

Comparative Analysis of the Effect of Chemical and Immobilization Stress on Hematological Parameters of Blood (Experimental Study)

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Abstract Stress is an important factor affecting the physiological state of the body, causing metabolic and hematological changes. The study conducted a comparative analysis of the effects of chemical and immobilization stress on the levels of glucose, hemoglobin, erythrocytes and leukocytes in guinea pigs. It was found that chemical stress causes a significant increase in glucose levels (+85.23%) and leukocytes (+75.10%), as well as a decrease in hemoglobin (-9.85%), which indicates a pronounced activation of stress and inflammatory reactions. Immobilization stress leads to less pronounced changes, including an increase in glucose (+56.45%) and white blood cells (+35.04%), as well as a moderate decrease in hemoglobin (-3.32%). Differences in the body's reactions to these stress factors confirm their varying degrees of influence. The results obtained allow for a deeper understanding of the mechanisms of adaptation to stress and can be used to develop strategies for the prevention and correction of stress-induced disorders in medicine and physiology. This study contributes to the study of the pathophysiological mechanisms of stress, emphasizing the importance of further analysis of compensatory processes under various types of stress.

Keywords Stress, Chemical stress, Immobilization stress, Glucose, Hemoglobin, Erythrocytes, Leukocytes, Hematological parameters

1. Introduction

Stress is a universal physiological reaction of the body to the effects of adverse factors, activating complex neuroendocrine, immune and metabolic adaptation mechanisms. Depending on the nature of the stressful effect, several types of stress are distinguished, among which chemical and immobilization stress occupy a special place. Chemical stress occurs under the influence of toxic substances and is accompanied by pronounced metabolic and inflammatory changes, whereas immobilization stress is caused by limited mobility and is characterized by less intense activation of compensatory processes. [1,4,5,6]. One of the key manifestations of stress is changes in blood parameters that reflect the state of metabolism, the hematopoietic system, and the immune response. In particular, the level of glucose, hemoglobin, erythrocytes and leukocytes can change significantly under the influence of stress factors, which indicates the degree of

mobilization of protective mechanisms. The analysis of these changes makes it possible to assess differences in the physiological reactions of the body to different types of stress and determine the mechanisms of their compensation. Despite a significant number of studies devoted to stress reactions, a comparative analysis of the effects of chemical and immobilization stress on metabolic and hematological parameters of blood remains insufficiently studied. Identifying differences and similarities in the mechanisms of adaptation to these types of stress is important for developing strategies to correct stress-induced disorders and prevent their consequences. [2,3,7,8]. In this work, a comparative study of changes in glucose, hemoglobin, erythrocytes and leukocytes levels under the influence of chemical and immobilization stress is carried out, which will allow for a deeper understanding of the metabolic and hematological reactions of the body to various stressful factors.

The purpose of the study. To determine and compare the effects of chemical and immobilization stress on the metabolic and hematological parameters of blood, including glucose, hemoglobin, erythrocytes and leukocytes, in order to identify differences in the mechanisms of adaptation of the body to these types of stress.

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Received: Jan. 28, 2025; Accepted: Feb. 20, 2025; Published: Mar. 8, 2025

Published online at <http://journal.sapub.org/ijge>

2. Materials and Methods of Research

The study was conducted on 60 male guinea pigs weighing 300-350 g, kept in standard vivarium conditions with free access to food and water. The animals were divided into three groups (20 in each):

- The control group consisted of animals that were not exposed to stress.
- Chemical stress group – animals that have been injected with a chemical agent that causes a stress reaction.
- The group of immobilization stress is animals that have been fixed to simulate immobilization stress.

After a certain time interval after exposure, blood was taken from the jugular vein under light ether anesthesia to determine the concentration of glucose, hemoglobin, as well as the level of red blood cells and leukocytes. All procedures complied with ethical standards and were carried out in accordance with international standards for working with laboratory animals.

3. The Results of the Study

Exposure to chemical stress is accompanied by a marked increase in blood glucose concentration (+85.23%), which is due to increased activity of the sympathetic nervous system and increased secretion of cortisol. At the same time, immobilization stress causes a less significant increase in this indicator (+56.45%), which indicates a relatively lower degree of activation of metabolic processes. However, the difference between these effects (15.51%) is statistically unreliable ($p>0.05$), probably due to the overlap of standard deviations or the similarity of the mechanisms of glucose regulation (Table 1).

Table 1. Changes in blood parameters during chemical and immobilization stress

Parameter	The control group	Chemical stress	Immobilization stress
Glucose level (mmol/L)	7,31±1,05*	13,54±3,72*	11,44±2,87*
Hemoglobin (g/l)	131,15±5,89*	118,23±15,16*	126,8±10,54
Red blood cells ($10^9/l$)	5,99±0,12*	6,62±0,79*	6,2±0,88*
White blood cells ($10^9/l$)	7,19±0,38*	12,59±0,59***	9,71±0,26***

Note (*- $p<0.05$), (**- $p<0.001$)

Exposure to chemical stress is accompanied by a decrease in hemoglobin concentration by 9.85% compared to the control values. In turn, immobilization stress also leads to a decrease in this indicator, but the severity of the changes is less significant and amounts to 3.32%. A comparison of these types of stress exposure shows that the difference between them reaches 7.25%, which indicates a more pronounced effect of chemical stress on hemoglobin levels (Table 1).

The indicator of the number of red blood cells remains within the physiological norm. Exposure to chemical stress is accompanied by a moderate increase in this parameter (+10.52%), which may be due to increased bone marrow activity in response to chemical exposure. In the case of immobilization stress, there is a less pronounced increase in the number of red blood cells (+3.51%), probably due to less intense activation of stress mechanisms. When comparing these two conditions, the difference between them is 6.34%, but the statistical significance of the differences has not been achieved ($p>0.05$), which suggests the similarity of compensatory mechanisms regulating the level of red blood cells in both types of stress (Table 1).

In the control group, the leukocyte level remains within the normal range ($7.19 \pm 0.38 \times 10^9/l$). Under chemical stress, there is a significant increase in this indicator (+75.10%), which is probably due to an increased response of the immune system and activation of inflammatory processes in response to exposure to chemical agents. Immobilization stress also leads to an increase in the number of white blood cells (+35.04%), but this reaction is less pronounced, which may indicate differences in the degree of stimulation of immune defenses. The difference between these types of stress is 22.88% and is statistically significant ($p<0.001$), which confirms differences in adaptation mechanisms. More pronounced leukocytosis under chemical stress is probably associated with its more intense damaging effect, provoking a strong inflammatory response of the body (Table 1).

4. Discussion

The results of our study show that chemical stress causes more pronounced changes in the metabolic and hematological parameters of blood compared with immobilization stress. In particular, a significant increase in blood glucose levels under chemical stress (+85.23%) may be associated with activation of the sympatho-adrenal system and increased cortisol secretion. Similar results were obtained in the study of Ostrovskaya I.G. (2006), where acute stress led to changes in metabolic processes in the pulp of rat teeth.

A decrease in hemoglobin levels when exposed to chemical stress (-9.85%) may be associated with inhibition of erythropoiesis or increased destruction of red blood cells. In the study by Makutina V.A. et al. (2012) showed that the combined effects of aluminum and immobilization stress lead to degenerative changes in the testicles of rats, which also indicates the negative impact of stress factors on various body systems.

An increase in the number of white blood cells under chemical stress (+75.10%) indicates a pronounced activation of the immune system and the development of inflammatory processes. In a paper published in the journal "Problems of Endocrinology" (2000), it was shown that acute immobilization stress increases the secretion of thyroid hormones in rats, which also indicates the activation of the endocrine system in response to stress.

Thus, our data are consistent with the results of other studies, confirming that various types of stress have a significant impact on metabolic and hematological parameters, and the degree of these changes depends on the nature of the stress factor.

5. Conclusions

Chemical stress has a more pronounced effect on the metabolic and hematological parameters of blood than immobilization. It leads to a significant increase in glucose levels (+85.23%) and leukocytes (+75.10%), as well as a more pronounced decrease in hemoglobin (-9.85%), which indicates a strong activation of stress and inflammatory reactions. Immobilization stress causes less pronounced changes. Differences in the body's responses to these stress factors confirm the varying degrees of their effects and the importance of studying adaptation mechanisms.

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