Anatomical and histological study of lings of Turkey *(Meleagris gallopava)*

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Abstract

Anatomical and histological study description of the lungs in the domestic turkey (*Meleagris gallopava*) (at one year of age), is the aim of this study. Ten apparently healthy birds employed in this study (five specimens for anatomical study and five specimens for histological study). The shape, position and components of lungs were recorded.Lungs were (elongated triangular-shaped), extend from the first to the sixth vertebral ribs , contain three surfaces (costal, vertebral, and septal surface) and medial and lateral borders, the latter contain four deep grooves caused by embedded the second to the fifth vertebral ribs which lead to divided the lung to five lobes. The mean length of right and left lungs were (6.37 ± 0.24 cm), (6.72 ± 0.17 cm) respectively, while the mean width of right and left lungs were (3.35 ± 0.4 cm), (3.68 ± 0.3 cm) respectively, and the mean thickness of right and left lung were (0.96 ± 0.06 cm), (1.025 ± 0.092 cm) respectively.Histological study proved that the lung contain secondary bronchi and lung lobules which formed from tertiary bronchi (parabronchi) separated by the interparabronchial septa. Parabronchi branched to atria, infundibula, and air capillaries, all these components lined by simple squamous epithelium. Smooth muscle fibers constituted the major part of the parabronchial walls which occur on the atrial openings edges. Air capillaries intertwined among numerous blood capillaries formed the blood-gas barrier; the mean thickness of this barrier was (0.5 ± 0.08 µm).

Introduction

Over the five years distinct subspecies of turkey occurring in the wild have been named, all native to North America but in different habitat areas. A sixth subspecies (*Meleagris gallopava*) originally inhabiting southern Mexico, the indigenous turkey is derived from the native wild turkey of North America which descendants of the Mexican turkey (1).The respiratory system plays a vital role in thermo-regulation, the sense of smell, and voice are associated with it (2). In avian it is described as non-tidal (3), composed of two main components the rigid gas exchanging bronchial lungs which allow for a union between air and blood and the non-vascularized ventilatory air sacs (4).Avian lungs more specialized organ, three important features of this specialization are enlargement of the respiratory epithelium, efficient mechanisms for ventilation, and an efficient circulation (5). The avian respiratory system infections had pertinent relation with human, and the lack of consistency in information on respiratory system of turkey in Iraq, therefore we were suggested to describe anatomical and histological in details of lungs.

1-Anatomical study:

Avian lungs are very small, when considered as a proportion of the whole body size and very stiff when fully inflated, appear as elastic bodies like balloon and firmly attached to the ribs that leave deep costal impressions. (6,7) **.**The lungs lie in the craniodorsal part of the thorax ,extend from the second rib cranially, to the six rib caudally (8, 7, 9, 10).The lung of the chicken, turkey, and duck appear as flattened rectangular structure and it is wedge-shaped in transverse section, elongated parallelogram (the craniocaudal axis being longer than the mediolateral), trapezium-shape respectively, in duck the medial border being about twice the length of the lateral border this makes the lung relatively long, narrow, and pointed craniomedially, the medial border carries six impressions for ribs, on the costal surface;The main trunk of the mediodorsal secondary bronchus are clearly visible, as well as parabronchi (11). While (8) describe the lungs of the duck as

bright red-trianglar or quadrilateral-shape, not divided into lobes, and has in the upper border several rows of grooves caused by embedded the vertebral ribs.In west african guinea fowl , the lungs are bright red trapezium shape, the rib impressions divide each lung into four parts, and the dorsal surface is convex, while the ventral surface is concave. The primary bronchus, tracheal artery and pulmonary vessels pass through the hilus into the lungs at the medial border. (5).The lung of the chicken and turkey have, three surfaces (the vertebral, visceral and costal surfaces) and thick medial and thin lateral borders (6,10, 11). In some species of the birds like duck, the costal surface is dorsolaterally in direction, the vertebral surface is dorsomedially in direction, and the septal surface is ventromedially in direction (6,8).In Japanese quail lungs appears as spongy-like, bright red in color, has no lobes, and has convex costal and medial, and concave ventral surfaces (12).

2-Histological study

The bulk of the avian lungs are formed by parabronchi (center of the pulmonary lobules are separated by inter parabronchial septa), which branch from the secondary bronchi and anastomizing with each other, (8, 11, 13). The lungs of ostrich are lacking to interparabronchial septa (14).Avian parabronchial wall build by three layers from internal to external, cuboidal or squamous epithelium without secretory units, a thin of the loose connective tissue layer, and the muscular layer contains bundles of smooth muscle cells, there is no cartilages (15, 16, 17).In birds like chicken, turkey, duck, and quail (*Coturnix coturnix*), the inner wall of each parabronchus is pierced by numerous openings, each of which leads into a cavity called an atrium (air vesicle) which lined by a squamous to cuboidal epithelium continuous with that lining of the air capillaries, and contain two distinct types of epithelial cells (the granular and squamous cells), the atria are separated by interatrial septa of loose connective tissue, and there are spiral of smooth muscle bundles on the arterial openings, (18, 19, 20, 21).In goose, duck, and other avian the tissue mantle of the parabronchi is make up of a meshwork of the blood capillaries and air capillaries which form the unite of gas exchange (6,22). The blood capillaries appear as interconnected segments that are wide and anastomose more regularly than the air capillaries approximately, and the tissue which separating adjacent blood capillaries are not distinguishable. The blood capillaries in the periparabronchial exchange tissue empty into the atrial veins that are located close to the parabronchial lumen (9).In domestic fowl the extremely tenuous simple squamous endothelium and epithelium which constructed blood and air capillaries respectively to provide only the minimum barrier to gas exchange which consist of essentially from endothelium, basal lamina, and a very thin squamous epithelial cell, (granular cells are absent) and the interstitial tissue is minimal (4,9). Blood-gas barrier thickness ranges from 0.314 µm for the domestic chicken to less than 0.1µm for the hummingbird and rock martin (*Hirundo fuligula)*, compared with values of 0.206, 0.338, and 0.62 µm, for bat, shrews, and humans, respectively (11, 22).

Materials and methods

1- The Experimental design:

The specimens for this study were 10 healthy adult turkeys about (4715± 43.3 gm) live weight , collected from the center of Diwanyia city, were killed by slaughtered divided into two groups, (five of turkeys for anatomical study and other for histological study).

2- Anatomical study:

In each specimens the lungs observed immediately after slaughtered, the position in situ, the shape, and the relations it with other organs were obvious and recorded, Subsequently, the lungs were separated from thoracic cavity carefully and the following anatomical indices recorded (Weights of left and right lungs and length, width, and thickness of the left and right lungs

3- Histological study:

The lungs were dissected out and washed with normal saline solution (0.9% NaCl), then small pieces of each specimens were fixed immediately in 10% formalin at room temperature. Then the routine histological processes were performed and used Harris Hematoxylin & Eosin stain to demonstrated the general histological structures under the light microscope (Olympus type) (23).

Morphometric measurements:

Five sections from each lung of each specimen were taken and the following data were recorded by ocular micrometer:

1- The thickness of the wall, epithelium, and mucous alveoli of secondary bronchi.

2- The thickness of the blood-gas barrier.

And for purposes of photography a colored films were used (Konica type), and (Sony type camera -12 MB).

Results

1- Anatomical study:

Morphological examinations of the lungs in the turkey in this study appeared as shiny-red elongated triangle-shaped, craniocaudally in direction, extend from the first to the sixth vertebral ribs. Firmly attachment with the ribs and vertebral column (Fig. 1), and they were characterized by presence of three surfaces and two borders (dorsal and medial borders):-

1- Costal surface: - was slightly convex dorsolaterally in direction, had on dorsal border of these surface four rows of deep grooves caused by embedded the second to the fifth vertebral ribs lead to divide the lung to five lobes (Fig. 1, 2).

2-Vertebral surface: - was convex dorsomedially in direction.

3-Septal surface:-was ventromedially in direction, apposite the mediastenum (heart and esophagus), and the hilus on the middle third of the medial border (Fig. 2).The mean length and width of right lung shorter than that of left lung and the mean weight and thickness of right lung also lesser than that left lungs (Table 1).

2- Histological study:

Microscopic examination of the lung in the turkey in this study explained that the secondary bronchi lined by ciliated, pseudostratified columnar epithelial with abundance various size mucous glands occupied the majority of the epithelium thickness with sporadic little goblet cells (Fig 3), the mean thickness of the secondary bronchial wall, epithelium, and mucous glands were (34.4 ± 1.96 µm), (9.2 ± 0.58 µm), and (6.2 ± 0.37µm) respectively (Table 2), lymphoid tissue appears under the epithelium in one to two ridges appeared as mounds, lamina propria and submucosa were dense irregular connective tissue but the bundles of collagen fibers were small, there were small layer of the smooth muscle bundles which encircled entire the secondary bronchi without cartilages (Fig 3).There were several openings along the secondary bronchial walls lead to small anastomozing parabronchi which form the building units of the lung (lung lobules), and opened into the several dilated chambers (atria), that led to the smaller dilated ducts (infundibula), which led to very small and complicated network of the air capillaries (Fig.4).Each lobules separated by interparabronchial connective tissue (interparabronchial septa). Interparabronchial arteries and veins passing in these septa (Fig 4).The wall of the parabronchi and wall of the all these passages were lined by simple squamous epithelium. The lamina propria and submucosa are loose connective tissue surround by smooth muscle bundles which surround the atrial openings.Air capillaries epithelium and blood capillaries endothelium were separated by basement membrane only , formed the blood-gas barrier, the mean thickness of the blood-gas barrier were (0.5±0.08µm) (Table 2)(Fig. 4).

Tables and figures

Table 1: Weights of each lung. (gm), and dimensions of each lung of the turkey (cm) ($\bar{X}$ ± SE)

Organs / measures	Right lung	Left lung
Weight	10 ± 0.97	10.68 ± 0.76
Length	6.37 ± 0.24	6.72 ± 0.17
Width	3.35 ± 0.4	3.68 ± 0.3
Thickness	0.96 ± 0.06	1.025 ± 0.092

Table 2: Measurements of the lung compounds of turkey (micrometer) (µm) ($\bar{X}$ ± SE)

Compound / Measures	Secondary bronchial wall	Secondary bronchial epithelium	Blood-gas barrier	Secondary bronchial mucous alveoli
Thickness	34.4±1.96	9.2±0.58	0.5±0.08	----------
Diameter	----------	----------	----------	6.2 ± 0.37

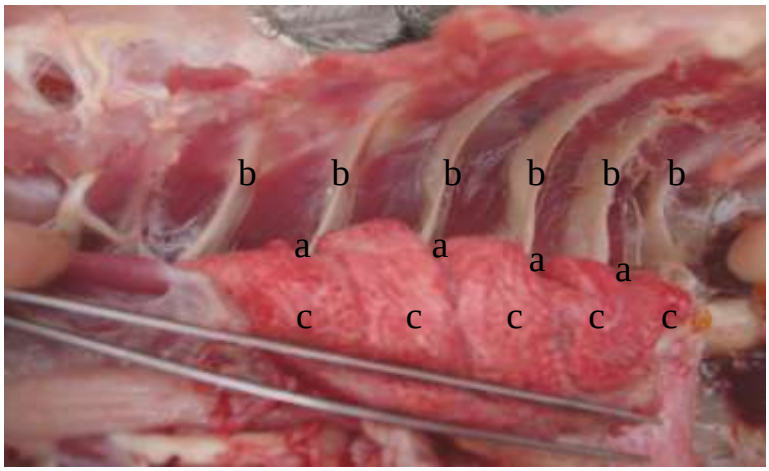

Fig. (1): Left lung lateral view showing the costal surface (a) four deep grooves of the costal surface (b) six costal ribs (c) five lobes of the lung

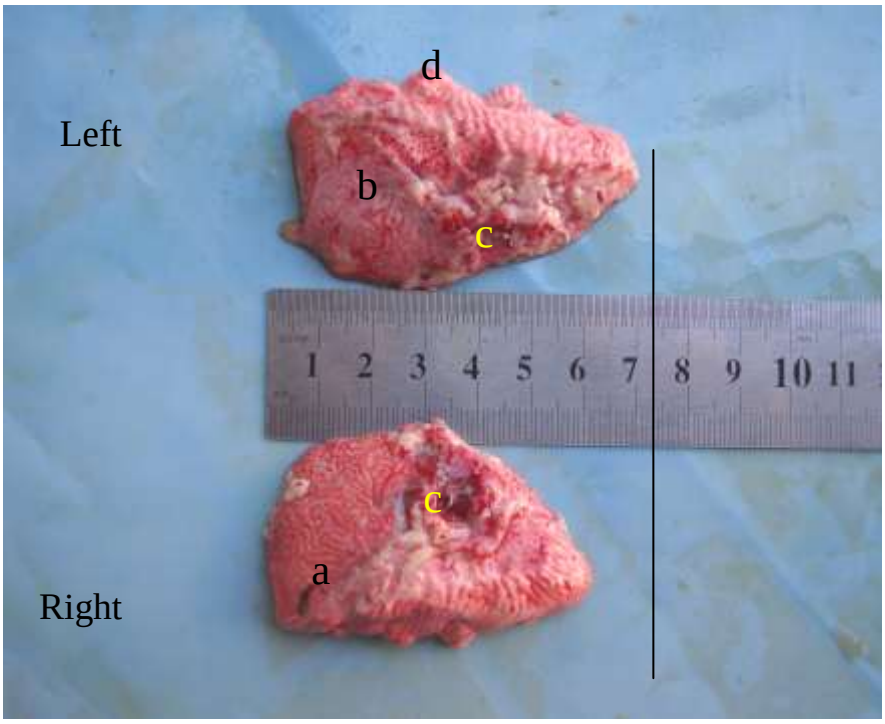

Fig. (2): Right and left lungs medial view showing (a) right lung (b) left lung (c) hilus opening of septal surface (d) deep grooves of costal surface .

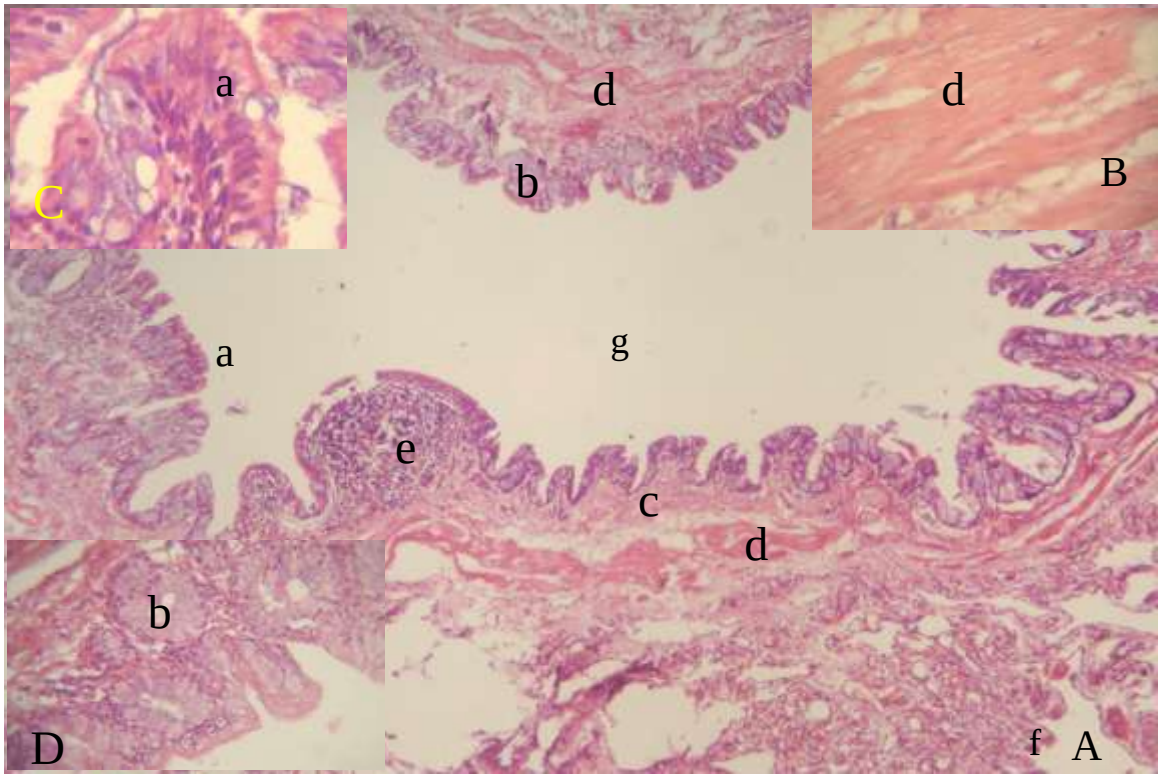

Fig. (3): Histological section of the secondary bronchi showing: (a) ciliated, pseudostratified columnar epithelium (b) alveoli of mucus glands (c) dense irregular connective tissue of submucosa (d) smooth muscle layer (e) lymphoid tissue (f) parabronchi (g) secondary bronchial cavity.H & E stain X 100 A H & E stain X 400 B, C, & D

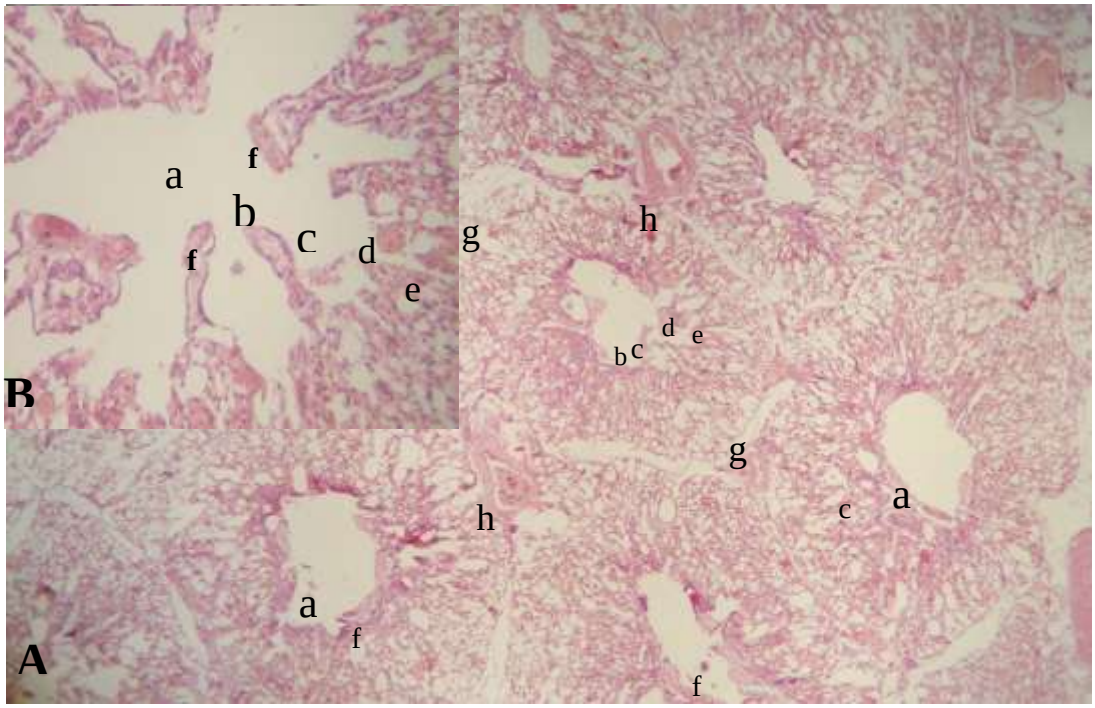

Fig. (4): Histological section of the lung A&B showing: (a) parabronchial lumen (b) atrial opening (c) atria (d) infundibula (e) air capillaries (f) smooth muscle fibers (g) interparabronchial septa (h) interparabronchial blood vessels
H & E stain X 100 A
H & E stain X 400 B

Discussion

The present morphological examinations of the lungs in the turkey clarified that they were shiny-red, elongated triangle-shaped, and craniocaudally in direction. These results agree with (8) in the duck, and with (12) in japanese quail, and incongruity, with (11) who showed that the lung appeared as flattened rectangular structure, elongated parallelogram, and trapezium-shaped in chicken, turkey, and duck respectively, and with (5) who made clear that the lungs were bright red trapezium-shaped in west african guinea fowl.This color of the lungs of turkey in our study referred to opulently the blood supplied of it. (12).The lungs of turkey in this study extend from the first to the sixth vertebral ribs firmly attachment with the ribs and vertebral column, (10) these provide rigidity and constant volume of the avian lung throughout the respiratory cycle which provide the mechanical foundation for an enlargement of the oxygen exchange surfaces into a three-dimensional mesh network of blood capillaries (10 times) larger than that found in mammalian lungs.. These findings consistence with other authors in avian (5, 7, 9).The lung of the turkey in this study similar to other birds like duck characterized by present three surfaces (Costal, Vertebral, and Septal) and two borders (dorsal and medial) (6, 8), but not in agreement, with (11) who name the septal surface as visceral and dorsal border as lateral border in chicken and turkey, and with (12) who explained that there were (convex costal and medial, and concave ventral surfaces) in Japanese quail.The mean length of the right and left lungs were (6.375 ± 0.24 cm) and (6.725 ± 0.17 cm) respectively, the mean width of the right and left lungs were (3.35 ± 0.4 cm) and (3.68 ± 0.3 cm) respectively, and the mean weight of the right and left lungs were (10 ± 0.97 gm) and (10.68 ± 0.76 gm) respectively. These results incongruity with (11) who clarified that the greatest length, width, of the lungs were (7cm), and (5cm) respectively in chicken, and the birds between (1600 and 2200 gm) body weight, the weight of the lungs of the male range from (9.8 – 19.5 gm), and with (5) who said the mean weight of the right and left lungs were (3.850 ± 0.115 g) and (4.050 ± 0.225 g) respectively in west african guinea fowl.The microscopical examinations of the lungs in the turkey in this study elucidated that secondary bronchi lined by ciliated, pseudostratified short columnar or cuboidal epithelium. These out comes well-matched with (24) in avian like chicken and turkey and there were abundance various size mucous glands occupied into majority of the epithelium thickness with sporadic little goblet cells. These results unaccordance with him who said the epithelium contain mucous cells rather than mucous glands in the same birds.The lamina propria and submucosa are dense irregular connective tissue and there were small layer of transverse smooth muscle bundles which encircled entire the secondary bronchi. These consequences fully confirmed with (11, 24) in avian like chicken and turkey.Lymphoid tissue appears under the epithelium in one to two ridges appeared as mounds. This result in agreement with (8, 11) in avian like chicken, turkey, rock dove, and ringer turtele dove, but disagree with (17) who said the oval lymphoid nodules underneath the epithelial layer especially at the junction of primary and secondary bronchi in chicken, these nodules and aggregations of lymphocytes were defense of respiratory system against invasion by bacteria and other organisms, which were enlarged of these nodules and increased thickness of submucosal layer (25).The building units of the lung were parabronchi. Which opened into the atria lead to infundibula, which lead to very air capillaries. These results agree with (15, 24, and 26) in avian.The epithelial layer of the parabronchi was simple squamous epithelium supported by loose connective tissue and thick smooth muscle bundles. Atria, infundibula, and air capillaries lined by similar that but the smooth muscles found on the atrial openings only these out comes fully confirmed with other birds (8,

22). But disagree with (18, 27) who showed that the epithelial layer of the parabronchi was cuboidal epithelium in avian.The mean thickness of the blood-gas barrier was (0.5 ± 0.08 µm) this result agree with (14) who said the blood–gas barrier was relatively thick was (0.56 µm) and (0.53 µm) in ostrich and penguin (*Spheniscus humboldti*) respectively, but disagreement with, (8) who explained thickness of the blood-gas barrier was (0.1 - 0.2 µm) in the fowl, (28) said the thickness of the blood-gas barrier was (1.20 µm) in domestic fowl, (14) noted thickness of the blood-gas barrier was (0.318 µm), (0.232 µm), (0.118 µm), (0.096 µm), and (0.153 µm) in domestic fowl, Emu (*Dromiceius novaehollandiae*), Goose, House sparrow (*Passer domesticus*), and Herring gull (*Larus argentatus*) respectively , with (29) who explained thickness of the blood-gas barrier was (0.322 ± 0. 01) and (0.252± 0.02) in the domestic fowl and the Red jungle fowl respectively.The thinness of blood-gas barrier essential for efficient flux of oxygen by passive diffusion, and strength was crucial for maintaining structural integrity (19).In the measurements appeared the blood-gas barrier moderately thick, (30) explain relatively thicker blood–gas barrier may prevent the lung from collapsing under high hydrostatic pressures under water occur in excellent diver the Humboldt penguin *(Spheniscus humboldti),* while contradictory with (29) who explained the blood-gas tissue barrier was thicker in the domestic fowl than in the Red jungle fowl, these features may made the modern domestic fowl susceptible to stress factors such as altitude, cold, heat or air pollution by predisposing to hypoxemia and perhaps thence to ascites.

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الخلاصة

دراسة تشريحية ونسجية للرئتين في الديك الرومي المربى محليا (*Meleagris gallopava*) (بعمر سنة واحدة) هو هدف هذه الدراسة. عشرة ديوك خالية من الأمراض ظاهريا/ استخدمت في هذه الدراسة بواقع خمس عينات للدراسة التشريحية وخمس عينات للدراسة النسجية. وسجل كل من الشكل والموقع والمكونات للرئتين. ظهرت الرئتين في هذه الدراسة بشكل (مثلث مُطَوَّل) تمتد من الضلع الأول إلى الضلع السادس، تحتوي على ثلاثة سطوح (ضلعي وفقاري وحاجزي) وحافتين أنسيه و وحشية وتحتوي الأخيرة على أربعة شقوق عميقة بسبب انطباع الأضلاع من الضلع الثاني إلى الضلع الخامس مؤدية إلى تقسيم الرئتين إلى خمسة فصوص .بلغ متوسط طول الرئة اليمنى واليسرى ± 0.24 (6.37 سم) و(6.72 ± 0.17 سم) على التوالي، بلغ متوسط عرض الرئة اليمنى واليسرى (3.53± 0.4 سم) و (3.68 ± 0.3 سم) على التوالي. بلغ متوسط سمك الرئة اليمنى واليسرى (0.96 ± 0.06 سم) و (1.025± 0.092 سم)على التوالي.أثبتت الدراسة النسيجية بان الرئة تحتوي على القصبات الثانوية و الفصيصات الرئوية التي تتكون من القصبات الثالثية والتي تفصل بواسطة (الحاجز بين الفصيصات) .القصبات الثالثية تتفرع إلى (الردهات والأقماع والشعيرات الهوائية)، جميع تلك المكونات تبطن بالظهارة الحرشفية البسيطة.تؤلف الألياف العضلية الملساء الجزء الأكبر من جدار القصبات الثالثية والتي تقع على حافات فتحات الردهات. الشعيرات الهوائية تتداخل بين العديد من الشعيرات الدموية مكونة الحاجز الهوائي الدموي الذي بلغ متوسط سمكه (0.5 ± 0.08 مايكروميتر).