Reheda Mykhailo Stepanovych, Kovalska Marta Yevhenivna, Baida Mariana Ljubomurivna. Peculiarities of changes in a functional condition of pro-oxidant and antioxidant systems in guinea pigs' lungs in experimental allergic alveolitis under the conditions of immobilization stress. Journal of Education, Health and Sport. 2017;7(10):253-260. eISSN 2391-8306. DOI http://dx.doi.org/10.5281/zenodo.1157117
http://ojs.ukw.edu.pl/index.php/johs/article/view/5215

The journal has had 7 points in Ministry of Science and Higher Education parametric evaluation. Part B item 1223 (26.01.2017).
1223 Journal of Education, Health and Sport eISSN 2391-8306 7

The authors declare that there is no conflict of interests regarding the publication of this paper.
Received: 10.10.2017. Revised: 27.10.2017. Accepted: 30.10.2017.

UDC: 616.24-002-008.6-056.3-092: (612.24.015.11+612.014.484)]-092.9

PECULIARITIES OF CHANGES IN A FUNCTIONAL CONDITION OF PRO-OXIDANT AND ANTIOXIDANT SYSTEMS IN GUINEA PIGS' LUNGS IN EXPERIMENTAL ALLERGIC ALVEOLITIS UNDER THE CONDITIONS OF IMMOBILIZATION STRESS

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Abstract

We have analyzed the results of investigation of alterations in indices of pro-oxidant (conjugated diene and malondialdehyde) and antioxidant (superoxide dismutase, ceruloplasmin, catalase) systems in guinea pigs' lungs in experimental allergic alveolitis in the dynamics of EAA development under the conditions of immobilization stress. The investigation was conducted on 62 female guinea pigs weighing 180-220 g, divided into 4 groups: I – intact guinea pigs (n=20), II – guinea pigs (n=14) with EAA under the conditions of IS (1st day); III – guinea pigs (n=14) with EAA under the conditions of IS (2nd day); IV – guinea pigs (n=14) with EAA under the conditions of IS (34th day). The results of experimental investigation showed that a significant increase in conjugated diene level in animals' lungs was observed at all stages of EAA development under the conditions of

immobilization stress as compared with control group, indicating activation of this marker. The same changes occurred with MDA content, indicating excessive accumulation of this lipid peroxidation product in lung tissue. Intensive synthesis of free radical compounds caused activation of some components of enzymatic system of antioxidant defense. In particular, a moderate decrease in superoxide dismutase activity in lung tissue is observed in response to increased level of LOPs at early stages of EAA and immobilization stress development as compared with the indices in intact animals. The same situation is observed with catalase and ceruloplasmin activity in the lungs of guinea pigs with modeled AA and IS.

Key words: **experimental allergic alveolitis, immobilization stress, peroxide lipid oxidation, antioxidant system.**

Introduction. Among urgent problems of health care worldwide, a significant place is occupied by exogenous allergic alveolitis (EAA), which attracts attention of internists and allergists and is associated with a high incidence of this pathology in the structure of allergic diseases and an increase in severe complicated forms of this disease [1-4]. Currently, EAA is regarded as the pathology, associated with the risk of disability, manifested by chronic respiratory insufficiency, pulmonary heart or pneumosclerosis [5].

Besides, at present there are hardly any individuals, especially in ecologically unfriendly industrial regions of Ukraine, who do not experience any signs of allergic diseases. Thus, taking into account such facts, etiopathogenic peculiarities of this nosological form of the disease should be more thoroughly studied by both clinical pulmonologists and scientists.

The problem of combined pathology is also very topical in contemporary medicine, the basic features of which being difficulties with diagnosis, especially at the initial stage of the disease, comorbid clinical course and, as a result, complicated treatment of such patients. In particular, combination of stress with other diseases is very common [3, 6-8]. In recent decades, many investigations have shown association between the nervous system and the lungs [7]. Functioning mechanisms of both systems are characterized by common pathogenic peculiarities acting in synergism, since the lungs play one of the leading roles in adaptation reactions of the body to stressful influences of various origins [5]. This is caused by the fact that the lungs are a target organ for “adaptation” hormones, because they are responsible for a large number of clearing (clearance) processes [9-15]. Accordingly, they are an optimal organ for the study of various effects, occurring due to stress and allergic processes by hypersensitivity types.

The aim of the research was to study lipid peroxidation processes and the condition of antioxidant protection in guinea pigs' lungs in different periods of experimental allergic alveolitis (EAA) formation under the conditions of IS.

MATERIALS AND METHODS OF INVESTIGATION

All experiments on laboratory animals were conducted following the principles of bioethics according to the regulations of *European Convention for the protection of vertebrate animals* used for experimental and other scientific purposes (Strasbourg, 1986), European Union Directive 2010/63/EU, Law of Ukraine № 3447-IV "On protection of animals from cruel treatment", general ethic principles of experiments on animals, approved by the first national congress of Ukraine on bioethics (2001).

The experiment was conducted on 62 female guinea pigs weighing 0.18-0.20 kg. The animals were divided into 4 groups:

I – intact guinea pigs (п=20);

II – guinea pigs (п=14) with EAA under the conditions of IS (1^{st} day from the start of injecting antigen);

III – guinea pigs (п=14) with EAA under the conditions of IS (2^{nd} day from the start of injecting antigen);

IV – guinea pigs (п=14) with EAA under the conditions of IS (34^{th} day from the start of injecting antigen).

Experimental allergic alveolitis (EAA) was induced by the method of O.O. Orehov and Y.A. Kyrylov [16]. Prior, the animals had been immunized with Freund's c*omplete* adjuvant (0.2 ml intramuscularly into a hind leg). In 2 weeks, 0.2 ml of 1% BCG solution was introduced intravenously every 10^{th} day. Experimental model of immobilization stress was induced by the following principle – the animals were immobilized on the back on an operation table, with atraumatic fixing of the extremities. Duration of immobilization lasted two hours. Immobilization stress was imitated by P.D.Horizontov method [17]. Later, the animals were decapitated; the level of LOPs and activity of antioxidant system enzymes were detected in lung homogenate on the 1^{st}, 2^{nd}, 34^{th} days after EAA and stress activity. The content of conjugated dienes was determined by the method of V.B. Havrylov and M.I. Myshkorudina [18], malondialdehyde (MDA) – by E.N. Korobeinikov method [19], superoxide dismutase activity – by R.Fried method [20], catalase activity – by R. Holmes [21], and ceruloplasmin – by V.H. Kolb and V.S. Kamyshnikov method [22].

All digital results were statistically processed using arithmetical mean (M), margin of error of arithmetical mean (m), and Student's criterion "t". The calculations were performed

using means of statistical and graphic analysis of electron tables Microsoft Excel (Microsoft office programs). Statistically reliable were the results with P≤0.05.

RESULTS OF INVESTIGATION AND THEIR DISCUSSION

The results of our experimental investigations showed that a significant increase in conjugated dienes in the lungs was observed on the 1st, 2nd and 34th day of EAA under the conditions of immobilization stress by 250.74 % (P<0.05), 151.74 % (P<0.05) and 217.68 % (P<0.05), respectively, in comparison with the control, indicating an intensive formation of free radical compounds (table 1, fig.1).

Table 1

Content of conjugated dienes in guinea pigs' lungs in EAA under the conditions of IS (M±m)

Form of experiment	Duration of the experiment	Number of animals	Conjugated dienes in nmol/ml (g)
Intact guinea pigs	Control	20	12.1 ± 0.6
EAA under the conditions of IS	1st day	14	42.44 ± 0.3 P<0.05
	2nd day	14	30.46 ± 0.3 P<0.05
	34th day	14	38.44 ± 0.3 P<0.05

Note. P – reliability of indices difference in comparison with the results in control group

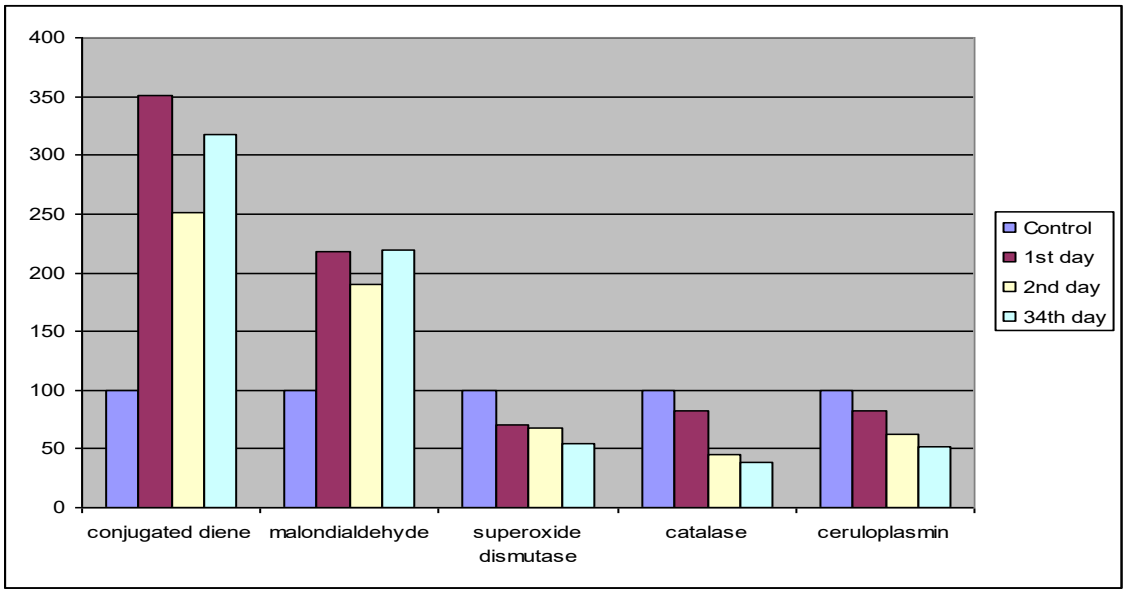

Fig.1. Condition of pro-oxidant and antioxidant systems in the animals' lungs in EAA under the conditions of IS (in % of control)

The changes similar to conjugated dienes occurred with MDA. Thus, a gradual elevation of MDA level in the lungs was recorded on the 1st, 3rd and 34th days of EAA under the conditions of stress development by 118.22 % (P<0.05), 89.57 % (P<0.05) and 119.57 % (P<0.05), respectively, in comparison with intact animals, indicating excessive accumulation of lipid peroxidation products (table 2, fig. 1).

Table 2

Content of MDA in guinea pigs' lungs in EAA under the conditions of IS (M±m)

Form of experiment	Duration of the experiment	Number of animals	MDA in nmol/ml (g)
Intact guinea pigs	Control	20	20.8 ± 0.8
EAA under the conditions of stress	1st day	14	45.39 ± 0.4 P<0.05
	2nd day	14	39.43 ± 0.3 P<0.05
	34th day	14	45.67 ± 0.3 P<0.05

Note. P – reliability of indices difference in comparison with the results in control group

Intensive formation of free radical compounds caused compensatory activation of some components of antioxidant defense system. Thus, as a response to increased level of LOPs at early stages of EAA development and immobilization stress (1st day), a moderate reduction of superoxide dismutase activity in the lungs by 29.52 % (P<0.05) was observed. Further, the activity of the enzyme gradually decreased by 31.83 % (P<0.05) and 45.19 % (P<0.05), respectively, in comparison with the control indices (table 3, fig.1).

Table 3

Content of superoxide dismutase in guinea pigs' lungs in EAA under the conditions of IS (M±m)

Form of experiment	Duration of the experiment	Number of animals	Superoxide dismutase in CU/ml (g)
Intact guinea pigs	Control	20	128.1 ± 3.2
EAA under the conditions of stress	1st day	14	90.29 ± 0.4 P<0.05
	2nd day	14	87.33 ± 0.4 P<0.05
	34th day	14	70.43 ± 0.5 P<0.05

Note. P – reliability of indices difference in comparison with the results in control group

Similar situation occurred with catalase activity in the lungs. Analysis of enzymatic activity of this marker in animals' lungs showed that a decreased in catalase activity by 17.32 % ($P<0.05$) was noticed in the dynamics of EAA development and stress (on the 1st day). Further (on the 2nd and 34th days), a gradual decrease in its activity was observed by 54.93 % ($P<0.05$) and 61.57 % ($P<0.05$), respectively, in comparison with the data of intact animals (table 4, fig. 1).

Table 4

Catalase activity in guinea pigs' lungs in EAA under the conditions of IS (M±m)

Form of experiment	Duration of the experiment	Number of animals	Catalase activity in IU/ml (g)
Intact guinea pigs	Control	20	47.7 ± 2.5
EAA under the conditions of stress	1st day	14	39.44 ± 0.4 P<0.05
	2nd day	14	21.5 ± 0.4 P<0.05
	34th day	14	18.35 ± 0.3 P<0.05

Note. P – reliability of indices difference in comparison with the results in control group

Intensive accumulation of LOPs caused depression of ceruloplasmin activity in the lungs. It decreased by 17.97 % ($P<0.05$) on the 1st day of EAA development and immobilization stress in comparison with the group of intact animals. Further, a reliable reduction of ceruloplasmin activity was observed on the 2nd and 34th days of the experiment by 37.32 % ($P<0.05$) and 48.54 % ($P<0.05$), respectively, in comparison with the data of intact animals (table 5, fig. 1).

Table 5

Ceruloplasmin activity in guinea pigs' lungs in EAA under the conditions of IS (M±m)

Form of experiment	Duration of the experiment	Number of animals	ceruloplasmin in mg/l
Intact guinea pigs	Control	20	26.1 ± 0.7
EAA under the conditions of stress	1st day	14	21.41 ± 1.1 P<0.05
	2nd day	14	16.36 ± 0.5 P<0.05
	34th day	14	13.43 ± 0.3 P<0.05

Note. P – reliability of indices difference in comparison with the results in control group

CONCLUSIONS. The obtained results indicate that a gradual accumulation of LOPs occurs in EAA under the conditions of immobilization stress, reaching its peak on the 34th day of the experiment. In its turn, at the initial stages of EAA development and stress, it caused a compensatory reaction, characterized by the activity of all investigated enzymes with their further exhaustion on the 2nd and especially 34th day of the experiment.

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