

Histological and Histochemical study of Lungs in Domestic Rabbits (*Oryctolagus Cuniculus*)

Masarat S. Al mayahi*

* Department of Anatomy & Histology / College of Veterinary Medicine / University of Baghdad / Iraq.

*Corresponding Author: E.mail: masarat.s@covm.uobaghdad.edu.iq

Abstract

Aims: The current study was performed to explore histological features of the lung in the domestic rabbits.

Methods: The lung specimens were collected from ten healthy rabbits taken from center at College of Veterinary Medicine / University of Baghdad animal housing. Pulmonary tissue specimens were studied via routine histological techniques.

Results: Histological findings revealed division of each bronchus into intra pulmonary bronchi that were frequently divided into primary, secondary and tertiary bronchi. Subsequent subdivision of the last bronchi showed four subdivisions that were primary, secondary, tertiary (terminal) and respiratory bronchioles. The walls of these respiratory passages were showed only mucosa and submucosa tunicae. The epithelial mucosa started from bronchial ciliated pseudostratified columnar epithelium till simple squamous type at alveoli. The tunica submucosa constructed of loose connective tissue in which invested hyaline cartilage segments in the main bronchus then gradually decreased in diameter to smaller and smallest segments. The hyaline cartilage disappeared in all types of bronchioles. The respiratory bronchioles were opened into alveolar ducts which in turn opened into alveolar sacs. Numerous walls' out-pocketings of simple squamous epithelium lined alveolar duct were observed. Alveolar sac composed of a group of alveoli clusters and the alveolus was just a small space lined by simple squamous epithelium of two types; Type-I pneumocytes (flattened lining cells) and type-II pneumocytes (large lumen-bulged cells with large nuclei).

Keywords: Bronchus, Histological technique, Lung, Mason's Trichrome, Rabbit

Introduction

Rabbits are belonged to the order Lagomorpha and to the Leporidae family. Many genera were classified under such family that was *Brachylagus*, *Bunolagus*, *Nesolagus*, *Oryctolagus*, *Pentalagus*, *Poelagus*, *Romerolagus*, and

Sylvilagus. Rabbits go by a lot of strange nonscientific names, i.e. European rabbit is the popular name for the *Oryctolagus cuniculus* species. In fact, only *O. cuniculus* species have been

farmed and as a result, distinct breeds have been developed from it [1].

Most of Iraq rural areas are home to large populations of wild rabbits (*O. cuniculus*) or as it is well known as the European rabbit (2). The rabbit is susceptible to varying degrees of stress because of its distinct mental and behavioral makeup. When these animals are used in laboratory research that includes creating, finding and evaluating distinct system pathways that are comparable to other animals, they are considered as very valuable models (3, 4, 5). There are several preclinical studies using rabbits to investigate potential drugs and vaccines for various human and animal illnesses (6).

Nowadays, many researches were used rabbit's respiratory system to investigate new routs of treatment against pulmonary diseases affected respiratory system of human being. So that, rabbits were serves as a useful and cheapest animal model to such aims and considerations. Pharmacologically, in this species, initial and close to the end phase airway responses enable mechanistic examination of each drug reaction and its related side effects. Researchers may use rabbits as a model since they are simple to handle and easily accessible. Additional advantages of using rabbits include their size and ability to monitor physiological changes without harming the animal (7). In the last decade, patho-pharmacological researches were documented using rabbits as an experimental model for the

sack of both human and animal's health and welfare, so that, histological features of many organs such as lung and respiratory passages of the rabbits were required for depth description and monitoring (8).

Because the respiratory systems of laboratory animals are useful for identifying rare species changes, they are employed as animal models in direct scientific investigations. The lungs are the most important component of the respiratory system. They are made up of a spongy mass of tissue covered with pleura that extends from the thoracic cavity within the thorax, as well as compact soft tissue (9). The lung is divided into many lobes that vary from side to side which are connected to the trachea, which branched into the bronchi of the right and left sides inside the lung tissue. The intrapulmonary bronchus is the hills area where the bronchi enter the lungs after that. It split off into main and secondary bronchioles, which are even smaller tubes, and culminated in clusters of minuscule air sacs known as alveoli. Alveoli resembled little balloons, grapes, or branches. The lungs get a very large amount of surface area from the bubble-shaped alveoli.

Up to this point, there is a paucity of research conducted on the histological structures of the of the lungs in the local rabbits up to date. Thus, the present study intended to add knowledge on the lungs of this significant experimental animal model. The information obtained could serve as basis for other veterinary

or medical fields such as pathology and physiology. Given the above, the current study was performed to investigate the

Materials and methods

Ten healthy rabbits were euthanatized in excellent health. The animals were dissected after their euthanasia and the lungs were extracted outside the body and washed well to remove all the surrounding wastes and debris, then small pieces of different sites of this organ were cut and preserved with preservation solutions (10% formalin for some specimens and Bouin's solution

Preparation and staining of pulmonary parenchyma

Tissue specimens were excised from different sites of each lung. After fixation in 10% Neutral buffer formalin solution for two days they were kept in labeled cassettes and in a tissue processor (Tissue-Tek® VIPTM 5, Sakura Finetek Inc., CA, USA). Some specimens were fixed in Bouin's solution for 16 hours. After fixation, steps were included 45 min. 80% ethanol solution, 45 min. 90% ethanol, 45 min. per a step of three absolute ethanol changes, 45 min. per a step of two xylene changes and then after 30 min.

Results

The lungs of the rabbit were located in the thoracic cavity and covering by the pulmonary pleura. Histologically such covering showed serous membrane constructed by tunica serosa of the lung.

lung histological features of the local Iraqi rabbits.

for others) for the subsequent purpose of histological sections preparation. Subsequently, hematoxylin and eosin stains were used to differentiate the general features of the lung tissues (pulmonary parenchyma), whereas, special stain such as Masson Trichrome was applied to specified the characteristic histochemical features of such studied tissues

61°C per a step of two paraffin wax changes. Finally, a traditional paraffin block of pulmonary parenchyma was prepared. The blocks were sliced at 5 µm using a rotary microtome. The histological sections were placed on histological slides and 60° C-heated for 60 mins for assuring their adherence. The sections were exposed to two xylene changes and rehydrated using a graded descending concentration system of ethanol to remove the paraffin from the sections before staining. Finally staining with either hematoxylin and eosin (H&E) or Masson Trichrome (MTC) was performed for light microscopy (10).

Results revealed that both left and right main extra-pulmonary bronchi were penetrated the lung parenchyma and continue as intra pulmonary bronchi that were divided into primary, secondary

and tertiary bronchi in a monopodial division series. The walls of these bronchi was build up by tunica mucosa and sub mucosa which was invested with plates of hyaline cartilage gradually changed to cartilaginous smaller and smallest plates. These bronchial passages were well surrounded by pulmonary parenchyma (Fig.1). Last division of bronchi will lost the plates and forming smaller and smallest channels of airway trees called bronchioles. In fact, they were four different histologically subdivisions that were primary, secondary, tertiary and respiratory bronchioles. Actually, two asymmetrical offshoot branches emerge from each of the primary branches (dichotomous) refers to two daughter branches with the same diameters, whereas, monopodial division of bronchus refers to two daughter branches with uneven diameters.

In the present findings, the mucosa of both extrapulmonary and intrapulmonary primary bronchi was built up by folded pseudostratified columnar ciliated epithelium with goblet cells which in turn rested on lamina propria of loose connective tissue containing numerous capillaries. Muscularis mucosa was well developed and circularly arranged. The submucosa showed simple coiled tubuloacinar glands (serous & sometime mucous) and often heavily infiltrated with lymphocytes. Staining with MTC showed that bronchial wall was well supported by the presence of several hyaline cartilage plates invested in a network of dense irregular connective

tissue fibers (Fig. 1). In the secondary bronchi, epithelium similar to that of the primary bronchi was observed but the tunica mucosa displayed lamina propria made of a thin layer of irregular dense connective tissue. The underneath muscularis mucosa appeared as a thicker and circularly arranged bundles of smooth muscle fibers. The supportive tunica submucosa was made of loose connective tissue with the absence of glands. The hyaline cartilage appeared as small segments (Fig. 2). While the tertiary bronchi, the epithelial mucosa was turned into ciliated simple columnar with sporadically distributed goblet cells supported by lamina propria of a thin layer of loose connective, while the submucosa displayed smallest and fewer sporadically distributed plates of hyaline cartilages (Fig. 3). Each cell in the pseudostratified epithelial layer that lines the bronchi mentioned above is crucial to ensuring that air can flow freely. In fact, defensive and preventive capabilities against foreign air particles are provided by these cells as a group. Respiratory epithelium of the large proximal airways was lined by goblet cells, basal cells and ciliated columnar cells. The tertiary bronchi were divided into four smaller respiratory channels that were in order primary, secondary, tertiary or called terminal and respiratory bronchioles. In the bronchioles, tunica mucosa was covered by simple epithelium and starting loss of goblet cells. The lamina propria was very thin layer of loose connective tissue with the presence of circularly arranged smooth

muscle fibers. In the primary and secondary bronchioles, the epithelium was simple columnar to low simple columnar, respectively. The findings showed the presence of few goblet cells in the earlier one but not in the latter secondary bronchioles. Smooth muscle fibers of the muscularis mucosa were reduced in the secondary bronchioles into 2 to 3 layers. Both types of bronchioles were lack to the cartilage plates and glands in their walls (Fig. 4, 5). By MTC staining it showed walls that were supported by loose connective fibers with absence of glands and cartilage plates. Histological features of the tertiary (terminal) and respiratory bronchioles revealed tunica mucosa of simple cuboidal epithelium and they were supported by a thin layer of lamina propria of loose connective tissue. One layer of smooth muscle fibers was observed in the terminal type and usually absent in the last type, i.e. the respiratory bronchioles. Their walls were supported by loose connective fibers with absence of glands and cartilage plates (Fig. 6). Current results found numerous blood capillaries in the lamina propria of the mucosa of the airways in addition highly vascularized pulmonary parenchyma. Submucosal vessels are linked to a cross network of vessels outside the smooth muscles and bronchial cartilages. Fine microscopic examination revealed that each respiratory bronchiole was opened into an alveolar duct. Numerous walls' out-pocketings were found in the

simple squamous epithelium that lines such alveolar ducts (Fig. 7). Alveolar ducts were running between and opened into alveolar sacs which in turn was constructed from a group of alveoli clusters and the alveolus itself was a small apace lined by simple squamous epithelium of two types, that were Type-I pneumocytes, flattened lining cells and type-II pneumocytes, that were large vacuolated cells which were processed prominently large nuclei causing a bulging into the adjacent alveolar lumen (Fig. 8). In fact, the first type pneumocytes were facing or adherent directly to the capillary wall. The basal lamina of each was adherent to the corresponding capillary endothelial cell to form blood barrier system.

The alveoli in the rabbit's pulmonary parenchyma showed well identified Type II cells. These cells are usually packed in a dense bilayer membrane they were suggested previously as very important cells.

The current findings showed the histological feature of the important airway respiratory bronchioles of the local rabbit. Between the terminal bronchial and alveolar ducts, respiratory bronchioles were partly alveolarized airways. It can be suppose that in case of their absence, insoluble particles may be transported straight from alveolar ducts to terminal bronchioles. As a result, efficacy of these may show pathological condition comes from clearance failure.

Discussion

The lungs of current rabbits were covered by the pulmonary pleura which were showed serous membrane constructed by tunica serosa of the lungs. Usually it is imperceptible in many other animal species as in rodents whereas, slightly thick in human (11).

Results revealed that both left and right main extra-pulmonary bronchi were penetrated the lung parenchyma and continue as intra pulmonary bronchi that were divided into primary, secondary and tertiary bronchi in a monopodial division series. Such branching of airway trees was recorded previously as 25 of generations in rabbits and 32 humans (12). Actually, two asymmetrical offshoot branches emerge from each of the primary branches (dichotomous) refers to two daughter branches with the same diameters, whereas, monopodial division of bronchus refers to two daughter branches with uneven diameters. However, branching in humans is nearly fully dichotomous, while monopodial in the rabbit (13) and other animals such as rats, pigs (14) and mouse (15).

In the present findings, the mucosa of both extrapulmonary and intrapulmonary primary bronchi was built up by folded pseudostratified columnar ciliated epithelium with goblet cells which in turn rested on lamina propria of loose connective tissue containing numerous capillaries. Each cell in the

pseudostratified epithelial layer that lines the bronchi mentioned above is crucial to ensuring that air can flow freely. In fact, defensive and preventive capabilities against foreign air particles are provided by these cells as a group. Respiratory epithelium of the large proximal airways was lined by goblet cells, basal cells and ciliated columnar cells. Similarly previous comparative records between rabbit and human showed that density of such epithelial cells in, human's lungs have a different higher cellular density than rabbits, which was one of the most noticeable distinctions between the two species (12).

By MTC staining, results showed bronchioles walls supported by loose connective fibers with absence of glands and cartilage plates. Similarly, previous reference recorded in African giant pouched rat the goblet cells even though there are a few in the early primary bronchioles (16).

Current findings demonstrated numerous blood capillaries in the lamina propria of the mucosa of the airways in addition highly vascularized pulmonary parenchyma. Submucosal vessels are linked to a cross network of vessels outside the smooth muscles and bronchial cartilages. Previous microscopic measurements recorded about five capillaries in each mm in rabbit lung, whereas, approximately

seven capillaries in each mm in human's lung (17, 18, 19).

Fine microscopic examination revealed that Alveolar ducts were running between and opened into alveolar sacs which in turn was constructed from a group of alveoli clusters and the alveolus itself was a small apace lined by simple squamous epithelium of two types, that were Type-I pneumocytes, flattened lining cells and type-II pneumocytes. In fact, the first type pneumocytes were facing or adherent directly to the capillary wall. The basal lamina of each was adherent to the corresponding capillary endothelial cell to form blood barrier system. The latter system is well known for its responsibility for gasses exchange between blood (internal environment) and inhaled air (external environment) (20).

The alveoli in the rabbit's pulmonary parenchyma showed well identified Type II cells. They play a role in air-liquid interface to prevent alveolar collapse due to their production and release of surfactant phospholipids and proteins from their secretory lamellar body vesicles (20) (21).

The current findings showed the histological feature of the important airway respiratory bronchioles of the local rabbit. Between the terminal bronchial and alveolar ducts, respiratory bronchioles were partly alveolarized airways. It can be suppose that in case of their absence, insoluble particles may be transported straight from alveolar ducts

to terminal bronchioles. As a result, efficacy of these may show pathological condition comes from clearance failure. In correspond, human respiratory bronchioles, unlike rabbits, seem to perform a function in the establishment of fibrosis and other conditions (22, 23, 24, 25).

Differences in both bronchial divisions style as monopodial other than dichotomous present in other species and human as well the presence distinctly of partly alveolarized airways between terminal bronchial and alveolar ducts in rabbit's lungs being in parallel with previous findings that acknowledged and indicated many differences between rabbit and other species even the laboratory animal specially those of class rodentia. The study findings were in agreement and confirmed previous records and postulations of (26) and (27, 28, 29, 30) that rabbits were different from rodents in their organs anatomically, histologically and histochemically.

Unique differences of such animal species in the present findings and previous above references in the local rabbits confirmed the reason by which rabbits were alienated and classified in new different order in the animal classification or taxonomy. Rabbits were considered rodents until 1912, but different indentation resulted in the establishment of a new order called Lagomorpha of the class mammalian (31).

Conclusions

Other species and human as well the presence distinctly of partly alveolarized airways between terminal bronchial and alveolar ducts in rabbit's lungs being in parallel with previous findings that acknowledged and indicated many differences between rabbit and other species even the laboratory animal specially those of class rodentia. The study findings were in agreement and confirmed previous records and postulations of (23) and (27, 28, 29, 30) that rabbits were different from rodents in their organs anatomically, histologically and histochemically.

Unique differences of such animal species in the present findings and

previous above references in the local rabbits confirmed the reason by which rabbits were alienated and classified in new different order in the animal classification or taxonomy. Rabbits were considered rodents until 1912, but different indentation resulted in the establishment of a new order called Lagomorpha of the class mammalian (28).

The present study provides distinct histological features of the lung tissues in the domestic rabbits, which can be used in advanced future studies to evaluate the evolutionary characteristic of this animal species as a model for both human and animal health investigations and experiments.

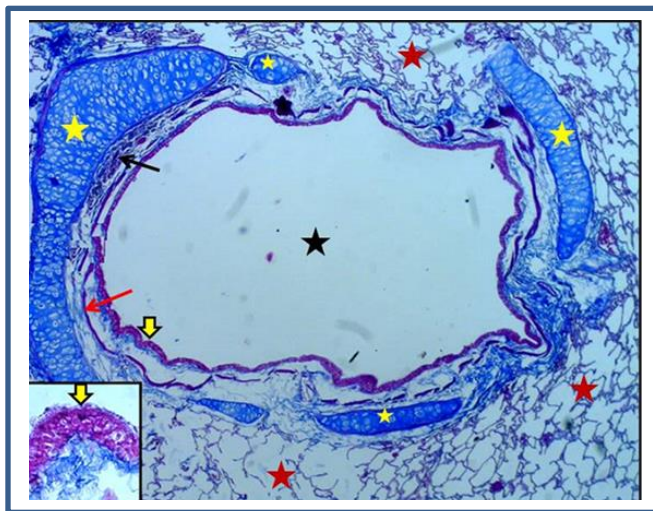


Fig. 1. Histological section showed primary bronchus characterised by pseudostratified epithelium (yellow arrows), muscularis mucosa (red arrow), submucosal glands (black arrow), wall supported by Hyaline cartilage (yellow stars), brochial lumen (black star) and pulmonary parenchyma (red stars). MTC, X200

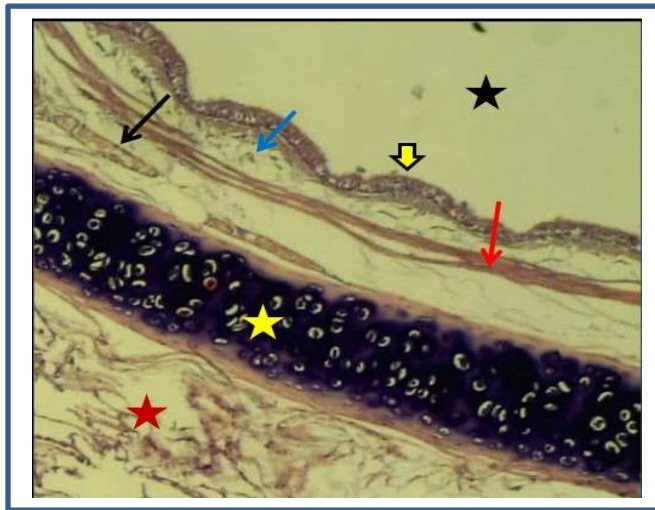


Fig. 2. Histological section showed secondary bronchus characterised by pseudostratified epithelium (yellow arrow), muscularis mucosa (red arrow), submucosal blood vessels invested in loose connective tissue (black arrow), Hyaline cartilage (yellow star), bronchial lumen (black star) and pulmonary parenchyma (red star). H&E, X400

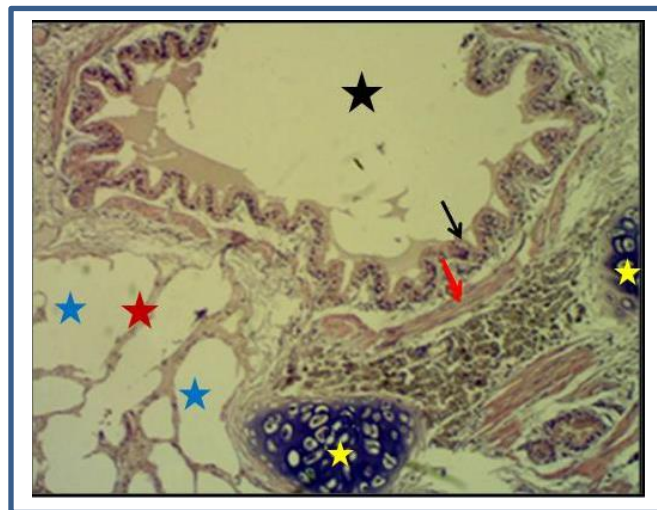


Fig. 3. Histological section showed tertiary bronchus characterised by ciliated simple columnar folded epithelium (black arrow), muscularis mucosa (red arrow), submucosal small plates of hyaline cartilage (yellow stars), bronchial lumen (black star) , many alveoli (blue stars) filling the pulmonary parenchyma (red star). H&E, X200

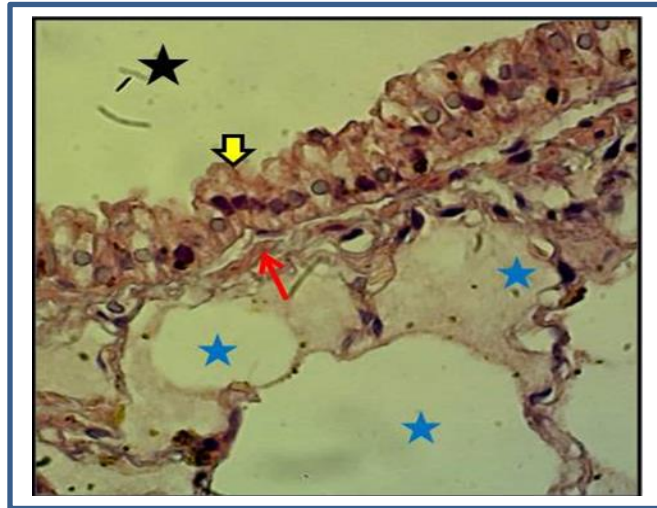


Fig. 4. Histological section showed primary bronchiole characterised by simple columnar epithelium (yellow arrow), thin layer of muscularis mucosa (red arrow), bronchial lumen (black star) and many alveoli (blue stars). H&E, X400

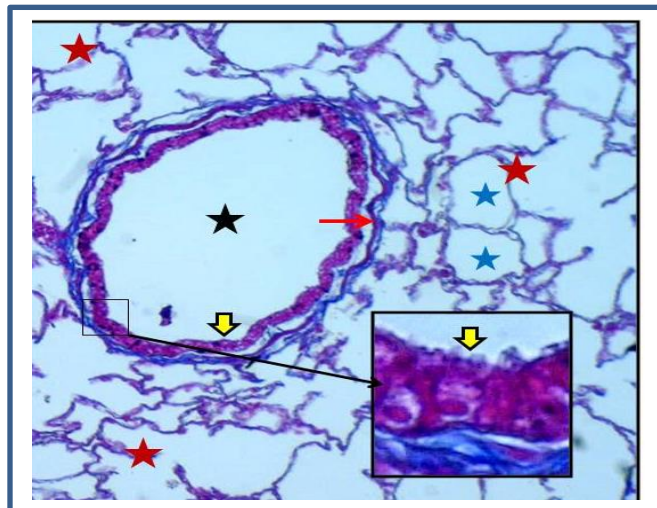


Fig. 5. Histological section showed secondary bronchiole characterised by simple low columnar epithelium (yellow arrow), very thin layer of smooth muscle fibers (red arrow), bronchial lumen (black star) and many alveoli (blue stars) forming the pulmonary parenchyma (red stars). MTC, X200

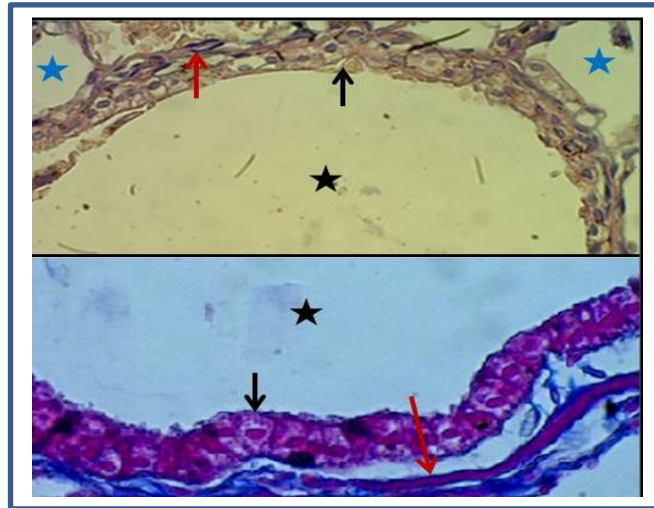


Fig. 6. Histological section showed tertiary (terminal) bronchiole characterised by simple cuboidal epithelium (black arrows), one layer of smooth muscle fibers (red arrows), bronchial lumen (black stars) and many alveoli (blue stars). H&E (upper panel), MTC (lower panel), X200

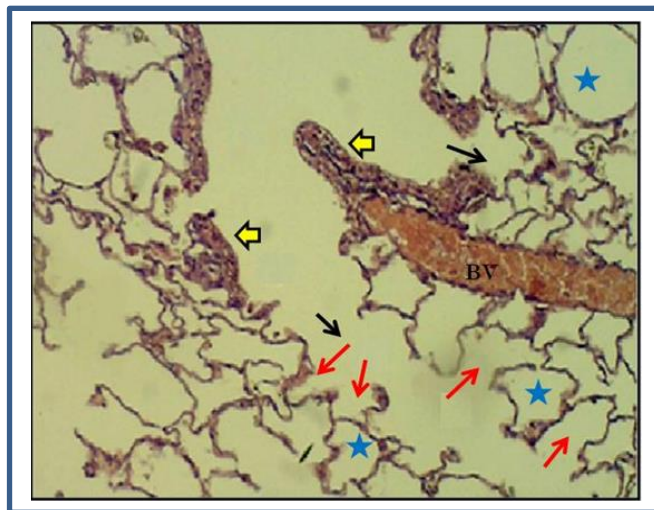


Fig. 7. Histological section showed respiratory bronchiole characterised by simple cuboidal epithelium (yellow arrows), opened into alveolar ducts (black arrows), to which opened alveolar sacs (red arrows) which in turn possessed many alveoli (blue stars) , blood vessel (BV) percised pulmonary parenchyma. H&E,X200

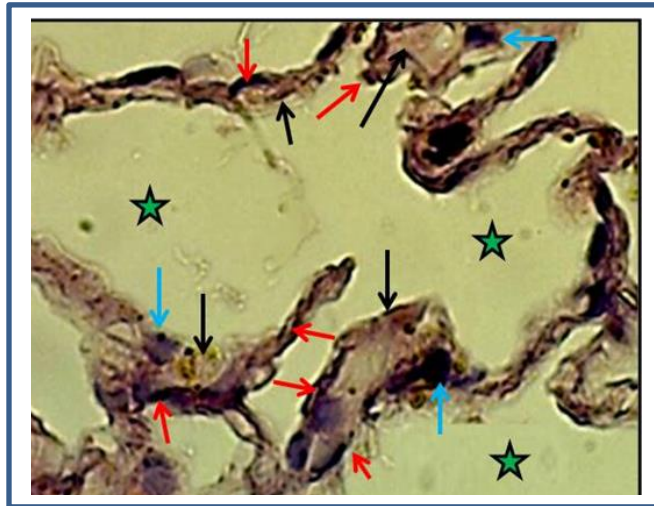


Fig. 8. Histological section showed many alveoli (green stars), their walls was formed by type I pneumocytes (red arrows) and type II pneumocytes (blue arrows). blood endothelial cells (black arrows) formed blood barrier system with type I pneumocyte. H&E, X400.

References

1. Nowland MH, Brammer DW, Garcia A, Rush HG. Biology and diseases of rabbits. In Laboratory animal medicine 2015 Jan 1 (pp. 411-461). Academic Press.
2. Duranthon V, Beaujean N, Brunner M, Odening KE, Santos AN, Kacskovics I, Hiripi L, Weinstein EJ, Bosze Z. On the emerging role of rabbit as human disease model and the instrumental role of novel transgenic tools. Transgenic research. 2012 Aug;21:699-713.
3. Ahmed Abdulla Hussein AA and Ibrahim RS. Histological Study of the Effects of Propranolol on the Kidney and Liver of Rabbit (*Oryctolagus cuniculus*). Diyala Journal for Veterinary sciences. 1(4), December 2023.
4. Mahmood MA. the biochemical, hematological and histopathological changes study induced by tramadol and treated by cucumin in local male rabbits. Diyala Journal for Veterinary sciences. 1(3), November 2023.
5. Ibrahim RS. Morphometric comparative study of the hind limb muscles in wild rabbit (*Oryctolagus cuniculus*) and domesticated rabbit (*Oryctolagus cuniculus domesticus*) Diyala Journal for Veterinary sciences. 1(2), Jun 2023.
6. Alves JM, Carneiro M, Afonso S, Lopes S, Garreau H, Boucher S, Allain D, Queney G, Esteves PJ, Bolet G, Ferrand N. Levels and patterns of genetic diversity and population structure in domestic rabbits. PLoS one. 2015 Dec 21;10(12):e0144687.
7. Zabetian M, Tahmoorespur M, Hosseini K. The applications of transgenic rabbits in agriculture and biomedicine. Journal of Animal and Veterinary Advances. 2011 Jan 1;10(6):780-90.
8. Al-Saffar FJ, Al-Hasnawy AH.

Histomorphological developmental study of advanced postnatal of the pancreas of local rabbit. *Journal of Biological Sciences*. 2014 Aug 20;14(6):387.

9. AUTIFI, Mohamed Abdul Haye; EL-BANNA, Ahmed Kamal; EBAID, Ashraf El-Sayed. Morphological study of rabbit lung, bronchial tree and pulmonary vessels using corrosion cast technique. *Al-Azhar Assiut Med. J*, 2015, 13: 41-51.

10. Otali D, Fredenburgh J, Oelschlager DK, Grizzle WE. A standard tissue as a control for histochemical and immunohistochemical staining. *Biotechnic & Histochemistry*. 2016 Jul 3;91(5):309-26.

11. HELKE, K. L. Book review: comparative anatomy and histology: a mouse, rat, and human atlas.

2018.

12. MURRAY, John F. The structure and function of the lung [Review article. 2010: The Year of the Lung. Series editor: John F. Murray]. *The International journal of tuberculosis and lung disease*, 2010, 14.4: 391-396.

13. RAMCHANDANI, R., et al. Airway branching morphology of mature and immature rabbit lungs. *Journal of Applied Physiology*, 2001, 90.4: 1584-1592.

14. MONTEIRO, Adilson; SMITH, Ricardo Luiz. Bronchial tree Architecture in Mammals of Diverse

Body Mass. *International Journal of Morphology*, 2014, 32.1.

15. LABODE, Jonas, et al. Evaluation of classifications of the monopodial bronchopulmonary

vasculature using clustering methods. *Histochemistry and Cell Biology*, 2022, 158.5: 435-445.

16. IBE, C. S., et al. Microscopic anatomy of the lower respiratory system of the African giant pouched rat (*Cricetomys gambianus*, Waterhouse 1840). *Int. j. morphol*, 2011, 27-33.

17. SONG, Jun, et al. Bacterial and pneumocystis infections in the lungs of gene-knockout rabbits with severe combined immunodeficiency. *Frontiers in Immunology*, 2018, 9: 324409.

18. VUCKOVIC, Aline, et al. Antenatal BAY 41-2272 reduces pulmonary hypertension in the rabbit model of congenital diaphragmatic hernia. *American Journal of Physiology-Lung Cellular and Molecular Physiology*, 2016, 310.7: L658-L669

19. TANGPHOKHANON, Wasan; LAMETSCHWANDTNER, Alois. The microvascular anatomy of the trachea in adult *Xenopus laevis* Daudin (Lissamphibia; Anura): scanning electron microscopy of vascular corrosion casts and correlative light microscopy. *The Anatomical Record: Advances in Integrative Anatomy and Evolutionary Biology*, 2012, 295.6: 1045-1052.

20. Bhattacharya J, Matthay MA. Regulation and repair of the alveolar-capillary barrier in acute lung injury. *Annual review of physiology*. 2013 Feb 10;75:593-615.

21. CRYSTAL, Ronald G., et al. Airway

- epithelial cells: current concepts and challenges. *Proceedings of the American Thoracic Society*, 2008, 5.7: 772-777
22. GLASSER, Stephan W., et al. Mechanisms of lung fibrosis resolution. *The American journal of pathology*, 2016, 186.5: 1066-1077.
23. SGALLA, Giacomo, et al. Idiopathic pulmonary fibrosis: pathogenesis and anagement. *Respiratory research*, 2018, 19: 1-18.
24. KAMARUZAMAN, Nurfatin Asyikhin, et al. The rabbit as a model for studying lung disease and stem cell therapy. *BioMed research international*, 2013, 2013.1: 691830.
25. B. MOORE, Bethany, et al. Animal models of fibrotic lung disease. *American journal of respiratory cell and molecular biology*, 2013, 49.2: 167-179
26. Al-Saffar FJ, Al-Hasnawy AH. Histomorphological developmental study of advanced postnatal of the pancreas of local rabbit. *Journal of Biological Sciences*. 2014 Aug 20;14(6):387.
27. Al-Saffar FJ, Al-Haik AG.
Histomorphological relationship of paneth cells with stem cells in the small intestine of indigenous rabbit at different postnatal ages. *Singapore J Chem Biol*. 2016;5(1):11-9.
28. Al-Saffar FJ, Al-Haik AG. Histochemical study of carbohydrates foundation in the gut of indigenous rabbits at different postnatal ages. *Inter J Curr Res*. 2016;8(8):37223-30.
29. Alhaaik AG. Histomorphological and Immunohistochemical postnatal developmental changes in the small intestine and colon of the indigenous rabbits (*Oryctolagus cuniculus*) (Doctoral dissertation, Baghdad University).
30. Al-Saffar FJ, AG AH. Gross and microscopic developmental study of the local rabbit's spinal cord. *J Entomol Zool Stud*. 2017b. 2017;5(6):2555-62.
31. Ghoshal NG, Bal HS. Comparative morphology of the stomach of some laboratory mammals. *Laboratory animals*. 1989 Jan 1;23(1):21-9.