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Morphological Features and Morphometric Parameters of the Lungs of Sexually Mature Horses (*Equus Ferus Caballus* L., 1758)

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Abstract. The lungs, which form part of the respiratory apparatus, provide gas exchange between the environment and the tissues of the human and animal body. Therefore, lung diseases are one of the most pressing issues for modern humane and veterinary medicine. This problem is caused by the progressive growth of diseases in mammals such as bronchial asthma, bronchitis, bronchopneumonia, pneumonia, coronavirus infections, etc. Therefore, to effectively solve this issue in terms of prevention, effective treatment, and prompt differential diagnosis of respiratory diseases, an essential area in morphology is the study of the respiratory apparatus, namely the lungs, in clinically healthy animals, to develop marker test criteria that will serve as indicators of the norm in the differential diagnosis of these diseases. The purpose of this study was to investigate the macro- and microscopic structure of the lungs, conduct a morphometric assessment of their morphological structures in domestic sexually mature horses (class Mammals, species – domestic horse (*Equus ferus caballus* L., 1758). The object of this study was the lungs of clinically healthy sexually mature horses (n = 5). Fresh lungs of the animals under study were subjected to anatomical preparation. For histological studies, generally accepted methods of fixing pieces of material and making histological sections were used, which were then stained with haematoxylin and eosin and according to Van Gieson's method. The basis of the lungs in horses are pyramidal or cone-shaped lobules. Part of the structure of the lobes are acini covered with a thin layer of connective tissue. The microscopic structure of acini is formed by alveolar ducts, alveolar sacs, and alveoli. According to the results of research, the alveolar tree in horses is shortened and wide and has a bubble shape. The results of morphometric studies showed that the average volume of pulmonary alveoli in clinically healthy horses is 699.80 ± 106.42 thous. μm^3. The respiratory part of the lungs in horses occupies 54.8 ± 7.4% of the total area of the lung parenchyma, the connective tissue base – 45.2 ± 7.4%. Such studies of morphological features and morphometric parameters of equine lungs are of practical importance in veterinary medicine since they are markers and criteria for pathomorphological diagnosis of diseases associated with the respiratory system

Keywords: morphology, asymmetry of the lungs, bronchi, terminal bronchioles, alveolar tree

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Introduction

The human and animal bodies are a complex biological system built from interconnected structural elements – organs and tissues that interact with each other [1]. The body's response to environmental influences, transforming all organs and systems into a single whole, occurs only with the normal morphofunctional activity of all its systems, including the respiratory apparatus, which includes the lungs [2].

The scientific literature currently holds a considerable number of studies on the morphology of lungs in animals [3]. According to the results of morphological studies of the lungs [4], their structure is described in detail in laboratory animals, rabbits, dogs, ruminants, and pigs. Thus, according to scientists [5; 6], cattle, sheep, and pigs have a tracheal bronchus in the branching of the bronchial tree, which is absent in horses. Furthermore, in most domestic mammals, each lung in its structure has cranial, middle, and caudal lobes, and on the right lung there is an added lobe, which causes their asymmetry.

Therewith, the features of lung morphology in domestic animals, including horses, with the use of complex research methods – anatomical, histological, organo- and histometric, statistical – are not described at all, despite the importance of this knowledge for the veterinary clinic (morphology, clinical diagnostics, pathological anatomy, surgery, etc.) and experimental physiology. In addition, the macroscopic structure, organometric characteristics of the lung lobes, their absolute and relative masses, branching of the bronchial tree, histometric parameters of the lungs in horses in the scientific literature are fragmentary.

Therefore, the priority area for the prevention of diseases, differential diagnosis [7], detection, and clarification of the mechanisms of occurrence of the development of the disease and its individual manifestations at different levels of the body (cellular, tissue, organ, systemic, organisational) should be to conduct an in-depth study of the lungs in clinically healthy animals, primarily at the macro- and microscopic levels [8; 9]. Furthermore, the establishment of data on macro- and organometric parameters of lung lobes in horses, features of branching of the bronchial tree, histo- and cytometric characteristics at the tissue level will contribute to the development of comparative morphology of the respiratory apparatus in domestic animals. This allows, based on the conducted studies, obtaining new data and establishing quantitative organo- and histometric characteristics of the lungs of horses in normal conditions, as tests for differential diagnosis of diseases associated with the respiratory system.

That is why the study of the lungs of domestic animals is of urgent importance in morphology [10; 11], which ensure gas exchange in the body and whose regulatory activity takes place involving the nervous system, which coordinates and regulates their work, uniting the body into a single entity [12].

The purpose of this study is to investigate the features of lung morphology, assess their morphological structures at the organo- and histometric level in domestic sexually mature horses.

Materials and Methods

The research was carried out at the Department of Anatomy and Histology, the Laboratory of Pathomorphology of the Faculty of Veterinary Medicine of Polissia National University (city of Zhytomyr) during 2019-2022. The entire experimental part of the study was conducted according to the requirements of the international principles of the "European Convention for the prote ction of vertebrates used in experiments and other scientific purposes" [13], Law of Ukraine "On the protection of animals from ill-treatment" (No. 3447-IV of 02/21/2006, Kyiv) [14].

Macro- and microscopic, morphometric and statistical research methods were used in this study. The object of the study was lungs taken from five clinically healthy sexually mature horses (domestic horse – *Equus ferus caballus* L., 1758).

Lungs from freshly slaughtered research animals at a meat processing plant were subjected to anatomical dissection. For histological studies, pieces of material were fixed in a 12% cooled solution of neutral formalin for 48 hours, followed by pouring it into paraffin according to the schemes proposed in the manual [15]. Paraffin sections were made on a sled Microtome MS-2, their thickness did not exceed 10-12 microns. To investigate cell and tissue morphology, histological sections were stained with haematoxylin (Diapath, Italy, 2020) and eosin (Leica Geosystems, Germany, 2020) after their deparaffinisation. Stained histological sections were used to obtain survey preparations and conduct histometric studies.

Histometric studies of the structural elements of the lung tissue: determination of the respiratory part and the connective tissue base of the lungs (per unit area equal to 5.0 mm^2), the average volume of the alveoli, was carried out using light microscopy with microscopes "Micros" (Austria, 2012) and MBS-10 (Micromed, Russia, 1998) with a constant tube length, according to the recommendations outlined in the manual [15]. Histological sections were photographed with a CAM V–200 video camera (Inter Med, China, 2017) mounted in a microscope with an image output system with histological sections. Anatomical and histological terms of structural parts of the lungs were presented according to the International Veterinary Anatomical Nomenclature [16]. Mathematical processing of research results was performed statistically using the Statistica 7.0 software package (StatSoft, Tulsa, USA). The reliability of the results obtained was determined according to the Student's t-test, considering the significance criteria: $P<0.01$, $P<0.001$.

Results and Discussion

The lungs of horses are contained in the chest cavity and according to morphotopography relative to the body of animals are divided into left and right lungs. They have a pale pink colour. On the lungs of horses, the dorsal and ventral edges are clearly differentiated. The dorsal edge of the lungs is blunt and adjacent to the spine. The ventral edge of the lungs is sharp and directed ventrally. On the lungs, their surfaces are contoured – costal and diaphragmatic. The costal (lateral) surface of the lungs in horses is adjacent to the ribs, the diaphragmatic surface is adjacent to the diaphragm, it is directed caudally.

Between the cranial and caudal lobes of the right and left lungs are interparticle surfaces, and between the right and left lungs are mediastinal surfaces that are adjacent to the mediastinum, and they are located on each lung on the medial side. On the same surface, there is indentation from

the aorta, oesophagus, and vena cava. Each lung in most mammalian animals is divided into three lobes: cranial, middle, and caudal. Therewith, the right lung also has an added lobe [17]. Consequently, the interstitial heart notch divides the right and left lungs in horses into only two lobes – cranial (much smaller) and caudal (large), which are separated from each other (Fig. 1). The average proportion of lungs that other domestic animals have is absent in horses. Furthermore, in the animals under study, in the caudal part of the lungs (craniodorsally), a small part of the lung tissue was separated – a dorsal added part, which had a pyramidal shape and was characteristic of one or both (right and left) lungs. On the right lung of the horse, there is also an added lobe on the medial side (Fig. 1).

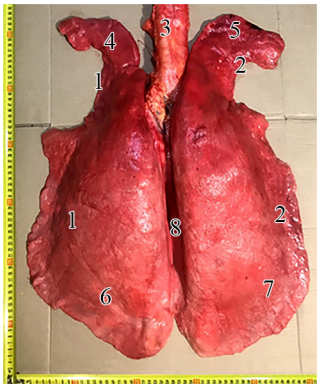

Figure 1. Anatomical structure of the lungs of a sexually mature horse (costal surface): 1 – left lung; 2 – right lung; 3 – trachea; 4 – left cranial lobe; 5 – right cranial lobe; 6 – left caudal lobe; 7 – right caudal lobe; 8 – added lobe of the right lung. Macropreparation

The particulate pattern of the surface of the lungs in horses, formed by the stroma of the lungs, is noticeable, but compared to other animals, their pattern is smoothed. Therefore, the surface of the lungs is smooth. On each lung, on their medial surface, there is a lung gate through which the main bronchus enters.

The lungs of horses, as in other domestic mammals, are formed by branches of the bronchi of various calibres, forming the bronchial tree and branches of histological structures of the respiratory department, forming the alveolar tree. They are accompanied by blood vessels, nerves, and layers of loose connective tissue. The bronchi, in turn, differentiate into extrapulmonary and pulmonary. Extrapulmonary bronchi are main and interlobular, and pulmonary bronchi are structures that form part of the parenchyma of the lungs and, branching there, form the bronchial tree.

A distinctive feature of the bronchial tree in horses is the absence of a tracheal bronchus, which is present in ruminants – cattle, sheep, pigs, and other animals [5]. Branching of the bronchi of the bronchial tree of the lungs in horses occurs according to the main type. In each lung, the main bronchi, at the base of their blunt edges, are divided into large, medium, and small – terminal bronchioles, forming a bronchial tree.

At the initial stage of the formation of the bronchial tree, the trachea of horses forms a considerably large bifurcation, where it branches into two main bronchi, which immediately (at the bifurcation of the trachea) in each lung, form their bifurcation and divide into two large bronchi – cranial and caudal. The cranial bronchus (slightly smaller) is located closer to the cranial lobe and is directed in the cranial direction at an angle of 30-35° relative to the tracheal axis, in the cranial lobe and is described by retrograde relative to the direction of the main movement. The caudal bronchus (slightly larger) is directed caudally, towards the caudal lobe (Fig. 2).

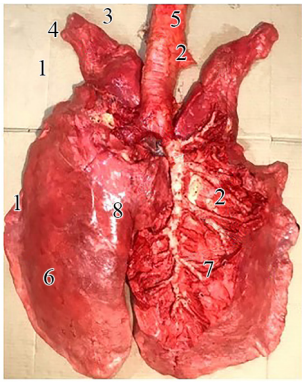

Figure 2. Anatomical structure of the lungs of a sexually mature horse (mediastinal surface): 1 – left lung; 2 – right lung; 3 – trachea; 4 – left cranial lobe; 5 – right cranial lobe; 5 – left caudal lobe; 6 – added lobe; 7 – tracheal bifurcation; 8 – main bronchus; 9 – cranial bronchus; 10 – caudal bronchus; 11 – branches of the caudal bronchus. Macropreparation

The main bronchus, which goes to the cranial lobe, after a certain interval divide into two branches, which, branching out, give rise to segmental bronchi of varied sizes. The main bronchi, which go to the caudal lobes of the lungs, branch into four dorsal and four ventral branches in the parenchyma of each lung. The smallest intralobular bronchi branch into the lung lobules, where they divide into terminal bronchioles, which divide into respiratory bronchioles, alveolar ducts, and then alveolar sacs, forming the alveolar tree.

The right lung in mammals is slightly larger than the left because the heart is shifted to the left. Therefore, an inherent feature of the structure of mammalian lungs is their pronounced asymmetry, which is manifested by varied sizes, ambiguous absolute mass of the right and left lungs, their position and ambiguous shape of their lobes, depending on the functional load [18]. The ratio of their size (left to right lung) is 1.21:1 in horses, 1.38:1 in cattle, 1.35:1 in pigs, and 1.32:1 in dogs [19].

Some scientists [20] consider the manifestation of lung asymmetry in domestic mammals to be a genetic trait. Others argue [21] that the asymmetry is associated with an asymmetric position of the heart and other organs in the chest cavity, depending on the intensity of their gas exchange function, which manifested itself during the evolutionary development of animals. The most pronounced asymmetry of all mammals is inherent in small rodents (rat, guinea pig, hamster), in which the left lung is not divided into lobes, and the right lung has four lobes [22].

According to the results of morphological studies, the coefficient of asymmetry of the left lung to the right in horses is 1:1.2 and this is due to the displacement of the heart and aorta to the left half of the chest cavity. Such data coincide with the results of other scientists, who indicate that the volume of the left lung in mammals, compared with the right lung, decreases due to the heart by two-thirds on the left side [23].

At the same time, the study of the lungs of various animal species showed the presence of individual morphological features in the lobular structure of the lungs [21]. Thus, in bats, the left lung is not divided into lobes, and in mink and sable, the left lung is divided into only two lobes – cranial and caudal [6].

According to the results of research, the distribution of lungs in domestic mammals into separate pronounced lobes directly depends on the very structure of the chest cavity and the characteristics of animal maintenance and individual physiological characteristics of animals, and, accordingly, the physiological load on the corresponding organ. Thus, in the left lung of horses there are only two lobes – cranial and caudal, in the right lung there are three lobes – cranial, caudal, and added. According to N.V. Zelenevsky, the caudal lobe of the lungs in horses is formed by the fusion of the caudal and middle lobes into one, and therefore is called the cardiorespiratory lobe [24]. According to the data obtained, such a lobe is caudal (phrenic), since there are no interlobe notches between the middle and caudal lobes in the right and left lungs, and their surface is adjacent to the diaphragm, and therefore the authors of this paper propose to call the cardiopulmonary lobe – phrenic (caudal).

An essential criterion for the development of an organ is its absolute mass, which directly indicates its morphofunctional maturity. At the same time, the relative lung mass in the animals under study depends directly on the animal's body weight and the absolute mass of the organ.

According to the organometry conducted by the authors of this paper, the absolute lung mass of sexually mature horses is 3,318.10 ± 364.40 g (Table 1). However, the relative lung mass in horses, which according to classical textbooks on pet anatomy [25] is 1.43% of the animal's body weight, does not coincide with the results of this study. Thus, according to studies, the relative lung mass in horses is much smaller and is equal to 0.60 ± 0.052%. Accordingly, the absolute mass of the left lung is 1,506.20 ± ± 60.48 g, and the right lung is 1,811.90±72.92 g (Table 1).

Table 1. Absolute and relative mass of horse lung lobules, M ± m, n = 5

Lobe Lungs	Left lung		Right lung		Left + right lungs	
	AM (g)	VM (%)	AM (g)	VM (%)	AM (g)	VM (%)
Cranial	197.43 ± 19.24	5.95 ± 0.51	214.02 ± 24.04	6.45 ± 0.62	411.45 ± 39.62	12.40 ± 0.94
Caudal diaphragmatic	1308.66 ± 8.75	39.44 ± 3.57▲	1423.80 ± 102.71	42.91 ± 4.06▲	2732.46 ± 209.97	82.35 ± 7.56
Added	–	–	174.20 ± 16.02•	5.25 ± 0.68	174.20 ± 16.02	5.25 ± 0.67
Total:	1506.10 ± 60.48*	45.39 ± 4.08	1812.0 ± 62.92*	54.61 ± 5.02	3318.10 ± 364.40	100

Note: ** – P<0.01, in comparison with the absolute mass (AM) of the left and right lungs; ▲ – P<0.001, compared to the cranial lobe; • – P<0.001, in comparison with the absolute mass of the caudal diaphragmatic lobe of the right lung; RM is the relative mass*

At the same time, the absolute mass of the cranial lobe of the left lung in horses is 197.43 ± 19.24 g. This indicator in the right lung is 214.02 ± 24.04 g, respectively. The caudal lobes of the lungs have the greatest absolute mass: in the left lung, this indicator averages 1,308.66 ± 98.75 g, and in the right lung – 1,423.80 ± 102.71 g, respectively. The smallest is the absolute mass of the added lobe of the right lung, which, accordingly, is 174.20 ± 16.02 g in horses (Table 1).

In terms of absolute mass, the left lung is 2.20 times smaller (P<0.01), while the right lung is 1.83 times smaller (P<0.01) compared to the absolute total mass of the horse's left and right lungs. At the same time, the relative mass of the caudal phrenic lobe of the left and right lungs is 6.63 times higher (P<0.001) and 6.65 times higher (P<0.001), respectively, compared to the cranial lobe. Therewith, there is a tendency to increase the relative mass of the caudal phrenic lobe of the right lung to the left.

The absolute mass of the added lobe of the right lung is 8.17 times less (P<0.001) compared to the absolute mass of the caudal diaphragmatic lobe (Table 1). Determination of morphometric parameters of organs and tissues, including lungs in domestic animals, is not only of cognitive importance, but also forms the basis for determining the shape, establishing comparative anatomical types of certain organs [9]. According to the results of organometry, the total length of the lungs in horses is 61.50±6.32 cm, width – 48.44±4.14, thickness – 9.60±1.10 cm. Therewith, the ratio of the total length of the lungs to their width in horses is 1.27:1. Therefore, the lungs of horses belong to the narrowed-elongated type.

Microscopically, the horse's lungs are formed by branches of the bronchi, the stroma of the lungs, and branches of the respiratory department of the lungs (Fig. 3), which form the alveolar tree. The basis of the lungs of horses are pyramidal or cone-shaped lobes that form the stroma of the lungs. Part of the structure of the lobes are acini covered with a thin layer of connective tissue.

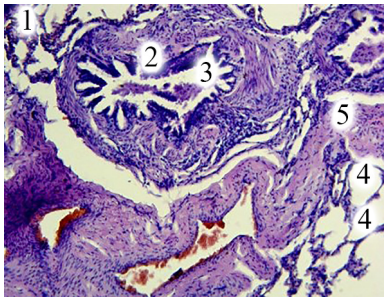

Figure 3. A fragment of the microscopic structure of a horse's lungs: 1 – respiratory part; 2 – small bronchus; 3 – lumen of the bronchus; 4 – alveoli; 5 – connective tissue stroma. Haematoxylin and eosin. x 280

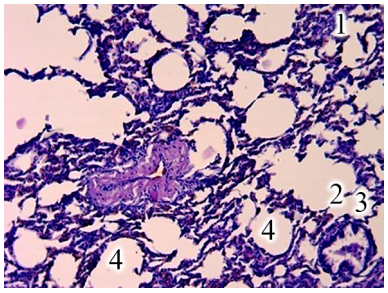

Figure 4. Fragment of the microscopic structure of the horse's lungs: 1 – respiratory part; 2 – alveolar passage; 3 – alveolar sac; 4 – alveoli. Haematoxylin and eosin. x 280

The bronchi of the lungs have varied sizes, which, according to their size, are divided into extrapulmonary (head and interlobe) and pulmonary (part of the lung parenchyma), where they branch out and form the bronchial tree. The bronchi in their composition have three membranes – mucous, fibrous-cartilaginous, and adventitia. The main bronchi of the lungs have the largest diameter. Compared to the middle and small bronchi, their membranes are clearly defined and have a microscopic structure similar to that of the trachea. Thus, their mucous membrane is formed by the epithelial, own, muscle plate and submucosal base (Fig. 5).

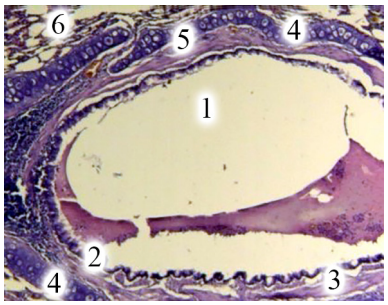

Figure 5. A fragment of the microscopic structure of the main bronchus of the lung of a horse: 1 – lumen of the bronchus; 2 – epithelial plate; 3 – muscle plate; 4 – fibrous-cartilaginous shell; 5 – lymphoid tissue; 6 – alveoli. Haematoxylin and eosin. x 280

The microscopic structure of the epithelial plate is represented by a single-layer multi-row ciliated epithelium, the epitheliocytes of which are located on its basal membrane. In the mucous membrane of its plate, formed mainly by loose fibrous connective tissue, lymphoid tissue appears in the form of clusters (Fig. 5). The muscle plate of the mucous membrane is formed by bundles of smooth muscle cells that form the circular and longitudinal layers. Consequently, the muscle plate of the shell of such bronchi does not form internal folds as in large, medium, and small bronchi (Fig. 5).

The submucosal base of such bronchi is formed by loose connective tissue, where the terminal parts of the bronchial glands are located. However, in comparison with other species of the animals under study, bronchial glands are found in them in small numbers [5]. Collagen fibres are also present in the submucosa. The microscopic structure of the fibrous-cartilaginous membrane of the main bronchi has certain features – their cartilage tissue is continuous, in the form of rings along the entire perimeter of the fibrous-cartilaginous membrane (Fig. 5).

The adventitious membrane of the main bronchi is formed by a thin layer of loose fibrous connective tissue. The wall of the large bronchi has a similar structure to that of the main bronchi. However, the cartilage rings of the fibrous-cartilaginous membrane do not have a continuous structure, but are formed by separate, pronounced, large cartilage plates (Fig. 6).

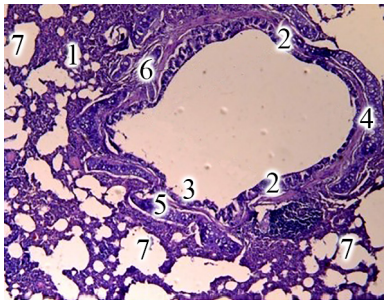

Figure 6. Fragment of the microscopic structure of the horse's lungs: 1 – respiratory part; 2 – large bronchus; 3 – epithelial plate; 4 – muscle plate; 5 – cartilage plates; 6 – lymphoid tissue; 7 – alveoli. Haematoxylin and eosin. x 280

The mucous membrane of the wall of the middle bronchi is covered with a single-layer multi-row respiratory epithelium, and the muscle plate of the mucous membrane forms well-defined folds. The fibrous-cartilaginous shell of the middle bronchi contains only individual cartilage islands of small size, which are formed by hyaline cartilage tissue (Fig. 7).

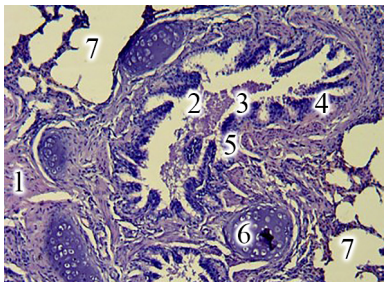

Figure 7. Fragment of the microscopic structure of the horse's lungs: 1 – respiratory part; 2 – middle bronchus; 3 – epithelial plate; 4 – muscle plate; 5 – cartilaginous plates; 6 – cartilage islands; 7 – alveoli. Haematoxylin and eosin. x 280

The lung wall of the small bronchi, as in other experimental animals, is formed only by the mucous membrane and adventitia. The muscle plate of such bronchi is clearly defined, so that the inner wall of the mucous membrane forms pronounced folds. Furthermore, cartilaginous islands in the walls of the small bronchi are not detected (Fig. 8).

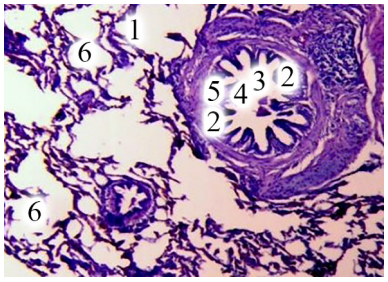

Figure 8. Fragment of the microscopic structure of the horse's lungs: 1 – respiratory part; 2 – small bronchus; 3 – bronchial lumen; 4 – epithelial plate; 5 – muscle plate; 6 – alveoli. Haematoxylin and eosin. x 280

The terminal bronchioles of the lung parenchyma are formed by a thin wall, similar to small bronchi, and its muscular plate is formed by smooth myocytes, which are in the form of a grid and do not form folds (Fig. 9). Bronchial arteries of varied sizes are found around the bronchi.

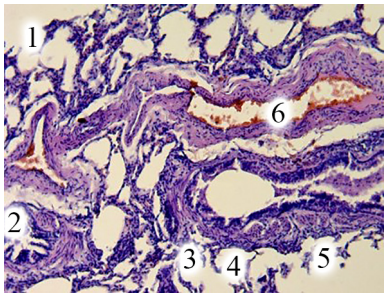

Figure 9. Fragment of the microscopic structure of the horse's lungs: 1 – respiratory part; 2 – small bronchus; 3 – terminal bronchiole; 4 – alveolar sacs; 5 – alveoli; 6 – vessel. Haematoxylin and eosin. x 120

The microscopic structure of the respiratory part of the lungs of horses is represented by the alveolar tree (respiratory bronchioles, alveolar ducts, alveolar sacs), in the walls of which there are alveoli (Fig. 10). Such histostructures form the structural and functional unit of the lungs – the pulmonary acinus. The microscopic structure of the respiratory bronchiole wall is similar to that of terminal bronchioles. At the same time, ciliated cells are absent in the epithelial cells of the lamina.

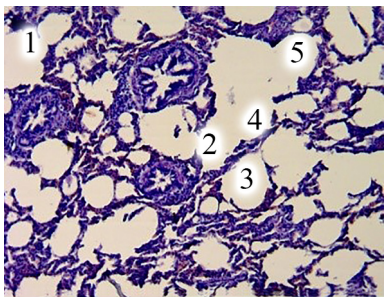

Figure 10. Fragment of the microscopic structure of the horse's lungs: 1 – respiratory part; 2 – terminal bronchiole; 3 – alveolar passages; 4 – alveolar sacs; 5 – alveoli. Haematoxylin and eosin. x 120

Alveolar passages formed because of branching of the second- and third-order bronchioles have two or three times the diameter of the respiratory bronchioles. Alveolar passages have many alveoli in their microscopic structure. Alveolar sacs (blind endings of alveolar passages) are formed by alveoli located next to each other.

Alveoli in the form of bubbles are connected to each other by interalveolar membranes, which are formed by delicate layers of loose connective tissue, which contains numerous elastic fibres. The inner wall of the alveoli is made up of alveocytes located on the basal membrane. The alveoli of the lungs have varied sizes – small, medium, and large (Fig. 11).

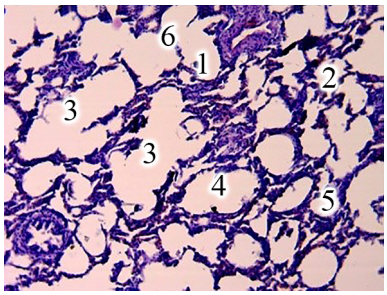

Figure 11. Fragment of the microscopic structure of the horse's lungs: 1 – respiratory part; 2 – alveolar sacs; 3 – large alveolus; 4 – middle alveolus; 5 – small alveolus; 6 – interalveolar membranes. Haematoxylin and eosin. x 280

According to the results of this study, the alveolar tree in horses is shortened and wide and has a bubble shape. Alveolar bronchioles are poorly differentiated. Due to expansion, the alveolar sacs are wide with smoothed alveoli. According to the results of morphometric studies, the average volume of pulmonary alveoli in clinically healthy horses is 699.80 ± 106.42 thous. μm^3. The respiratory part of the lungs in horses occupies 54.8 ± 7.4% of the total area of the lung parenchyma, the connective tissue base – 45.2 ± 7.4% (Fig. 12).

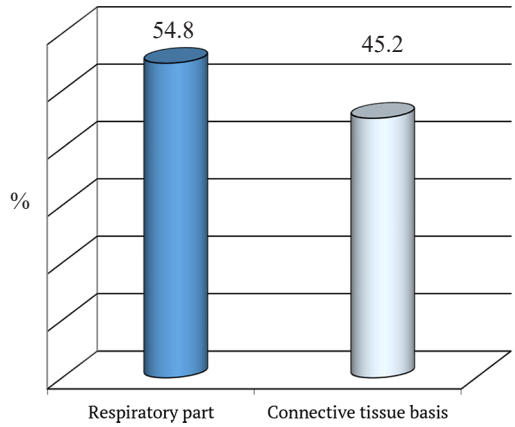

Figure 12. Histometric parameters of equine lungs

Conclusions

The lungs of horses have a partial structure: the left lung – cranial and caudal, the right – cranial, caudal, and added. The coefficient of lung asymmetry (left to right) is 1:1.2. The ratio of the total length of the lungs to their width is 1.27:1, so the lungs of horses are of a narrowed-elongated type.

The absolute lung mass of sexually mature horses is 3,318.10±364.40 g, the relative weight is 0.60±0.052%. Therewith, the absolute mass of the left lung is 1,506.20±60.48 g, the right lung – 1,811.90±72.92 g. The relative mass of the diaphragmatic lobes of the left and right lungs is 6.63 times ($P<0.001$) and 6.65 times ($P<0.001$) higher compared to similar cranial lobes.

The internal histoarchitectonics of the lung tissue is formed by cone-shaped or pyramidal lung lobes, which are separated by connective tissue partitions that form their connective tissue stroma. The connective tissue stroma (45.2±7.4%) is formed by loose connective tissue and contains elastic fibres, blood, and lymphatic vessels.

The respiratory parenchyma of the lungs (54.8±7.4%) is formed by respiratory bronchioles, alveolar passages, and alveolar sacs, in the walls of which alveoli are located, the average volume of which is 699.80±106.42 thous. μm^3.

In the future, the research will be aimed at ultramicroscopic examination of the respiratory part of the lungs of domestic animals.

References

[1] Lyabakh, K.G. (2019). Regulation of cell oxygen regime based on free diffusion. *Physiological Journal*, 65(3), 12-21. doi: 10.15407/fz65.03.012.

[2] Bilash, S.M., Pronina, O.M., & Koptev, M.M. (2019). The value of complex morphological research for modern medical science. Literature review. *Bulletin of Problems of Biology and Medicine*, 2, 2(151), 20-23. doi: 10.29254/2077-4214-2019-2-2-151-20-23.

[3] Gorvat, M.P., & Dankovich, R.S. (2020). Morphological characteristics of the respiratory and digestive organs of the grape snail (*Helix pomatia L.*, 1758). *Scientific Messenger of LNU of Veterinary Medicine and Biotechnologies. Series: Veterinary Sciences*, 22(97), 7-9. doi: 10.32718/nvlvet9702.

[4] Blagojevic, M., Bozickovic, I., Uscebrka, G., Lozance, O., Dordevic, M., Zoric, Z., & Nesic, I. (2018). Anatomical and histological characteristics of the lungs in the ground squirrel *(Spermophilus citellus)*. *Acta Veterinaria Hungarica*, 66(2), 165-176. doi: 10.1556/004.2018.016.

[5] Goralsky, L.P., Glukhova, N.M., & Sokulsky, I.M. (2020). Morphological features of rabbit lungs. *Scientific Horizons*, 93(8), 180-188. doi: 10.33249/2663-2144-2020-93-8-180-188.

[6] Autifi, M.A.H., El-Banna, A.K., & Ebaid, A.E.-S. (2015). Morphological study of rabbit lung, bronchial tree and pulmonary vessels using corrosion cast technique. *AL-Azhar Assiut Medical Journal*, 13(3), 41-50.

[7] Asanov, E.O., Holubova, Yu.I., Dyba, I.A., & Asanova, S.O. (2021). Breathing exercises with PEEP: Efficiency and duration for correcting the cardiovascular system functional state in older patients with COPD. *Zaporizhzhia Medical Journal*, 23(6), 806-810. doi: 10.14739/2310-1210.2021.6.231350.

[8] Mylostyvyi, R., Sejian, V., Izhboldina, O., Kalinichenko, O., Karlova, L., Lesnovskay, O., Begma, N., Marenkov, O., Lykhach, V., Midyk, S., Cherniy, N., Gutyj, B., & Hoffmann, G. (2021). Changes in the spectrum of free fatty acids in blood serum of dairy cows during a prolonged summer heat wave. *Animals*, 11(12), article number 3391. doi: 10.3390/ani11123391.

[9] Vazquez, Y., Gonzalez, L., Noguera, L., Gonzalez, P.A., Riedel, C.A., Bertrand, P., & Bueno, S.M. (2019). Cytokines in the respiratory airway as biomarkers of severity and prognosis for respiratory syncytial virus infection: An update. *Frontiers in Immunology*, 10, article number 1154. doi: 10.3389/fimmu.2019.01154.

[10] Garg, A., Sui, P., Verheyden, J.M., Young, L.R., & Sun, X. (2019). Consider the lung as a sensory organ: A tip from pulmonary neuro-endocrine cells. *Current Topics in Developmental Biology*, 132, 67-89. doi: 10.1016/bs.ctdb.2018.12.002.

[11] Kargopoltseva, D.R., Katelnikova, A.E., Kryshen, K.L., & Gushchin, Ya.A. (2020). Features of the respiratory system of animals used in preclinical studies that need to be considered when modeling lung pathologies. *Laboratory Animals for Scientific Research*, 4, 71-77. doi: 10.29296/2618723X.10.

[12] Horalskyi, L.P., Kolesnik, N.L., Sokulskiy, I.M., Tsekhmistrenko, S.I., Dunaievska, O.F., & Goralska, I.Y. (2020). Morphology of spinal ganglia of different segmentary levels in the domestic dog. *Regulatory Mechanisms in Biosystems*, 11(4), 501-505. doi: 10.15421/022076.
[13] European Convention for the protection of vertebrate animals used for research and other scientific purposes. (1986, March). Retrieved from https://zakon.rada.gov.ua/laws/show/994_137#Text.
[14] Law of Ukraine No. 3447-IV "On Protection of Animals from Cruelty". (2006, February). Retrieved from https://zakon.rada.gov.ua/laws/show/3447-15#Text.
[15] Horalskyi, L.P., Khomych, V.T., & Kononskyi, O.I. (2019). *Fundamentals of histological technique and morphofunctional research methods in normal and pathology*. Zhytomyr: Polissia.
[16] Khomych, V.T. (2005). *Nomina embryologica veterinaria: In Latin, Ukrainian and English*. Kyiv: Polissia.
[17] Mandal, P., Lyons, J.D., Burd, E.M., Koval, M., Mocarski, E.S, & Coopersmith, C.M. (2021). Integrated evaluation of lung disease in single animals. *PloS One*, 16(7), 14-18. doi: 10.1371/journal.pone.0246270.
[18] Ilgun, R., Yoldas, A., Kuru, N., & Özkan, Z.E. (2014). Macroscopic anatomy of the lower respiratory system in mole rats *(Spalax leucodon)*. *Anatomia, Histologia, Embryologia*, 43(6), 474-481. doi: 10.1111/ahe.12098.
[19] Rudik, S.K., Krishtoforova, B.V., Pavlovsky, B.V., Khomych, V.T., & Levchuk, V.S. (2001). *Anatomy of domestic animals*. Kyiv: Agricultural Education.
[20] Kling, M.A. (2011). A review of respiratory system anatomy, physiology, and disease in the mouse, rat, hamster, and gerbil. *The Veterinary Clinics of North America. Exotic Animal Practice*, 14(2), 287-294. doi: 10.1016/j.cvex.2011.03.007.
[21] Pantoja, B.T.S., Silva, A.R.M., Mondego-Oliveira, R., Silva, T.S., Marques, B.C., Albuquerque, R.P, Sousa, J.C.S., Rici, R.E.G., Miglino, M.A., Sousa, A.L., Franciolli, A.L.R., Sousa, E.M., Abreu-Silva, A.L., & Carvalho, R.C. (2020). Morphological study of larynx, trachea, and lungs of *Didelphis marsupialis* (*Linnaeus*, 1758). *Veterinary World*, 13(10), 2142-2149. doi: 10.14202/vetworld.2020.2142-2149.
[22] Samborska, I.A. (2021). Comparative characteristics of histological changes in lung tissue in rats of different ages under conditions of hyperhomocysteinemia. *Bulletin of Vinnytsia National Medical University*, 25(2), 196-199. doi: 10.31393/reports-vnmedical-2021-25(2)-02.
[23] Maina, J.N., & Igbokwe, C.O. (2020). Comparative morphometric analysis of lungs of the semifossorial giant pouched rat (*Cricetomys gambianus*) and the subterranean Nigerian mole rat (*Cryptomys foxi*). *Scientific Reports*, 10(1), article number 5244. doi: 10.1038/s41598-020-61873-8.
[24] Zelenevsky, N.V., & Zelenevsky, K.N. (2014). *Animal anatomy*. St. Petersburg: Fallow Deer.
[25] Akaevsky, A.I., Dichev, Yu.F., & Seleznev, S.B. (2005). *Anatomy of prenatal animals*. Moscow: Aquarium-Print.

Морфологічні особливості та морфометричні показники легень статевозрілих коней (*Equus ferus caballus* L., 1758)

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Анотація. Легені, які входять до складу апарату дихання, забезпечують газообмін між навколишнім середовищем і тканинами організму людини й тварин. Тому, хвороби легень – одна з актуальних проблем для сучасної гуманної та ветеринарної медицини. Ця проблематика зумовлена прогресивним зростанням у ссавців таких захворювань, як бронхіальна астма, бронхіти, бронхопневмонії, пневмонії, коронавірусні інфекції тощо. Тому, для ефективного вирішення зазначеної проблеми щодо профілактики, ефективного лікування та своєчасної диференційної діагностики захворювань органів дихання, важливим напрямком у морфології є дослідження апарату дихання, зокрема легень, у клінічно здорових тварин, задля розробки маркерних тест-критеріїв, які будуть слугувати показниками норми у диференційній діагностиці цих захворювань. Метою роботи було дослідження макро- та мікроскопічної будови легень, проведення морфометричної оцінки їх морфологічних структур у свійських статевозрілих коней (клас Ссавці, вид – кінь свійський (*Equus ferus caballus* L., 1758). Об'єктом дослідження були легені клінічно здорових статевозрілих коней (n = 5). Анатомічному препаруванню піддавали свіжі легені досліджуваних тварин. Для проведення гістологічних досліджень застосовували загальноприйняті методи фіксації шматочків матеріалу та виготовлення гістологічних зрізів, які у подальшому фарбували гематоксиліном та еозином і за методом Ван-Гізон. Основою легень у коней є пірамідальної або ж конусоподібної форми часточки. Частиною будови часток є ацинуси, що покриті тонким шаром сполучної тканини. Мікроскопічна будова ацинусів сформована альвеолярними ходами, альвеолярними мішечками та альвеолами. За результатами досліджень альвеолярне дерево у коней, укорочене та широке і має пухирчасту форму. Результатами морфометричних досліджень встановлено, що середній об'єм легеневих альвеол у клінічно здорових коней становить 699,80 ± 106,42 тис. мкм^3. Дихальна (респіраторна) частина легень у коней займає 54,8 ± 7,4 % від загальної площі паренхіми легень, сполучнотканинна основа – 45,2 ± 7,4 %. Такі дослідження морфологічних особливостей та морфометричних показників легень коней мають практичне значення у ветеринарній медицині, оскільки є маркерними ознаками та критеріями патоморфологічної діагностики захворювань пов'язаних з органами дихання

Ключові слова: морфологія, асиметрія легень, бронхи, термінальні бронхіоли, альвеолярне дерево