Morphological Characteristics of Adaptation of the Lungs in the Ground Spinal

K.A. Saparov[1], Z.B. Yessimsiitova[1], B.A. Abdullayeva[1], S.A. Mankibaeva[1], B.M. Tynybekov[1], G.K. Atanbayeva[1] and S.N. Abdreshov[2]

[1]Kazakh National University, Al-Farabi, Almaty, Kazakhstan

[2]Institute of Human and Animal Physiology of the National Academy of Sciences of Kazakhstan, Laboratory of the Physiology of the Lymphatic System, Kazakhstan

Abstract: This article discusses the morphological changes in the structures of the lungs when adapting to some extreme factors and environmental conditions.

One of the most pressing problems of biology is the elucidation of the mechanisms of adaptation of the human body and animals to changing environmental conditions [1-7].

This problem can be viewed in two aspects: firstly, in terms of the emergence of adaptive rearrangements in the body when exposed to environmental factors as a manifestation of the body's plasticity in ontogenesis, secondly, in terms of the emergence of adaptation, as genetically and phenotypically fixed adaptation of living organisms to the conditions environment, which arose in the course of evolution [8-13].

The key point here is the identification and comparison of subtle mechanisms of similar (to the same environmental factor) adaptation that arise in ontogenesis and formed in phylogenesis [14-21].

Keywords: Morphological, characteristics of adaptation, lungs, ground, spinal.

INTRODUCTION

This paper presents the results of a study at the cellular level of similar adaptations of the respiratory part of the lungs of terrestrial vertebrates in ontogeny and phylogenesis. For this purpose, an electron microscopic study of the respiratory part of the rats' lungs was carried out during various experiments, in particular under the influence of extreme natural (high and low temperatures, hypoxia, physical activity) and anthropogenic (tobacco smoke) factors. At the same time, to clarify the ultrastructural basis of the evolutionary adaptation of the lungs, data from electron microscopic studies from representatives of some species of terrestrial vertebrates (amphibians, reptiles, mammals) from steppe and mountain biotopes are examined with the aim of a central organ of external gas exchange to various biotopes during evolution as in animals of different species, and the same species.

Such studies are very important both for theoretical biology (evolutionary theory, ecological, comparative morphology and physiology), and for medicine [22-25].

Address correspondence to this article at the Kazakh State National University of al-Farabi, Almaty, Kazakhstan; Tel: +77073851878;
E-mail: zhanat_2006@mail.ru

DISCUSSION

Ultrastructural analysis of the respiratory section of the lungs when exposed to tobacco smoke, cooling, high temperature, hypoxia, physical activity revealed a number of submicroscopic adaptive reactions in the form of pronounced functional stress of all lung structures. A characteristic feature of these adaptive reactions was their non-specificity. Adaptive Remedies In caudate amphibians (common triton) inhabiting the steppe, adaptive reactions manifested themselves in enhanced secretion of surfactant, hyperplasia of mucous cells, “mixed” cells with ultrastructural signs of pneumocytes of type II and mucous membranes, apparently preventing fluid loss from the respiratory surface of the lungs. On the apical surface of the “mixed” type cells, many microvilli were found. The thickness of the aerohematic membrane system was significant. Increased secretion of mucous cells and cells of the "mixed" type was also confirmed by scanning microscopy data.

In caudal amphibians (frog-crested) living in a mountain biotope, the number of glandular mucous cells decreased, secretion of surfactant decreased, the aerohematic membrane system thinned, and the area of the respiratory surface increased. Scanning microscopy data showed an increase in the respiratory surface area, which was documented by pronounced tortuosity (“twisted”) capillaries.

ISSN: 2223-3806 / E-ISSN: 1927-5951/19

In tailless amphibians (danatinskaya toads) of one species living in different biotopes, an adaptive response was also detected, but it was different.

Thus, in the steppe population, adaptation was manifested in the form of enhanced synthesis of surfactant and mucus, carried out by hyperplastic and hypertrophied type II pneumocytes, mucous cells and “mixed” cells. In addition, the folding of blood capillaries is noted, which helps to reduce the loss of endogenous fluid from the respiratory surface. According to scanning electron microscopy data, numerous and elongated microvilli on the apical surface of type I and II pneumocytes contributed to the retention of the felt-like surfactant structures.

In the mountain population of tailless amphibians of the danatin toad, there was a scanty content of osmiophil lamellar bodies in the cytoplasm of type II pneumocytes. The aerohematic membrane system was thinned. Scanning electron microscopy revealed the absence of significant surfactant masses, a sharp decrease in the number of microvilli, an increase in the respiratory surface of the lungs.

In reptiles (lizards and snakes), of different or the same species, inhabitants of the steppe, production of the surfactant phospholipid complex sharply increased. In snakes (viper, steppe and steppe populations of the paplas shchitomordnik), the proportion of “mixed” type cells with ultrastructural signs of type II pneumocytes and mucous membranes increased. The mucoid component enhanced the surfactant phospholipid complex, which prevented the excessive loss of moisture through the respiratory surface of the lungs. The increased folding of the interstitium capillary network attracted attention. The basal membrane of the aerohematic membrane system remained fairly wide. When scanning electron microscopic examination, a significant secretion of mucus and surfactant was confirmed, as well as a decrease in the length of the aerohematic membrane system due to folding of the capillary network.

In reptiles living in the mountain biotope, there was a decrease in the content of surfactant. A thinning of the aerohematic membrane system, the convergence and fusion of the basement membranes of the epithelium and endothelium, a significant increase in the length of the respiratory surface due to bulging of the loops of the capillary network in the form of “leaves” were noted.

The respiratory part of the lungs of reptiles living in both steppe and mountain biotopes was characterized by a pronounced formation of vesicles in the epithelium and endothelium of the air-hematomatic membrane system, which reflected a high level of gas exchange and moisture extravasation in both vector directions.

The ultrastructural data obtained by us showed that despite the primitive nature of the morphofunctional differentiation in amphibians and reptiles, we can still speak of the adaptive reactions that they develop in the respiratory part of the lungs, both under the influence of the direct (and the main) temperature factor and under the influence of hypoxia, having a very relative value.

In rodents of both steppe and mountain species, ultrastructural adaptive changes have been noted in the respiratory region of the lungs.

In the inhabitants of the steppes (common vole) they were manifested in hypertrophy of the surfactant alveolar complex, the “folding” of the capillary network, which reduced the degree of evaporation of moisture from the respiratory surface of the lungs.

In rodents of mountain biotopes (Tien Shan vole), the characteristic submicroscopic feature of the respiratory part of the lungs was the thinning of the aerohematic membrane system. The respiratory surface was also enlarged to more effectively perform the function of gas exchange and fluid transfusion. surfactant alveolar complex was not changed.

CONCLUSION

Thus, our morphofunctional studies revealed significant inter - and intraspecific adaptation changes in the lungs of terrestrial vertebrates to various habitats.

The adaptive responses of the respiratory part of the lungs in inhabitants of steppe and mountain biotopes were expressed in changes in the ultrastructural organization of capillaries (increase or decrease in working areas), as well as the functional mode of synthesis of surfactant (in rodents) and surfactant and mucus (in amphibians and reptiles). For the inhabitants of mountain biotopes, an important adaptation feature was the thinning of the aerohematic membrane system, which facilitated the diffusion of gases.

Consequently, in animals living in various biotopes, adaptive mechanisms were carried out due to the functional stress of various structures, as noted by us under the influence of extreme factors, and due to more economical organization of pulmonary capillaries and optimization of the functional mode of surfactant synthesis.

REFERENCES

[1] Antipchuk YuP, Sobolev AD. Materials on ecological morphology. Novosibirsk: Science 1976; 176s.

[2] Sobolev AD, Shishkin GS, Ustyuzhaninova NV. Features of the structure of the lungs of mammals of the Far North. The reaction of homeostatic systems in individual and species adaptations. Novosibirsk: Nauka 1976; 81-106.

[3] Masenov TM. Evolutionary-morphological patterns of lung tissue and cell differentiation in some vertebrates due to their ecology. IV conference Morphologists of Central Asia and Kazakhstan. Karaganda 1988; 116-117.

[4] Nurushev MKh. Ecological morphology of light rodents.Alma-Ata: Abai Kazakh State Pedagogical University 1992; 140s.

[5] Nurtazin ST. Lung biodynamics TETRAPODA and some issues of evolutionary morphology. Almaty: Sazaj University, 1997; p. 384.

[6] Bekembetova RA. Features of energy metabolism in animal tissues during exercise in mountain conditions. Actual problems of experimental and clinical physiology. Almaty 2001; pp. 48-49.

[7] Nurtazin ST. Ultrastructural features of cytophospholiposomes in the lungs of vertebrates of various habitats.

[8] Udartseva TP. Mechanisms of adaptation to the combined effects of lead and organic movements. Almaty 2001; p. 226.

[9] Lizurchik LV, Sheyda YeV. The influence of tobacco smoke on the content of toxic elements in the rat organism. Bulletin of Orenburg State University. Orenburg 2014; pp. 73-91.

[10] Kagazezheva NKh, Kolomiytseva NS. The influence of active and passive tobacco on the indicators of the cardiorespiratory system of adolescents in mountainous areas. Bulletin of the Adyghe State University. Adygea 2013; pp. 39-52.

[11] Katashinskaya LI, Gubanova LV. The influence of tobacco smoking on the functional state of the respiratory system. Bulletin of the Tyumen State University. Tyumen 2014; pp. 171-177.

[12] Marushchak MI, Volkov KS, Yarema NI. Ultrastructural changes in the respiratory part of the lungs of rats in the early stages of general lung damage. News of Biology and Medicine Issues. Kiev 2012; pp. 122-131.

[13] Lutsenko MM. Metabolic processes in the general cooling of the body. Fiziol Zh M 2007; pp. 61-67.

[14] Anderson KE, Carmella SG, Ye M, Bliss RL, *et al*. Metabolites of tobacco-specific lung carcinogen in nonsmoking women exposed to environmental smoke tobacco. Cancer Treat Res 2001; 105: 31-52.

[15] Broeckaert F, Clippe A, Knoops B, Hermans C, *et al*. Clara cell secretory protein (CC 16): features as a peripheral lung biomarker. J Biomed Opt 2001; 6(1): 31-40.

[16] Eugstrom G, Hedbland B, Valind S, Janson L. Asymptomatic atherosclerosis in smokers. Longitudinal and cross-sectional results from Men born in 1914. Sweden, Cancer Res 2001; 15(61): 778-784.

[17] Pignatelli B, Li CQ, Boffetta P, Chen Q, *et al*. Nitrated and oxidized plasma proteins in cancer patients. Cancer Res 2001; 15(61) 612-615.

[18] Brainerd EL. Functional morphology of lung ventilation in urodeles. Abstr, 3rd World Cong. Herpetol., Prague 2-10 Aug., 1997. Prague 1997; p. 28.

[19] Growozdz B. Skutki przegrzania organizmu ludzkiego. Ergonomia 1997; 20(1): 15-28.

[20] Muller B, Seifart C, Barth PJ. Effect of air pollutants on the pulmonary surfactant system. Eur J Clin Invest 1998; 28(9): 762-777. https://doi.org/10.1046/j.1365-2362.1998.00342.x

[21] Nurtazin S. Cellural and tissue peculiarities of the reptilian lung structur. Herpetol. 97: Abstr. 3rd World Congr. Herpetol., Prague, 2-10 Aug, 1997. Prague 1997; p. 152.

[22] Pinot F, Bachelet M, Francois D, Polla BS, *et al*. Modified natural porcine surfactant modulates tobacco smoke – induced stress response in human monocytes. Mol Pharmacol 1998; 54(5): 779-788. https://doi.org/10.1016/S0024-3205(98)00542-6

[23] Wyatt TA, Schmidt SC, Rennard SI, Tuma DJ. *et al*. Acetaldehyde-Stimulated cells and other cigarettes. Life Sci 1999; 64(2): 125-134.

[24] Saparov K. Protective and adaptive reactions induced by cigarette smoke 2015; p. 1295.

[25] Saparov KA, Esemsiitova ZB, Bazarbayeva JM. Morphological Bases of Hygiene, Anatomy 2015; p. 1300.

Received on 06-02-2019 Accepted on 05-03-2019 Published on 14-03-2019

DOI: https://doi.org/10.29169/1927-5951.2019.09.02.7