.L. & Sulimov, A.V., 2015. Titration of ASD-2F. *Problems of Modern Science and Education*, (4(34)), pp. 38–45.
- [4] Abdrakhmanov, V.I., Krasnov, V.L., Logutov, V.I., Orlov, A.V. & Sakhpov, V.R., 2019. Chromatographic study of the chemical composition of ASD-2F substance. *International Journal of Applied and Fundamental Research*, (6), pp. 168–173.
- [5] Abramov, V.E., Abdrakhmanov, V.I., Dorogova, O.A.,

- Kiryutkin, G.V. & Krasnov, V.L., 2004. Determination of quality indicators of ASD-2F. *Veterinary*, (9), pp. 13–16.
- [6] Abramov, V.E., Kugeleva, T.I., Sirotkina, V.P. & Kasperovich, V.P., 2010. Quality indicators of ASD-2F substance. *Veterinary*, (2), pp. 42–44.
- [7] Absettarova, A.I., Makalish, T.P. & Abdullaeva, V.D., 2019. Morphology of red bone marrow and spleen in the post-radiation period following xenogenic fluid administration in an experiment. *Crimean Journal of Experimental and Clinical Medicine*, 9(1), pp. 5–11.
- [8] Aleksakhin, R.M., Buldakov, L.A., Gubanov, V.A. et al., 2001. *Radiation Accidents*. Edited by L.A. Ilyin & V.A. Gubanov. Moscow: Publishing House. p. 752.
- [9] Alfonsova, E.V., 2012. Functional morphology of connective tissue stroma of the spleen in an age aspect. *Advances in Gerontology*, 25(3), pp. 415–421.
- [10] Afanasyev, Y.I., Yurina, N.A. & Kotovsky, E.F. et al., 2012. *Histology, Embryology, Cytology: Textbook*, 6th ed. Revised and supplemented. p. 800.
- [11] Akhmatova, N.K., Egorova, N.B. & Akhmatov, E.A. et al., 2010. Expression of Toll-like receptors in spleen and lymph nodes with mucosal immunization methods. *Journal of Microbiology, Epidemiology and Immunobiology*, (1), pp. 50–54.
- [12] Babichev, V.N., 2013. Organization and functioning of the neuroendocrine system. *Problems of Endocrinology*, 59(1), pp. 62–69.
- [13] Bazanov, G.A., Bazanova, E.M. & Melnikenko, V.N., 2015. Biogenic stimulants: from discovery to use in modern medicine. *Youth and Medical Science*, pp. 19–22.
- [14] Bakhmet, A.A. & Koplik, E.V., 2014. Spleen reaction in active and passive rats under stress exposure with prior administration of synthetic ACTH analog Semax. *Academic Journal of Western Siberia*, 10(2(51)), pp. 115.
- [15] Bashina, S.I., 2013. New methodology for studying the spleen of large white pigs. *Bulletin of Bryansk State Agricultural Academy*, (2), pp. 28–29.
- [16] Bessarabov, B.F., Melnikova, I.I. & Lazutkina, E.A., 2006. Stimulation of egg production in female quails with ASD-F2. *Veterinary Medicine*, (2–3), pp. 37–38.
- [17] Bibik, E.Yu. & Brest, A.Yu., 2011. Modern concepts of morphogenesis of the primary lymphoid organ. *Ukrainian Morphological Almanac*, 9(3), pp. 43–46.
- [18] Bobrysheva, I.V., 2013. Morphological reactivity of the spleen in rats of different age periods under immunostimulation. *Journal of Clinical and Experimental Medical Research*, 1(3), pp. 315–321.