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Histological studies on the trachea and lungs in dogs

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Abstract

The present work was undertaken with the aim to study the histological features of trachea and lung of dog. The lung was collected from six apparently healthy dogs, cut into small pieces, routine histological processing done and images were recorded. Histologically trachea consisted of four tunics namely tunica mucosa, submucosa, fibrocartilaginous layer and serosa. The glands and lymphoid accumulation were not observed in the lamina propria of the mucosa,but some solitary lymphocytes could be observed. The submucosa contained mucous secreting glandular alveoli with clear foamy cytoplasm and spherical to flat nucleus found lying at the basal part of the cells The parenchymatous portions showed intrapulmonary bronchi, tertiary bronchioles and respiratory bronchioles, alveolar ducts, sacs and alveoli. Terminal bronchioles could be well distinguished in the terminal part of the conducting pathway. The respiratory bronchioles were lined by cuboidal epithelium without cilia. The alveolar ducts, alveolar sacs and alveoli were lined by simple squamous epithelium. The alveoli showed type 1 pneumocytes, type 2 pneumocytes and alveolar macrophages.

Keywords: *Histology, lungs, trachea, dogs*

The respiratory system of dogs and other mammals extends from nostrils to the lungs. The upper airway conducting system includes nostrils, nasal cavity and pharynx. The lower respiratory tract consists of larynx, trachea, bronchi, bronchioles and alveoli within the lung parenchyma. The respiratory system is divided into conductive and respiratory portions. The conductive portions include larynx, trachea, bronchi and terminal bronchioles which do not possess alveoli on their walls and has thick walls to prevent diffusion of gases. The respiratory portions include respiratory bronchioles, alveoli duct and sacs which possess alveoli on their walls and includes alveoli too which function in gaseous exchange. The lung parenchyma possessed parenchymal and non-parenchymal structures. The parenchymal structures include the terminal bronchiole, respiratory bronchiole, alveolar ducts, alveolar sac and alveoli. The non-parenchymal structures

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include arteries, veins, capillaries, lymphatics vessels, nerves, interlobular septa and pleura. Visceral pleura covered the right and left lung parenchyma and septa from this pleura entered the parenchyma of the lung and divided it into lobes and lobules. Histological studies on the trachea and lung of the dogs are scanty. So, the present work was undertaken with the aim to study the histological features of trachea and lung of dog.

Materials and methods

The lung was collected from six apparently healthy dogs of small size aged between 2-4 years (irrespective of sex) and studied for their histological details. These dogs were donated to the Department of Veterinary Anatomy, VCRI, Tirunelveli for the purpose of education and research with the consent from the owner. The lung was cut into small pieces, fixed in neutral buffered formalin and Bouin's fluid and routine histological processing were done and paraffin blocks were obtained. Paraffin sections of 4 to 5 µm thickness were taken from the blocks using manual rotary microtome and stained using Haematoxylin and Eosin (Luna, 1968). Images were recorded using image size recording system and digiscope imaging system.

Results and discussion

The histology of the lung of the dog comprised of two components namely conductive pathways and respiratory pathways as in other mammals (Dellmann and Eurell, 1998). The lining epithelium of conductive pathways were pseudostratified columnar epithelium or respiratory epithelium but the respiratory pathways were lined by ciliated cuboidal to simple squamous epithelium. The airway conductive systems started with trachea which divided into two principal bronchi which in turn divided into secondary and terminal bronchioles within the lung parenchyma. The bronchi were divided into smaller and smaller components. The smallest component was the terminal bronchioles.

The histological features of the trachea of the present study consisted of four tunics from lumen to outside namely tunica mucosa, submucosa, fibrocartilaginous layer and serosa as the findings of Moussa and Hassan (2015) in red fox. The tunica mucosa was found with lining epithelium of pseudostratified ciliated columnar epithelium with goblets cells (Fig. 1) as stated by Bosch *et al.* (2021) in humans. Goblets cells secreted mucins which played a vital role in clearance of pathogens, pollutant particle and inflammatory stimuli from the airways (Tam *et al.*, 2011) in humans. The pseudostratified epithelium has tall columnar cells with basally located oval shaped nucleus and small angular basal cells with round shaped nucleus and all cells resting on the basement membrane. Basal cells function as a reserve cell for the epithelial replication and also for the attachment of columnar cells to the basement membrane (Alexander *et al*., 1971 and Corkmark and Ham (1981) in humans. Gartner and Hiatt (2007) in human also observed brush cells and serous cells in the pseudostratified epithelium and was not observed in the present study which may be due to species difference. The tunica mucosa contained lamina propria below the lining epithelium and was found to be made of loose connective tissue fibres and cells with blood vessels like artery, vein, capillaries and nerves (Fig. 2) as observed by Moussa and Hassan (2015) in red fox. The glands and lymphoid accumulation were not observed in the lamina propria. But some solitary lymphocytes could be observed. Muscularis mucosa was not observed in the present observation as per the findings of Moussa and Hassan (2015) in red fox. The submucosa also found to be made up of loose connective tissue cells and fibres with large blood vessels. The blood vessels separated the mucosa from submucosa. The submucosa contained mucous secreting glandular alveoli with clear foamy cytoplasm and spherical to flat nucleus found lying at the basal part of the cells (Fig. 3). Similar findings were also observed in human trachea (Fraser, 2005) but in red fox tracheal submucosa did not contain submucosal glands (Moussa and Hassan, 2015). The hyaline cartilage layer was found below the submucosa and contained homogenous matrix and chondrocytes within the lacunae. Isogenous cell nests and perichondrium were also observed (Figs. 2, 3). The overlapping of the cartilage was also observed. Tunica serosa was found to be

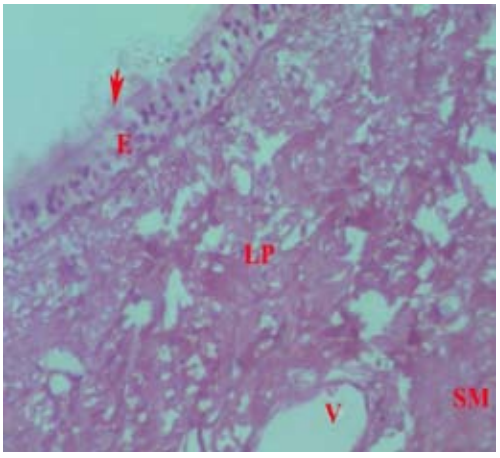

Fig. 1: Photomicrograph showing the cross section of trachea of dog. E – Epithelium, Cilia (Arrow), LP – Lamina propria, V – Blood vessel, SM – Submucosa H & E x 400

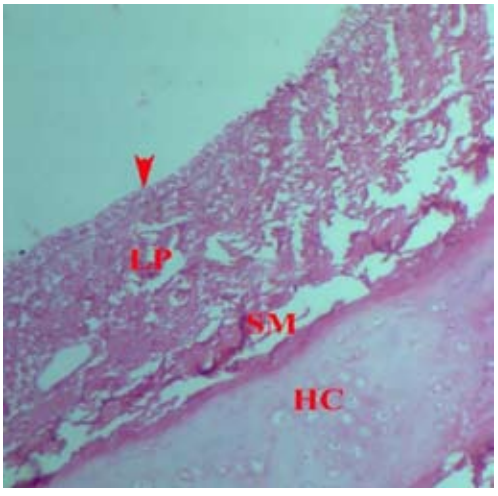

Fig. 2: Photomicrograph showing the cross section of trachea of dog. Arrow – Epithelium, LP – Lamina propria, SM – Submucosa, HC – Hyaline cartilage H & E x 100

consisted of loose connective tissue cells and fibres. It showed the presence of trachealis muscle.

Histology of the lung of dogs showed the presence of intrapulmonary bronchi, tertiary bronchiole and respiratory bronchioles, alveolar duct, alveolar sac which possessed alveoli on its walls and alveoli (Fig. 4). The above said structures formed the part of parenchymatous portion of lung. The non-parenchymatous portions of lungs included visceral pleura, interlobar and interlobular septa which were

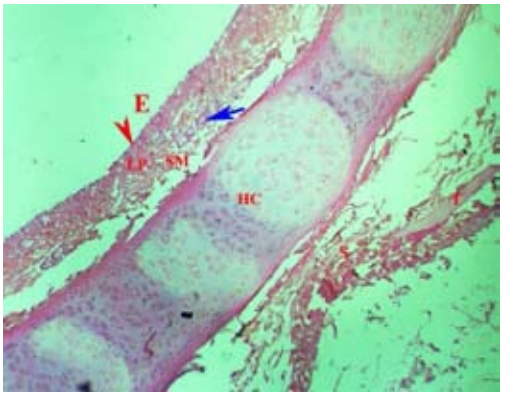

Fig. 3: Photomicrograph showing the cross section of trachea of dog. Arrow (E) – Epithelium, LP – Lamina propria, SM – Submucosa, HC – Hyaline cartilage, S - Serosa H & E x 40

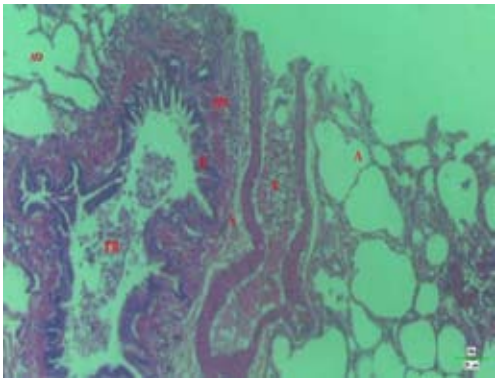

Fig. 4: Photomicrograph of lung of dog showing TB – Terminal bronchioles, E – Epithelium SM – Submucosa, S – Serosa, V – Vein, AD – Alveolar duct and A – alveoli H & E x 100

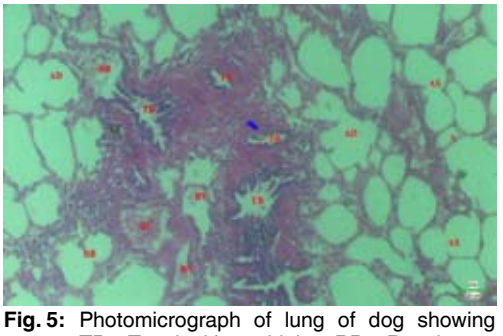

Fig. 5: Photomicrograph of lung of dog showing TB – Terminal bronchioles, RB – Respiratory bronchiole BV – Blood vessel, AD – Alveolar duct, As – Alveolar Sac, A – Alveoli, Red dot - Epithelium and Blue line – smooth muscle H & E x 100

derived from pleura and were connective tissue elements, arteries, veins, capillaries, nerves and lymphatic vessels (Fig. 4).

The histology of the intrapulmonary bronchi from inside to outwards were of

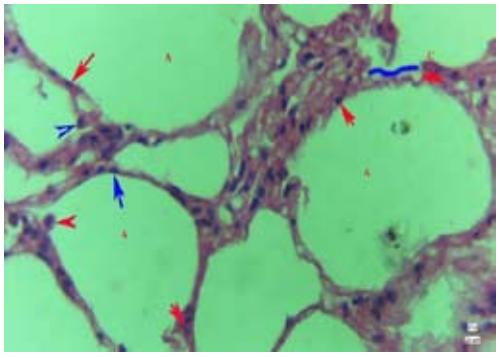

Fig. 6: Photomicrograph of lung of dog showing A – Alveoli, Red and blue arrow head – Alveolar macrophages Blue arrow – Pneumocyte II, Red Arrow – Pneumocyte I, Blue line – Alveolar basement membrane covered with connective tissue, Red line – Alveolar basement membrane in connection with capillary basement membrane H & E x 400

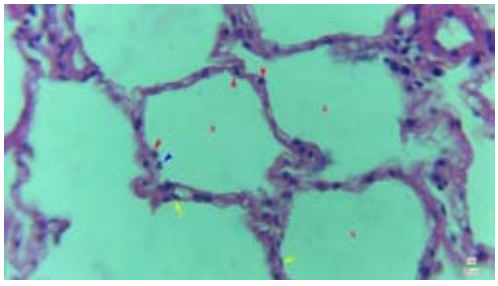

Fig. 7: Photomicrograph of lung of dog showing A – Alveoli, Red arrow – Pneumocyte II, Blue arrow – Alveolar macrophage, Yellow Arrow – Pneumocyte I H & E x 400

four layers namely tunica mucosa, tunica submucosa, fibro-cartilaginous and serosa. Similar findings were observed by Koptyev *et al.* (2014) in rats. The tunica mucosa was found to be lined with respiratory or pseudostratified ciliated columnar epithelium, a thin loose connective tissue lamina propria and submucosa, tunica muscularis layer with a band of smooth muscle and plates of hyaline cartilage and thin layer of loose connective tissue serosa. When the bronchi divided from primary to tertiary bronchi, the epithelium was changed from respiratory to ciliated simple columnar epithelium with goblet cells, the proportion of hyaline cartilage decreased and smooth muscle proportion increased and the wall the bronchi and diameter was also reduced as stated by Koptyev *et al.* (2014) in rats and Bosch *et al.* (2021) in humans. Along with the ciliated simple columnar epithelium, goblet cells and non-ciliated Clara cells were also observed as found by Koptyev *et al.* (2014) in rats. But he also observed brush cells which were not found in the present study and it may be due to species difference.

The terminal bronchioles were the terminal part of conductive pathway. It was also lined by columnar to cuboidal cells without goblet cells which were surrounded by thin layer loose connective tissue lamina propria, hyaline cartilage was not found and smooth muscle was found as a thin discontinuous band (Fig. 4) whereas in red fox, epithelial cells were simple columnar nonciliated to cuboidal and possessed some goblet cells which may be species difference (Moussa and Hassan, 2015). Fraser (2005) stated the bronchiolar epithelial cells in human possessed ciliated columnar cells. Moreover, the human bronchioles contained exocrine bronchiolar cells which secreted surfactant and regenerated the bronchiolar epithelium and was not found in the present study which may be a species difference. Horalskyi *et al.* (2023) mentioned that terminal bronchioles were not well developed in dogs but it was found in the present study which may be due to environmental variation.

Respiratory pathways consisted of respiratory bronchioles, alveolar duct, alveolar sac and alveoli as stated by Koptyev *et al.* (2014) in rats and Horalskyi *et al.* (2023) in dogs. Horalskyi *et al.* (2023) found that terminal bronchioles in dogs were found surrounded by many respiratory bronchioles which were not observed in the present study but branching of terminal bronchioles into respiratory bronchioles were observed. This might be due to environmental variation. The respiratory bronchioles were lined by cuboidal epithelium without cilia whereas Horalskyi *et al.* (2023) found in dogs that it was lined by simple prismatic epithelium. The alveolar duct, alveolar sac and alveoli were lined by simple squamous epithelium (Fig. 5) as stated by Horal skyi *et al.* (2023) in sexually mature dogs. The gaseous exchange will be taking place between the alveoli and the surrounding capillaries.

The alveolar region consisted of alveolar ducts, sacs and alveoli and the wall of all these structures were made of alveoli. The alveolar ducts opened into the alveolar sac

which in turn contained alveoli (Fig. 5). The structures of alveolar region were lined by simple squamous epithelium surrounded by a thin layer of connective tissue fibres. The alveolar region was found in contact with capillaries which is essential for gas exchange. The epithelium of alveoli was located on the basement membrane and connected with the basement membrane of the capillary endothelial cells in some parts as stated by Koptyev *et al.* (2014) in rats. In other parts the alveolar epithelial basement membrane was found surrounded by loose connective tissue fibres (Fig. 6) as declared by Horalskyi *et al.* (2023) in sexually mature dogs.

The alveoli were lined with simple squamous epithelium with two types of lining cells namely type 1 respiratory pneumocytes and type 2 secretory pneumocytes (Fig. 6). Similar observations were also recorded by Koptyev *et al.* (2014) in rats, Moussa and Hassan (2015) in red fox and Horalskyi *et al.* (2023) in dogs. But Koptyev *et al.* (2014) in rats also identified type II brush pneumocytes which were observed in the present study and may be due to species differences. The type 1 pneumocytes were simple squamous cells with fusiform shape and had a flat nucleus (Fig. 7) as stated by Koptyev *et al.* (2014) in rats. The type 2 pneumocytes were bigger cells, cuboidal in shape with centrally placed round nucleus and were found projecting into the lumen (Fig. 7) between the type 1 pneumocytes which were involved in the production of surfactant and also function in repair of alveolar epithelium after the destruction of type 1 pneumocytes. Similar results were also observed by Koptyev *et al.* (2014) in rats regarding the shape of type II pneumocytes but they also found microvilli and secretory granules which were not observed in the present study and this may be due to species difference. Within the lumen of alveoli, alveolar macrophages were also found projecting from the wall of the alveoli (Fig. 6) which played an important role in immune system. The alveolar macrophages possessed many cytoplasmic processes and were basophilic and contained many vesicles. Nucleus of alveolar macrophages were small and irregular in shaped and centrally placed (Fig. 7). Similar findings were also recorded by Koptyev *et al.* (2014) in rats.

Conclusion

The histological study of trachea and lungs of dogs will form the basis research for understanding the disease mechanism involved in upper respiratory tract and lower respiratory tract like chronic obstructive pulmonary disease, asthma etc in dogs. Further study is also needed in this field regarding the identification and study of cells involved in the function of respiration with immunohistochemistry and electron microscopy.

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Conflict of interest

There is no conflict of interest

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