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Histomorphological study of the trachea and lungs in male and female guinea pigs

(Cavia porcellus)

A Research

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Declaration

I certify that, this thesis entitled: **Histomorphological Study of trachea and lungs in male and female guinea pigs** (*Cavia Porcellus*) By (sajad Khalid and Mohammed jawad)has been prepared under my supervision at the College of Veterinary Medicine/ University of Qadysiha in partial fulfillment of the requirements for the Graduation research of Science in Veterinary Medicine

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Summary

This study was conducted to determine the anatomical features and histological structure of the trachea and lung in domesticated local adult male and female guinea pigs. The present study was carried out on 10 local guinea pigs for both sexes which divided in to three groups :

First group include 4 male and female used for anatomical study including the gross anatomy ,topography for trachea and lung, number of tracheal rings.

Second group included 4 male and female guinea pigs used for study of bronchial tree.

Third group in clouded 2 male and femal guinea pigs used for histological study using two types of stain, the hematoxyline and eosin and special stain periodic Acid Schift (PAS).

The anatomical study showed that the trachea was a flexible cartilaginous tube composed of a series of incomplete cartilaginous C-shaped rings connected with one other by annular ligament. The trachea extends from the level of the second servical vertebrae to the level of the fourth thoracic vertebrae where it bifurcated into right and left principal bronchi.

The lungs were paired organs (right and left) occupy much of the space in the thoracic cavity.

The lung appear as a pink color covered with pulmonary pleural membrane. The right lung consist of four lobes include the apical, middle, caudal and accessory lobes whereas the left lung consist of apical, middle and caudal lobes.

The anatomical study showed that the total length of trachea reach 41.164 ± 0.32 mm in male and 40.214 ± 0.37 mm in female. The diameter of trachea was 6.064 ± 0.084 mm in male $,5.932\pm0.036$ mm in female . The total number of tracheal rings were 35.8 ± 0.343 in male, 36 ± 0.672 in female . This study showed that total weight of lung was 3.45 ± 0.120 g in male and 3.29 ± 0.221 g in female.

The total size of lung was2.78±0.135mm in male and 2.6±0.116mm in female . The histological study of the trachea showed that it was consist of four tunica,tunica mucosa, tunica submucosa ,musculocartilaginous layer and tunicaadventitia

The tunica mucosa was lined by pseudostratified ciliated columnar epithelium with goblet cells which showed a positive reaction with PAS stain. The tunica mucosa separated from hyaline cartilage by thesubmucosa which contain avery few mucous glands which were tubuloacinar glands. The smooth trachialis muscle connect the ends of the C-shaped hyaline cartilages rings attached from the internal aspect of the cartilaginous rings. The primary bronchi showed similar histological structure to the trachea with smaller diameter.

The primary bronchi divided into primary ,secondary and tertiary intra pulmonary bronchi where the cartilaginous rings replaced by several hyaline cartilage plates which disappear in the bronchioles that ends at the terminal bronchiole which opened directly in the several alveolar ductless ,alveolar sacs and alveoli due to absence of the respiratory bronchiole.

Generally the alveoli appear as small,roughly,spherical structures opened into alveolar ducts and alveolar sacs.Histologically the alveoli lined by two types of cells ,the type I and type II penumocyte. The type I penumocyte was the predominate type cells, squamous cells and constitutes the most of the alveolar wall.Type II appear as large cell and less frequent cells.

The lung was covered by visceral pleura which composed of athin layer of connective tissue covered by a layer of mesothelium.

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Introduction

The labrotary guinea pig a species of rodents belong to : Kingdom : Animalia Phylum : Chordata Class : Mammlia Order : Rodentia Suborder :Hystricomorpha Family : Caviidae Genus : Cavia Species : Porcellus (Weir,1974).

The domestic guinea pig Cavia porcellus (also Known as the cavy or cuy), is a small ,stocky, tailless rodent commonly used in biomedical reseach. Guinea pigs are hystricomorph rodents related to the porcupine and chinchilla. They are not at all closely related to swine. Guinea pigs originated in the Andes of mountains South America, where they are still of importence as a meat animal , and have arole in religious ceremonies and local medicine (**Muller-Haye,1981**). Guinea pigs are large for rodents, weighing between 700-1200 g and its length 20-25 cm, live an average of four to five years. Female guinea pigs are refferred to as sows and the male called boars . Males reach sexual maturity at 3-5 weeks, female can be fertile as early as four weeks (**Aitken et al., 1993**).

They are still used in research ,primarily as models for human medical condition such as juvenile diabetes tuberculosis, scurvy ,and pregnancy complications .(**Aitken** *et al.*,**1995**).The biological characteristic of guinea pigs make these animals a valuable animal models for human medical conditions , for research in fields of biology medicine and immunology (**Noonan**,**1994**;**Chiou** *et al.*,**2000**;**Abidu-Figueiredo** *et al.*,**2008**).

The guinea pig is commonly used in biomedical research for purposes such as asource of red blood cells, polyclonal antibodies ,complement and tissue such as kidney.Guinea pigs have been used in amultitude of research role including biochemical,physiological and pharmacological tests.They are used as animal models for the study of disease conditions such as respiratory anaphylaxis, delayed - type hypersensitivity reactions, genital herpes and scurvy. For information on the uses of guinea pigs as animal models of human diseases (Noonan, 1994). Of the similarities, the sensitivity of the respiratory system and susceptibility to infectious diseases such as asthema and tuberculosis (Kashino *et al.*, 2008). With respect to the pathogensis and immune response to these diseases ,guinea pigs were more representative of human than models using a rodent species such as mice (Williams *et al.*, 2009). The respiratory system functions to provid appropriate levels of oxygen to the different tissues throughout the body by the circulatory system and in the same time remove the carbon dioxide from these same tissues (Sellnow, 2006; Sameulson, 2007).

Also the respiratory plays important role in olfaction, phonation, regulation of body temperature (Sellnow 2006; Baba and Choudhary, 2008). The lower respiratory tract include the trachea, bronchi, bronchioles and the lungs. The structures of respiratory tract are varied among species and within each species (Legaspi,2010). Trachea is a flexible tube composed of cartilaginous rings, connected by a fibromuscular membrane and lined internally by mucosa. It is composed of various of C-shaped tracheal cartilages in different species which are open dorsally and the space is bridged by tracheal muscle (Dabanoglu and Kara ,2001). It is positioned midline in the neck and courses slightly to the right in the upper thoracic cavity. It extends from the cricoids cartilage superiorly to the carina inferiorly (Getty, 1975; Mawby et al., 2006). The bronchial tree consist of an extrapulmonary bronchis (primary bronchi) and intrapulmonary bronchi ,bronchioles,terminal bronchioles and respiratory bronchioles,the alveolar ducts and sacs (Sameulson ,2007;Legaspi ,2010). The primary function of the lung in mammalian is to distribute the fresh air and blood to a vast surface area, thereby assist diffusion and exchange of respiratory gases .Blood and air are delivered to the alveolar capillary surface through intimately interwoven airway and vascular trees (Glenny and Robertson, 2011).

Aims of the study:

- 1- Determine the anatomical features of trachea and lungs.
- 2- Describe the bronchial tree by using Resin.
- 3- Describe the histological stracture of trachea and lungs by using the routine and special stains.

2.1. Anatomical Study

2.1.1 Trachea:

As a general the trachea is a flexible cartilaginous and membranous tube which is extends from the larynx down the neck through the cranial mediastinal cavity to the middle mediastinum .It bifurcates just dorsal to the base of the heart into the right and left principal bronchi. The trachea is divided into two parts ,cervical and thoracic parts ,according to the region of body that it transverse. The trachea is essentially median structure but near its bifurcation it is pushed over slightly to the right side of median plane by the aortic arch ,which is related to its left side just cranial to the left principal bronchus(**Getty,1975**).

The trachea is a tube like structure used as an air way to supply the lung with oxygen. It is linking the cricoid cartilage of larynx to the bronchi (Mawby *et al.*,2006). It is lies on the ventral aspect of the neck, below the esophagus. It is considered part of the lower respiratory tract which transport air from the external environment to the lung (Getty ,1975 ;Amis and Mckiernan,1986;Hudson and Hamilton, 1993;Dyce *et al.*,2010).

In cats the trachea is divided into two parts the cervical and thoracic parts according to position: Cervical trachea that extends from the cricoid cartilage to bifurcation within the thoracic cavity and consist of 38-43 rings of hyaline cartilage that form incomplete ring dorsally them .Trachealis muscle attached externally to the cartilage and complete each ring shape .Annular ligaments joint the adjacent tracheal cartilage (Aspinall *et al.*, 2009).

2.1.2 Lung: Gross Anatomy :

The lung is a pair of sponge like organs and are the site for gaseous exchange, and are situated within the thoracic cavity .They are enclosed by two layer of pleura inside pleural cavity (Getty,1975;Legaspi,2010). The left and right lungs lie within their pleural sac and are only attached by their roots, to the mediastinum ,so they are fairly free within the thoracic cavity. The right lung is always larger than the left, due to the positioning of the heart. In most species, the lungs are divided into lobes by bronchial tree. Left lung had cranial and caudal lobes and the right lung had four lobes: cranial ,caudal , middle and accessory lobes. The cranial lobe is further divided by an external fissure (**Dyce** *et al.*,**2010**).

As a general the color of the lung varies according to the amount of blood is contained .During life the lung has pink color. In the cat the lungs appear bright red in color which completely surrounding the heart (Hudson and Hamilton,1993; Mirhish and Nassar,2013).

Al-Anbaki, (2013) explained that both lungs of rabbits had three surface, the costal surface which was convex surface, the medial (mediastinal) narrow surface and the diaphragmatic surface which was large and corresponding to the There were differences ,between the animals species in the diaphragm. anatomy of the lung. In dog the lungs have an apex, costal, medial, diaphragmatic surface and three border dorsal, ventral and caudal borders. Each lung is divided by deep fissures into distinct several lobes. The right lung has four lobes; apical, middle, diaphrgmatic and intermediate (accessory). There are three fissures in the right and two in the left lung .The left lung had three lobes middle Nakakauki,1994 apical, and diaphragmatic (Ishaq,1980; ;Legaspi,2010).

2.1.3 Bronchial tree:

At the end of the trachea the first division of the airway occur, resulting in the right and left extrapulmonary primary bronchi. This bifurcation subsequent arborizes and gives rise to the bronchial tree that form the basis of the right and left lungs within the thoracic cavity .Each bronchial tree consists of an extrapulmonary primary bronchus and the sequential intrapulmonary orders of airway that are connected, including intrapulmonary bronchi ,bronchioles .The number and distribution of the bronchial tree varies among the species of animals and also differs between the right and left lungs. The intrapulmonary division eventually give rise to the area of gaseous exchange, the alveolar ducts and sacs and alveoli, which collectively constitute the parenchyma. The bronchial trees, in turn, are enveloped by a layer of connective tissue and epithelium collectively known as the visceral pleura (Nickel *et al.*,1979;Sameulson,2007).

2.1.5 The Cast of the lung

Description of tracheobronchial tree of lungs with its actual orientation is relatively difficult task for students to understand. This could be made easy, if an actual and durable cast of interior of tracheobronchial tree is made available. In tropical countries, the cadavers are usually embalmed for gross anatomy teaching. It has been observed that embalming has many fallacies with regard to the irritant and carcinogenic effects of its preservative fluides and its temporary existence in preservation. In this context ,plastination can be a better substitue because the preseved anatomical structure is dry,odourless,easy to handle and most everlasting and also a helpful tool for teaching students. This economical method can also be helpful for making cast of other hollow viscera (**Parashurarn** *et al.*, **2010**). Using moulds from the respiratory airway essential to give clear perception of the inside of the lung. Several ways to prepare such models were cast performed using plastic, resin, paraffin, silicon rubber and rubber(**Phalen** *et al.*, **1973; Nettum, 1995**).

The resin cast of bronchial tree of dog show that principal bronchi is divided in the lung to four lobar branch for apical ,middle,caudal and accessory lobes of right lung,while the left principal bronchi divided into apical and caudal bronchi for apical and caudal lobe (**Nakauki,1994**).

Histological Study:

2.2.1 Trachea:

Generally the trachea in most domestic animals is a cartilaginous tube, its wall is composed of four layers: mucosa, submucosa, muscularis and adventitia with incomplete cartilaginous rings (Mariassy and Plopper, 1983; Samuelson, 2007; Habib and Mahammed, 2010).

The mucosa is not folded but in dorsal membranous portion, the mucosa has longitudinal folds and lined by pseudostratified ciliated columnar epithelium composed of ciliated ,goblet and basal cells. The basal and ciliated columnar cells easily constitute the majority of the total cell population (**Jeffery and Reid**

,1975 ;;Kuchae and Junqueira,2000; Samuelson, 2007 ; Yang et al.,2010).

The ciliated columnar epithelial cells was clearly the predominant cell type in the trachea as well as in the bronchi down to the level of terminal bronchiole ,these cells have oval nucleus and situated slightly basally (**Romrell** *et al.*,1989).

The goblet cells lining the trachea were widely dispersed and usually surrounded by ciliated cells .The surface of the goblet cells was covered by microvillus projections. The nucleus of the goblet cells is often crescent shaped and basally located (Jeffery and Reid ,1975; ;Kuchae and Junqueira,2000; Yang *et al.*,2010).

2.2.2 Bronchi:

The bronchi arise from the trachea after bifurcation in to right and left extrapulmanary primary bronchi. Each primary bronchus divided to give rise to the intrapulmonary bronchi after entering the lung at hilum, which can be considered secondary and tertiary bronchi. The intrapulmonary bronchus also can be referred as the lobar bronchus which provide the segmental bronchi (**Dellman and Brown ,1993;Samuelson ,2007).**

The histological structure of primary bronchi is similar to the trachea (Cartener and Hiatt,2000;Hamid *et al.*,2005).

The mucosa is lined by pseudostratified ciliated columnar epithelium that can be further grouped into ciliated goblet cells (secretory cells) and basal cells. Ciliated cells and goblet cells attached to the basal lamina. The underlying cells lie in contact with basement membrane (**Breeze and Wheedom,1977;Jaffery ,1983**).

The lamina properia is generally composed of loose connective tissue that surround simple mucous and mixed tracheal glands and well defined elastic lamina (Cartener and Hiatt,2000; Samuleson, 2007).

2.2.3 Lung:

Histologically the lung could be divided in to the parenchyma ,which mainly consist of the alveoli ,blood capillaries and the tissue of inter alveolar septum, and the non parenchyma which comprised the large air conducting passage like the bronchi and bronchioles ,the large blood vessels and connective tissue elements such as lobar septa and the pleura .The interalveolar septa separated adjacent alveoli and were frequently perforated by interaleveolar pores (Maina,1987).

2.2.4 Bronchioles:

The last branching of the intrapulmonary bronchi results in the formation of the several orders of bronchioles designated as primary, secondary, tertiary or terminal and respiratory bronchioles (Horsifield *et al.*, 1982; Samuelson, 2007). This terms based on the decreased in luminal diameter ,less folded mucous membrane, differing characteristics of lining epithelium

The mucus membrane of primary and secondary bronchioles is thrown into longitudinal folds which decrease in height toward the end of secondary bronchioles. Usually no folds are found beyond the secondary bronchioles. Characteristically, all bronchioles lack cartilage. The mucosa is lined by simple columnar epithelium in primary and secondary bronchioles (**Dellmann and Brown,1993**).

The bronchiolar epithelium of hamster consist of low columnar cells as well as nonciliated cells (clara cells) which are increase progressive in number as the size of airway decrease (**Becci** *et al.*, **1978;Kennedy** *et al.*, **1978**).

2.2.5 Terminal Bronchiole :

In mammals the Terminal bronchiole is considered to be the transition site between the conducting part and respiratory part (**Dellmann and Brown,1993**).

In most laboratory rodent the terminal bronchiole opens into a completely alveolar ducts(Schwartze *et al.*,1976;Tyler and plopper,1985). In mice ,rat, hamster, rabbit, gerbil and guinea pig the terminal bronchiol,bronchioles open directly into several alveolar duct or its very short respiratory bronchioles (Bal and Ghoshal, 1988).

Green(1966) mentioned that in the mouse the terminal bronchiole give rise to the respiratory bronchioles, each in turn branching into several alveolar ducts. The alveolar ducts lead into alveolar sacs, each comprising several alveoli ,while **Banks(1981)** reported the absence of respiratory bronchioles in mouse such that the terminal bronchioles open directly into several alveolar ductules.

2.2.6 Respiratory Bronchiole:

The respiratory bronchioles are short branching tubes divided into several alveolar ductless ,the wall of which are honey combed with wide opening of alveoli (**Banks 1981;Cludio** *et al.*,2004 ;**Samuelson**,2007). The histological structure of the wall of respiratory bronchioles is identical with that of terminal bronchioles except that their walls are occasionally interrupted by lateral openings leading to few alveolar saccules. The respiratory bronchioles are lined by the cuboidal cells with occasional cilia are present only in larger respiratory bronchioles which become non ciliated and finally squamous in smaller bronchioles (**Vonhayck**, **1960;Bacha and Bacha**, 2000;**Samuelson**,2007).

2.2.7 Alveolar Duct:

The alveolar ducts extend from respiratory bronchioles and numerous alveoli are open in it .The alveolar ducts lined by simple squamous or simple cuboidal epithelium .The subepithelial tissue is predominantly elastic connective tissue fibers are sparse and smooth muscle cells are particularly prominent around the openings in to the alveoli and the alveolar sacs (**Dellmann and Brown ,1993;Bacha and bacha,2000;Eurell,2004**).

The alveolar sacs are large sac like structures into which the surrounding alveoli open (Plopper and Adams,1993; Baba and Choudhary, 2008).

The pulmonary alveoli are roughly spherical structures through its walls the gases exchange between air and blood takeplace (**Dellmann and Brown,1993**).

3.1 The Experimental Design :

Ten healthy appearance male and female adult guinea pigs (*Cavia porcellus*) were used for anatomical and histological study of trachea and lung, collected from the Al - Kindy company of Baghdad. The 28 adult guinea pigs were divided in to three groups :

- First group include 4(2 male and 2 female) used for anatomical study.
- Second group include 4(2 male and 2 female) used for preparation cast to study of bronchial tree branching .
- Third group include 2(male and female) used for histological study.

3.2 Anatomical study:

The animal was sacrified in away that euthenasia and then cutting the common carotid arteries then open the skin on the venteral surface of the neck of taking into account the non-injured the trachea after sacrificing of the animal .The skin of thracic region of the guinea pigs was removed then the thoracic region was opened by midline thoracotomy to expose the trachea , lungs and thoracic content ,the anatomical observation recorded as following:

- Topographical relationship of trachea and lungs in situation was recorded. After removing of trachea and the lungs from thoracic cavity, the following observations and anatomical measurments were recorded:
- Gross anatomy of trachea and lung which include shap, color and lung lobation.
- Length of trachea from the cranial border of first tracheal ring to the bifurcation by using the measurement tap.
- Diameter of trachea dorsoventerally and laterolaterally were measured by using the electronic digital vernier calper.
- Counting of tracheal rings.

- Weight of the lung using electronic sensitive balance (Sartorius 1212 mp) made in Germany
- Weight of body using sensetive balance (Mettler PC 2000 of 0.01gram sensivity.
- Size of lung ,using the volume of water displacement method in agraduated cylinder .

The second group

which included 4 (2male and 2female) adult guinea pig were used to study trachea and bronchial tree branching and making corrosive resin cast. After euthanasia of 4 adult guinea pigs of both sexes ,these animals were sacrified by the same method of the anatomical study the larynx ,trachea and lungs were taken out carfully from carcasses with parts of the attached adjacent organ to avoid tissue injury which may lead to resin discharged during injection . The chosen resin which was used in this study(Pyrax rapid repair) must show no change in its volume during its setting (solidifcation) and has a suitable viiscosity at room temperature similar to that of blood .And should be sufficient rigid to support its own study dealing after maceration (Tompestt,1970).

We chosen (pyrax rapid repair),liquid and powder product by pyrax polmars,Roorkee 247667 india.

3.3 Cast Technique :

Suitable plastic cannula (4mm) in diameter was inserted through larynx and fixed by surgical suturing silk to prevent discharge resin during injection .The resin was prepared to set after 10 minutes.The injection was done by hands pressure using plastic syringe of 20ml,the injection start 5 minutes before the time of setting which was determined previously.The first specimen was injected by 1ml of resin, then second specimen injected by 1.25ml and third specimen injected by 1.50ml and the fourth specimen by 1.75ml and finally the fifth specimen injected by 2 ml resin.After the resin injection completed ,the cannula closed by pinching it by artery forcipes.

The injected specimen was left moist over night at room temperature (25-30 c°) to complete setting and hardening of resin.After complete solidification each specimen was transported to the next step which was maceration.

The maceration take place following ,each specimen was putting separated plastic jar of suitable size contaninig 500 ml of 40% KOH for 4-5 days after completing maceration occurs the cast was thoroughly washed by tap water for at least one houre,then the cast dried by hot air to become ready for examination either by nicked eye or by dissecting microscope.

3.4 The histological study:

For histological study 2 adult guinea pig were used after euthenasia and the common carotid artery was opened until death of the animals ,then removal of the trachea and lung from the thoracic cavity immediately .The sample was taken as soon as possible from all lobes of both lungs (crainal , middle ,caudal and accessory) lobes,from trachea(cranial,middle and caudal parts) and from the left and right primary bronchus.These samples were fixed in 10% formalin and the solution must be 1:10 of the size of specimen and left for 48 hours(Luna,1968).

After fixation, the tissue was trimmed and the specimens were washed by tap water for 4-6 hours to remove the formalin solution then the steps processing began as follows :

1) **Dehydration:**

This process was done to remove the extractable water by passing the samples through series of ethyl alcohol (70% -80%-90%-100%) twice in each run .These specimens were allowed to stand in each grade for two hours , in order to remove all the extractable water from it.

2) Clearing:

Clearing was achived by passing the specimens through xylene in two steps for 30 minutes to 1 houre for each step

3) Infiltration and Embedding (Blocking)

The specimens were transported to melted paraffine in two steps.Each step rest for four hours in electron oven at 58°c.After that the specimens were put in blocks of pure paraffin.(Edward ,1962).

4) Sectioning:

The sectioning was made by using the rotary microtome thickness of sections (5-6 μ m).The histological sections were transferred to water bath (52 °c) to plain the tissue.

5) Mountig:

The sections were carried out from bath and fixed on aslide contained mayers albumin (Mixture of egg albumin with glycerin)and the ratio of which was 1:1 .A little thymol was added to it to prevent decay (growth of fungi and bacteria) The slides were dried by an oven with 40°c for 24 hours (luna , 1968).

5) Staining:

Two types of stains were used in this study"

-Harris Haematoxyline and Eosin stain :

it is aroutin stain in histological study used for appearance of general structure of tissue .

- Periodic Acid schiff (PAS) :

It is aspecial stain used for carbohydrate, muco-proteint, glycorprotein and basement membrane (Luna,1968).

4.1 Anatomical results

Topographic and gross anatomy of trachea and lung

4.1.1Trachea

The present result revelead that the trachea in male and female guinea pigs appear as apliable hollow cylinderical tube composed of aseries incompelet Cshaped cartilaginous rings which connected with each other by anular ligament and tracheal muscle attached to the ring edges from their enternal surface (Fig1).

The position of the trachea was midline in the ventral surface of neck (Fig 1), and its extend caudally from cricoid cartilage of larynx superiorly at the level of the second cervical vertebra to the carina inferiorly at the level of the fourth thoracic vertebra (Fig 1, 2). This finding agree with (Ishaq,1980; Amis and Mackiernan,1986) in dog (Aspinall *et al.*,2005; Caccamo *et al.*,2007) in cat and in ruminant by (lee-wilk *et al.*, 2009) and in rabbit by (Al-Anbaki,2013).

At the fourth thoracic vertebral level, at the base of the heart it bifurcates into right and left principale bronchi (Fig 2,3) ,this result agree with results (Aspinall *et al.*, 2005;Caccamo *et al.*,2007;Nassar,2012) in cats .

The present study revealed that the mean total tracheal length was 41.164 ± 0.32 mm in male and 40.214 ± 0.37 mm in female .There was no a significant differences between male and female at p ≥ 0.05 , and the mean number rings of trachea in male was 35.8 ± 0.343 rings and 36 ± 0.672 rings in female .There was no significant difference between male and female at p ≥ 0.05 .

The tracheal rings of guinea pigs were semi-circular or oval shape in the cross section (Fig 3). This results is differs from that in dog which is elliptical in shape (Jackson and Krevan ,1984) but similar to that found in cats by (Nassar ,2012) which appear as semi-circular similar to that found in rabbit appears as oval shaped by (Al-anbaki,2013).

Topographically the trachea can be divided into two regions or parts according to its location ,the cervical and thoracic regions(Fig 2).

The length of cervical region of trachea was 28.742 ± 0.320 mm in male and 29.246 ± 0.721 mm in female , There is no significant difference between male and female at P \ge 0.05. The number rings in the cervical region of trachea was 23 ± 0.36 rings in male and 25 ± 0.29 rings in female. There was no significant difference between male and female at P \ge 0.05. The length of thoracic region of trachea was 10.242 ± 0.718 mm in male and 10.826 ± 0.589 mm in female . There is no significant diffrenece between male and female at P \ge 0.05.

The number rings in the thoracic region of the trachea was 12.8 ± 0.349 ring in male and 11 ± 0.192 ring in female. There is no significant diffrenece between male and female at P \ge 0.05.The length of the trachea and the number of plates in the trachea vary both within aspecies and from one species to another .In the horse and in the ruminant there are 48-60 palates; in the dog , 42 to 46 plates; in the cat , 38 to 43 plates and in the pig,32 to 36 plates (Getty,1975).

The mean diameter of trachea was 6.064 ± 0.084 mm in male and 5.932 ± 0.036 mm in female .There is no significant diffrence at P \ge 0.05 between male and female.

The diameter of right principale bronchus was 4.073 ± 0.075 mm in male and 3.984 ± 0.067 mm in female (table1). The diameter of left right principale bronchus was 3.856 ± 0.046 mm in male and 4.011 ± 0.033 mm in female . There were no significant difference between male and female at P \ge 0.05.

4.1.2 Lung

4.1.2.1 Anatomical description

The present study showed that lungs of male and female guinea pigs appear as paired, pink color, spongy organs surrounding the heart and occupy most of the thoracic cavity and its shape is conforming with the shape of the thoracic cavity (Fig 3), as observed in the domestic animals (Nickel et al., 1979; Pasquini et al., 1997; Nassar, 2012).

Each lung has a cranial apex, caudal base, and have dorsal, ventral and caudal borders. The dorsal border is rounded and thick , the ventral border is flatten and the caudal (basal) border is sharp (Fig 5,6). The apex of right lung is large bland rounded and the left lung is small and pointed (Fig 5,6). As observed in rabbit by (Al-Anbaki,2013) and disagree with that reported by (Nickel *et al.,1979*) that the right lung has pointed apex.

Also the lungs of guinea pigs have three surface, the costal which was convex (Fig 6) ,medial was narrow surface and the diaphragmatic surface was large surface (Fig 7) .This findings agree with the previous study by (Getty,1975) in domesticated animals (Thrall,2002) in ruminants and (Nassar,2012) in cats.

The lung of guinea pig is divided by deep interlober fissures into distincted lobes. The right lung has four lobes these are apical, middle (intermediate), caudal (diaphragmatic) and accessory lobes (Fig 5,8). Similar observation in cat by (Nassar,2012) who observed that the right lung of cat has four lobes separated by deep fissures into apical ,middle, caudal and accessory lobes. But the present result found in guinea pigs was differs from than observed in goat by (Habib and Mahammed ,2010) and from that observed in camel by (Al-Abasi and Mirhish,2001) they observed that the right lung in goat and camel had three lobes. The left lung of guinea pig was smaller than the right lung due to the position of the heart that form the cardiac notch. This result is in compatible with (Hudson and Hamiton ,1993) in cat and (legaspi ,2010) in dog .The left lung of guinea pigs had three lobes include apical , middle and caudal lobes (Fig 7).This result was disagree with that found in cat ,that the left lung is divided into two distinct lobes including left apical lobe which subdivided into two parts the apical lobe (the cranial apical and caudal apical) and the caudal

lobe (diaphragmatic lobe) (Oliveira *et al.*,2001; Nassar,2012), and differs from dog by (Amis and Mckiernan,1986), They reported that the left lung of dog has two lobes an apical (cranial) and diaphragmatic (caudal) lobes. Also the present result differs from that observed in left lung of camel which consist of two lobes (apical and diaphragmatic lobes) by (Al-Abasi and Mirhish , 2001) and differs from that in hamster which have only one lobe (Kennedy *et al.*,1978) in elephant by (West , 2000) who reported that left and right lung had one lobe only.

4.1.2.2 Weights and dimensions the lung

This study revealed that the total body weight of male guinea pig was 415 \pm 22.19g while in female was 389.8 \pm 33.739 g (Table2) there is no significant difference between male and female at p \geq 0.05.

As showed in .The mean total weight of lungs reach in male 3.45 ± 0.120 g and in female 3.29 ± 0.221 g, the mean weight of the right lung was 1.860 ± 0.033 g in male and 1.846 ± 0.085 g in female while the mean weight of the left lung in male was 1.584 ± 0.046 g and in female was 1.578 ± 0.060 g there are no signifecant differences between male and female at P ≥ 0.05 in all parameters.

The mean weights of each lobe of the right lung were $0.16\pm0.002g$, $0.594\pm0.009g$, $0.936\pm0.094g$, and 0.202 ± 0.170 g,for apical, middle, caudal and accessory lobes in male respectively while in female were 18 ± 0.0004 g , $0.578\pm0.020g$, $0.892\pm0.078g$, and $0.196\pm0.0015g$, for apical, middle, caudal and accessory lobes respectively. there were no significant difference between male and female at P \ge 0.05.

The mean weight lobes composed of the left lung in male were 0.648 ± 0.078 g, 0.404 ± 0.072 g , and 0.786 ± 0.019 g and 0.664 ± 0.001 g, 0.402 ± 0.053 g $\,$ and

 0.800 ± 0.012 g in female for apical, middle and caudal lobes respactively .there were no significant difference between male and female at P \ge 0.05.

4.1.2.3 Volume of lungs:

The mean total volume of right lung was 2.78 ± 0.135 ml in male and 2.6 ± 0.116 ml in female .There were no significant difference between male and female at P ≥ 0.05

The mean volume of each lobes of right lung was $0.14\pm0.0007~\text{ml}$, $0.802\pm0.0006~\text{ml}$, $1.501\pm0.007~\text{ml}$ and $0.19\pm0.008~\text{ml}$ for apical middle, caudal and accessory lobes in male and $0.134\pm0.0006~\text{ml}$, $0.808\pm0.004~\text{ml}$, $1.498\pm0.039~\text{ml}$ and $0.208\pm0.0001~\text{ml}$ for apical,middle,caudal and accessory lobes respectively. There were no significant difference between male and female at $P{\geq}0.05$.

The mean total volume of the left lung was 2.83 ± 0.039 ml, in male and 2.72 ± 0.089 ml in female . there is no significant differences as between male and female at P ≥ 0.05 .

The mean volume of each lobes of the left lung was 0.69 ± 0.0008 ml ,0.042±0.015 ml and 1.401 ± 0.016 ml for apical, middle and caudal lobes respectively in male . and 0.73 ± 0.0006 ml ,0.394± 0.033 ml and 1.396 ± 0.012 ml for apical, middle and caudal lobes respectively in female . There were no significant differences between male and female at P≥ 0.05.

4.2 Histological Results

4.2.1 Trachea

The present study revealed that the histological structure of trachea in male and female guinea pigs is similar and its appeared as a hallow rigid tubular organ composed of four layer mucosa, submucosa, muscularis (musculo cartilage) and adventitia (**Amiri and Gabella**, **1988**).

4.2.1.1Tunica Mucosa

The mucosa is lined by pseudostratified ciliated columnar epithelium ,consist of three cell types , the ciliated columnar cells ,goblet cells and basal cells all these cells are rest on the basement membrane but not all of them reach the luminal surface and their nuclei disposed at different levels (Fig 11) .The histological structure of tracheal epithelium in guinea pigs similar to that observed in most mammalian species and human

(Liu *et al.*,2007;Ibe *et al.*,2011), in the sheep (Mariassy *et al.*,1991), in the goat by (Kahwa and Purton,1996; Caceci ,2008;Habib and Mohammed,2010) and also resemble to that found in caiman by (Santos *et al.*,2011), (Shraideh and Najjar,2011) in Albino rat.

The ciliated columnar cells are one the most abundant cell types appear as a tall columnar cells, possesses cilia covering their apical surface and extending into the trachea lumen (Fig.11), their cytoplasm are slightly stained and large oval nuclei located near the epithelial surface (Fig.11,12). Similar observation in Yak by (**Yang** *et al.*,**2010**). The goblet cells showed appositive reaction for PAS and appear a magenta color due to its amucopolysaccharide, similar result reported by (**Nassar**,**2012**). The mucous produce by goblet cell act as a protective for the epithelium by lubricating ,insulating and providing an appropriate condition for mucociliary clearance (**Buchner and Maxwell**,**1993**).

The goblet cells are numerous cells with goblet shaped and basally located nuclei, containing mucus secretion (Fig .13).

The basal cells appeared as small ,triangular shape rest on the basement membrane but do not reach the luminal surface (Fig.12,14) similar observation by(Jeffery and Reid ,1975) in rat,(Terzaghi *et al.*,1978) in hamster, in agora goat by (Habib and Mohammed,2010).The tracheal epithelia recorded in the present study were similar to that found in rodents as reported by (Kennedy *et al.*,1978;Reznik ,1990). The lamina propria lie beneth the epithelium ,not well

developed and consist of a thin layer of loose connective tissue with elastic and collagenous fibers (Fig 12,14) The muscularis mucosa, very thin layer consist of few smooth muscle fibers (Fig.15). This result agreement with the result of (Nassar,2012) in cat and in rabbit by (Al-Anbaki,2013).

4.2.1.2Tunica Submucosa

The tunica submucosa appear as a loose connective tissue contain different connective tissue cell types ,lymphocyte , monocyte , macrophage and plasma cells blood vessel and the the submucosal glands which are very few ,small and appear as tubule - acinar mucus type glands that gave appositive reaction for APS (Fig.15,16,17) .The glands opened in to slit shaped in the lumen of trachea(Fig.18). As reported by (**Hughes,1965**)in rabbit. The guinea pig shows considerable individual variation in the density of glands similar observation by (**Widdicombe** *et al.*,2001).The submucosa also contains (Fig15,16).

This result is similar to that observed by (Okamura *et al.*, 1996; Widdicombe *et al.*, 2001) in guinea pigs and hamster (Ibe *et al.*, 2011) but disagree with others whose reported that the tracheal submucosal glands in mice by (**Pack** *et al.*, **1981**); in guinea pig were absent (**Jeffery**, **1983**; **Yeadon** *et al.*, **1995**), some mammals by (**Choiu** *et al.*, **2000**) and (**Widdicombe** *et al.*, **2001**) in rabbit , mice and hamster in which the trachea is glands free.

This study observed avery rare or low in density of the submucosal glands while in other species of animal there were substantial number of submucosal glands such as in sheep by (Mariassay and plopper ,1984) ,in ferret by (Robinson *et al.*,1986),in camel by (Raji and Naserpour,2007) and in yak by (Yang *et al.*,2010).

The present study showed that the tracheal glands were few and mucous secreting type .These glands lined by simple cuboidal or low columnar cells with large round basally located nuclei and wide lumen (Fig16).The submucosal glands showed a positive reactive for PAS (Fig 17).The result is differ from that

reported by (Yang *et al.*,2010) in yak and (Nassar,2012)in cat that the submucosal glands are mostly serous and few are mucous, but agree with (Widdicombe and Pecson,2002)in equine that the submucosal glands are mucous secreting.

The mucus produced by the glands are involved in trapping inhaled foreign bodies which are subsequently expelled by mucociliary escalator (Wanner,1986;Thornton and Shechan,2004).

The mucus secreted comes from two main source: goblet cells in the surface epithelium and submucosal glands (Widdicomb *et al.*,2001).

The goblet cells produce a mucus secretion which is added to the secration of submucosal glands and protect the epithelium by lubricating ,humidity ,waterproofing insulating and providing an appropriate condition for normal mucociliary clearance (**Buchner-Maxwell,1993**).

4.2.1.3 Muscularis (Musculo cartilage) Layer :

The submucosal layer merges with perichondrium of underlying hyaline cartilage ring and with the dense fibroelastic tissue between the cartigenous rings (Fig. 15,19).Hyaline cartilage contain the chondrocytes inside the lacuna within an amorphous matrix (Fig.19). As observed in small ruminant by (**Habib and Mahammed,2010**).

The cartilaginous plate are C-shape with the opening dorsally ,the dorsal opening of each cartilaginous ring is fill by connective tissue and trachealis muscle which is the smooth muscle that attached on the internal side of cartilaginous ring(Fig.20).This result is similar to most species except the dog ,cat and rat that the trachealis muscle is attached to the outside of the plats(Getty,1975), (Nassar,2012) in cats , (Ibe *et al.*,2011) in rat ,(Al-Anbaki,2013) in rabbit and (Danmaigero *et al.*,2013) in bat.

4..2.1.4 Tunica adventitia

Tunica adventitia appear as a loose connective tissue covered the cartilage (Fig.21) as observed in the rabbit (Al-Anbaki,2013).

4.2.3 Bronchi

4.3.1Extra pulmonary bronchi (Principale bronchi)

The bronchi arise from the tracheal bifurcation at the carina into right and left principale bronchus .The histological structure of principale bronchi is the same histological structure of trachea. It is consist of:

Mucosa that lined by pseudostratified ciliated columnar epithelum which formed by columnar ciliated cells ,goblet cells and basal cells (Fig.22) .As observed in goat by (Kahwa and Purtong ,1996;Sarri,1997) in Reindeer .

The submucosa composed of loose connective tissue has tubuloacinar mucus glands (Fig 23). The fibrocartilaginous layer contain hyaline cartilage (Fig 22).

The adventitia is the outer most layer composed of loose connective tissue. This results are similar to that reported by(Al-Anbaki,2013)in rabbit and (**Robinson** *et al.*, **1986**) in ferret.

4.3.3 Intra pulmonary bronchi

4.3.3.1 Secondary bronchi

The primary bronchi give rise to the intra pulmonary bronchi after it's dividing forming the secondary bronchi that again divide forming the tertiary bronchi .The histological structure of the secondary bronchi composed of :

Mucosa which is folded and lined by pseudostratified columnar ciliated epithelium with goblet cells that give a positive reaction for PAS (Fig 24,25).

Thin lamina propria with a prominent layer of smooth muscle which separated the lamina propria from submucosa .The submucosa very few mucus and difficult to distinguish (Fig.25).

The cartilaginous rings in the trachea and primary bronchi replaced by many large separated cartilaginous plates of hyaline cartilage (Fig 24,25).

The adventitia contain blood vessels and surrounded directly by lung tissue (Fig 24,25) .This results are compatible with that observed in domestic animals by (Sameulson,2007;Caceci,2008).

4.2.4 Tertiary bronchi

The secondary bronchi divided again forming the tertiary bronchi that characterized histologically by:

The mucosa is folded and consist of simple columnar ciliated epithelium with goblet cells that give a positive reaction for PAS (Fig.26,27), In the smaller bronchi the epithelium become low simple ciliated columnar epithelium (Fig 28). Similar result is found in the hamster by (Kennedy *et al.*, 1978), and (Nassar, 2012) in cats.

The lamina properia is thin connective tissue with many elastic fibers, prominent smooth muscle layer surrounding the lamina properia (Fig 28,29).

The hyaline cartilage plates are smaller and irregular in its placement (Fig 29), the connective tissue of the submucosa merges with that of adventitia (Fig 29). The present finding agree with the observation of (**Mariassy and plopper**, **1983**) in sheep and with that found in domestic animals (**Dellman and Browen**, **1993**).

4.2.5. Bronchioles

The most characteristic feature of bronchiole in the guinea pigs as in other domesticated animals include the changes in lining epithelium that become low simple ciliated columnar epithelium with few goblet cells and also present of non ciliated cells or clara cells that have dome shape , light staining cytoplasm and centrally located nucleus(Fig 30,31), and the lacking of supporting hyaline cartilage plates and the glands in the wall of the bronchiol (Fig 30,31). This results was compatible with that observed (**Becci** *et al.*, **1978; Dellmann and Brown,1993; Sameulson**, **2007**) The lamina properia is thin loose connective tissue surrounded by alayer of smooth muscle fibers (Fig 30,31). The submucosa is lacking to the glands, no cartilaginous plates observed and adventitia is merges with the parenchyma of the lungs (fig.30,31).

This results were similar to that noted by (Kennedy *et al.*,1978) in hamster ,(Al-abasi and Mirhish ,2001) in camel, (Caceci,2008) in domestic animals and (Habib and Muhammed ,2010) in goat. They reported that the bronchioles are lined by simple ciliated columnar epithelium interspersed with non ciliated (clara cell). The goblet cells are found only in the large bronchioles.The lamina properia surrounded by smooth muscle .The wall of bronchioles not supported by cartilage and lack of glands.

4.2.6 Terminal bronchioles

The terminal bronchioles represent the last parts of the air conducting system in guinea pigs. The mucosa is folded prominently and lined by simple ciliated columnar to simple cuboidal epithelium, no goblet cells are present (Fig 32) similar observation in pig by (**Kalita**, **2014**).

Thin smooth muscle layer surrounded the thin lamina properia was lacking (Fig 32,33). Similar observation were recorded in domestic mammals by (**Banks**,1993;Kahwa and Purton,1996;Adam's and Dellmann,1998;Bacha and Bacha,2000;Aughey and Frye,2001). In pig by (Kalita,2014) and in the laboratory animals by (Jeffery and Reid,1975;Bal and Goshal,1998). The terminal bronchioles leading almost immediately in to alveolar ducts that lead to alveolar sacs .and did not recognize the existence of typical respiratory with characteristic interruption on walls projecting into alveoli(Fig 22,23), this finding is in agreement with (Schreider and Hutchens,1980;Banks,1981;

Sarikas *et al.*,1985 ; Tyler and Poppler,1985;Ibe *et al.*,2011;Al-Anbaki,2013), as all terminal bronchioles ended in alveolar ductules ,in most laboratory rodents mice ,rat, rabbit , gerbil ,hamster ,the terminal bronchiole opens in to a completely alveolarized airway(alveolar ducts),that leads into alveolar sacs ,each comprising several alveoli. These researches designated the points of transited from cuboidal bronchiolar to attenuated alveolar epithelium as bronchio alveolar junction .

4.2.7 Alveolar Ducts

The alveolar ducts are long , straight tubular structure lined by simple squamous epithelium and display numerous out pocketing of alveoli (Fig 32,33) . Alveolar ducts end in alveolar sacs ,which composed of groups of alveoli clustered around a common air space (Fig32,33). As observed in most domestic animals (Samuelson,2007) , in goat by (Baba and Choudhary ,2008), and in laboratory animals rabbit ,hamster ,gerbil by ((Bal and Ghoshal ,1988) ,(Al-Anbaki ,2013) in rabbit .

The parenchyma of guinea pig lung ,like that mammalian lung ,was essentially made up of the alveoli, blood capillaries and the tissue of the interalveolar septum . The alveolus is the basic structural and functional unit for gas exchange in the lung parenchyma .The alveoli appear as spherical or irregular small air space partially surrounded by highly attenuated epithelium(Fig 32,33,34,35) .It is lined by two types of cells ,type I pneumocyte that appear as squamous cell with perinular area and centrally located nucleus (Fig 34,35) .The second type of cell is type II pneumocyte ,they appear as rounded or cuboidal cells interspersed among the type I pneumocyte (fig.35) .Similar observation found in by (Terzaghi *et al.*, 1978) in rats , (Maina ,1987) in monkey ,(Bouljihad and leipold,1994) in sheep (Tartaglia and Waugh ,2002) (Dahlin *et al.*,2004),(Baba and choudhary ,2008; Carvalho and Goncalres,2011). In

goat . Type I pneumocyte formed the main lining epithelium of alveoli .These cells were stated to be mainly responsible for maintaining an interface between the air and blood to allow the gas exchange (**Banks**, **1993**).

Type II pneumoncyte were found among the type I cells in the alveolar epithelium ,these cells were secretary in nature ,possessing well developed cell organelles. When the secretion is librated onto the epithelial surface ,it lowers the surface tension there by preventing the alveoli from collapsing during expiration (Craigmyle ,1986 ;Plopper and Adams ,1993;Banks,1993). (Kahow and purton 1996) reported that the alveolar epithelium of goat was of simple squamous type only ,wheres (Kahow *et al.*, 1997) demonstrated both typeI and type II cells in same species and(Rybicka *et al.*, 1974) ,(Burri,1985) in rats (Iovannitti *et al.*, 1986) identified both these cell types in cattal and babbon in lung respectively

The alveolar wall or interalveolar septa was composed of a thin single layer of epithelium, very thin layer of connective tissue composed of fin elastic , collagen reticular fibers and blood capillaries underlying the epithelium (Fig 34) .This finding generally resembled with the reports in domestic animals by (**Plopper and Adams,1993**) and in the goat by (**Baba and Choudhary ,2008;Caceci,2008).** They reported that the common septa between that adjacent alveoli formed that interalveolar septa .The septa were covered on both sides by alveolar epithelium and were interenally supported by fine elastic, reticular and collagen fibers.These delicate interalveolar walls provided with very extensive capillary network.The connective tissuue fibers were continous with surrounding interstitial tissue. The visceral pleura was composed of athin layer of connective tissue and alayer of mesothelium (Fig 36).This result was similar observation in most mammalian spcies such as goat by (**Habib and mohammed ,2010) cat by (Nassar,2012).**

5-1 Conclusion :

- 1- The gross anatomy of trachea and lung were similar in male and female guinea pigs. The trachea extends caudally from the cricoid of the larynx to its bifurcation at the base of heart into right and left principal bronchi
- 2- The shape of tracheal rings are semi-circular in cross section and the trachealis muscle attached to the inner surface of the cartilaginous rings.
- 3- The tracheal wall consist of four tunics ,tunica mucosa ,tunica submucosa, musculocartilage and tunica adventitia.
- 4- The mucosa of trachea is lined by pseudostratified ciliated columnar epithelium with goblet cells which give a positive reaction for periodic acid schift(PAS).
- 5- The Extra pulmonary bronchi were similar in histological structure to the trachea.
- 6- The bronchioles were lack of cartilage and glands.
- **7-** The respiratory bronchioles were absent in guinea pigs due to that terminal bronchioles were opened directly into several alveolar ductless.
- 8- The lung was divided by deep fissures into distict lobe. The right lung has four lobes while the left lung has three lobes.
- **9-** The lung parenchyma unit composed of alveoli that opened into the alveolar ducts and alveolar sac.
- **10-** The bronchial tree divided into right and left principal bronchi.

5-2. Recommendations:

- 1- Study the blood and nerve supply of the lower respiratory system in guinea pigs.
 - 2- Ultra structure study of lung by using the electron microscopy.
 - 3- Developmental study of trachea and lung in guinea pigs.

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