

Anatomicosurgical arterial segmentation of the cat lungs (*Felis catus domesticus*, L., 1758)

Segmentação anátomo-cirúrgica arterial dos pulmões de gato (*Felis catus domesticus*, L., 1758)

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SUMMARY

The aim of this research was to establish the anatomicosurgical segments through lobation and arterial intralobar branching in cats lungs. After dissection of twenty lungs, it was noted that the right pulmonary artery, usually, emits a branch to the cranial lobe and a branch to the middle lobe, arising together from a trunk. A large branch irrigates the caudal lobe in most of the cases. Two branches arising in common origin from the caudal lobe branch irrigate the accessory lobe. The left pulmonary artery originates a trunk that, in most of the cases, emits a branch to the cranial and a branch to the caudal part of the left cranial lobe. It can be concluded that the right lung is formed by four and the left by two lobes, and variations occur in the pulmonary arterial branching.

UNITERMS: Arterial segmentation; Cats; Lungs.

INTRODUCTION

In anatomy and surgery, segment is a portion of an organ that owns independent irrigation and blood drainage, separated from other portions, surgically removable and morphologically identifiable. The segment has the same function of the organ that it belongs to and although it is recognizable by blood vascular distribution, its lymphatic vessels and nerves are also disposed as satellites, accompanying the segmental vessel architecture. Thus, anatomicosurgical segments are natural or artificially portions independent from parenchymal organs or even extended to walls of hollow organs³.

According to Bruni; Zimmerl², the right lung of carnivorous is divided into apical, cardiac, basal and azygos lobes. In the left lung, there are an apical and a cardiac lobe, besides a caudal one. These authors denominate left and right branches the pulmonary arteries that enter the lungs.

According to Hare⁷, the carnivorous lungs are subdivided in lobes by deep interlobar fissures. The right lung is formed by four lobes: apical (cranial), middle (cardiac), caudal (diaphragmatic) and accessory (intermediate) and it is larger than the left lung, which has two lobes: an apical (cranial) and an diaphragmatic (caudal). Light⁶ also describes this same lobar division in the feline lungs.

Ellenberger; Baum *apud* Nakakuki⁸ divided the right lung of domestic animals into apical (cranial), middle (cardiac), diaphragmatic (caudal) and accessory (intermediate) lobes, and the left lung into apical (cranial), middle (cardiac) and diaphragmatic (caudal) lobes. These authors affirm that just the

equine lungs differ from those of other domestic animals, since the right lung is formed by apical (cranial), diaphragmatic (caudal) and intermediate (accessory) lobes, and the left lung by apical (cranial) and diaphragmatic (caudal) lobes.

The pulmonary trunk is the stem artery that arises from the fibrous pulmonary ring. It extends into the media of the pulmonary trunk peripherally and centrally serves for the attachment of muscle fibers from the conus arteriosus⁵. According to Hare⁷, the pulmonary trunk bifurcates in the left side of the tracheal bifurcation into right and left pulmonary arteries, which emit branches to right and left lungs.

As a rule, the pulmonary arteries may be found in the cranial surface of the bronchi that lie transversal or oblique to the longitudinal axis of the lung. They are found too in the lateral surface of the bronchi that lie parallel and caudal to the longitudinal axis of the lung and in the medial surface of the bronchi that lie cranial to the longitudinal axis of the lung⁷.

The lobar division of Ellenberger; Baum *apud* Nakakuki⁸, in pigs, was greatly accepted during many years. They related in the horse that apical, cardiac, diaphragmatic and intermediate lobes constituted the right lung and apical, cardiac and diaphragmatic lobes the left lung, but in the horse. In this animal, they considered that apical, diaphragmatic and intermediate lobes formed the right lung, and apical and diaphragmatic lobes formed the left lung. However, in the horse lung, Seiferle *apud* Nakakuki⁸ considered that the left cardiac lobe noted by Ellenberger; Baum *apud* Nakakuki⁸ is a part of the apical lobe, but in the horse lung, to which the lobar division of Ellenberger; Baum *apud* Nakakuki⁸ is accepted.

Dyce et al.⁴ describe that the carnivorous right lung is constituted by cranial, middle, caudal and accessory lobes. The left lung has a subdivided cranial lobe and a simple caudal one. They denominate right and left pulmonary arteries those originated from the pulmonary trunk, each one headed to the hilus of the correspondent lung, alongside the large bronchus and pulmonary veins. The pulmonary arteries establish their first ramification before reaching the lungs.

In dogs, the left pulmonary artery curves dorsally cranial to the vein from the cranial part of the cranial lobe that crosses the large lobular bronchus. Just prior to this crossing, a pulmonary arterial trunk arises and bifurcates. The larger terminal branch runs cranially as the main vessel to the cranial part of the left cranial lobe. The branch to the caudal part of the left cranial lies cranial to the bronchus and caudal to the large vein⁵. Alongside the bronchial tree, the pulmonary artery divides into a branch to the caudal lobe and a branch to the cranial lobe which will originate the descendant and the ascendant branch, respectively, to the subdivided cranial pulmonary lobe¹⁰.

The portion of the pulmonary artery that ramifies in the caudal lobe is bigger than all left pulmonary artery branches together. Before reaching the lobe, this artery runs dorsally to the bronchus, which bifurcates to air the cranial and caudal parts of the left cranial lobe. After entering the lobe, the artery irregularly ramifies to irrigate it as a whole. The lobar veins compose the most ventral portion of the basis of the lung¹⁰.

The right pulmonary artery is shorter than the left one. It runs caudolaterally ventral to the left lobar bronchus and dorsal to the large left lobar veins. The artery unequally divides into a small branch that runs to the right cranial lobe and a large branch that courses caudally into the right caudal lobe. Near the origin of the large artery to the caudal lobe, the relatively short right middle lobar artery runs laterally and enters the dorsal third of the lobe. It is related to the dorsal surface of its satellite vein and lies dorsocranial to the right middle lobar bronchus and it may arise from the right cranial lobar artery. The pulmonary lobar artery to the accessory lobe of the right lung enters the thickened middle portion of the lobe and trifurcates. This lobar artery lies ventral to the respective bronchus and dorsally to its satellite vein⁵. In carnivorous, the right pulmonary artery divides into a branch to the cranial, to the middle and to the caudal lobe. In all domestic mammals, the branch of the caudal lobe originates the branch to the accessory lobe of the right lung. The consequent branching of the right pulmonary artery is correspondent to that one of the bronchi¹⁰.

Adrian¹ observed in 30 adult cat lungs that two branches to the right apical lobe and two branches to the right middle lobe are originated from the right pulmonary artery. The caudal and accessory lobes are supplied by arterial branches, which bifurcate in the middle third of their route into ventral and dorsal branches. Two branches to the cranial lobe are originated from the left pulmonary artery, one to the cranial and one to the caudal part. Just a branch supplies the caudal lobe.

Suzuki; Ohkubo¹¹ described the distribution of the pulmonary arteries in dogs. The left pulmonary artery, as well as the right one, originates the cranial lobe branch and the middle lobe branch in common origin, and it keeps on as caudal lobe

branch. The right pulmonary artery still originates the accessory lobe branch in the middle third of its route.

Nakakuki⁹, using 33 pigs, related that there are the dorsal, ventral, medial and lateral bronchiolar systems in both sides, and one tracheal bronchus appearing on the right side of the trachea. Cranial, middle, caudal and accessory lobes constitute the right lung, and a subdivided middle lobe and a caudal lobe formed the left lung. The left and right pulmonary arteries go through the dorsolateral side of the right and left bronchi, respectively. During their course, they emit branches that mainly look over the dorsal or lateral side of each bronchus.

MATERIAL AND METHOD

Twenty adult crossbreed *post mortem* cats, of both sexes, were collected from the Department of Medical Clinics and Surgery of the Universidade Estadual Paulista (UNESP), Jaboticabal, São Paulo, Brazil.

The animals were frozen and transferred to the Anatomy Laboratory at the same institution, thawed in water, and then prepared through an arterial vessels injection technique.

The aorta was isolated (thoracic portion) through an opening of the thoracic cavity in the left side, in the fourth intercostal space. The vessel was canalized through short cut, with a tube of compatible caliber to the vessel, and injected with coloured latex, in cranial direction. The prepared pieces were immersed in a 10% formalin solution. The block lungs plus heart was taken out from the thoracic cavity for a better view and further dissection.

Line drawings and photographs were made for documentation.

RESULTS

Just one pattern of pulmonary division was checked out (100% of the cases). There are four lobes in the right lung (cranial, middle, accessory and caudal lobes) and two in the left lung (subdivided cranial lobe and caudal lobe).

In eighteen specimens (90% of the whole), the right pulmonary artery emits a branch to the cranial and a branch to the middle lobe, arising from a trunk. In two, (10%), the branches to the cranial and middle lobes have different origins (Fig 1). In fourteen cases (70%), a large branch that gives off side branches during its course irrigates the right caudal lobe. In six (30%), two arterial branches irrigate this lobe. The accessory lobe is irrigated by two branches arising in common origin in the arterial trunk of the caudal lobe (Fig 2).

In fifteen specimens (75%), the left pulmonary artery originates a trunk that gives off a branch to the cranial part and a branch to the caudal part of the subdivided cranial lobe. In five cases (25%), the branch to the caudal part of the cranial lobe is originated from the arterial trunk of the caudal lobe (Fig. 3). A trunk that emits side branches in its course supplies the caudal lobe.

As for the broncoarterial relation, it was verified that the pulmonary arteries lie ventral to the bronchus in the right cranial lobe and cranial part of the left cranial lobe, medial to the right middle lobe and caudal part of the left cranial lobe, and dorsal to the right caudal and left and accessory lobes.

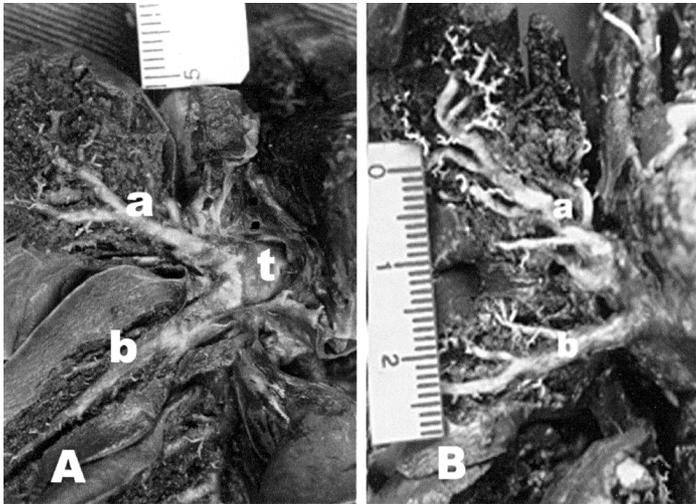


Figure 1

A: Right lung of a cat indicating a branch to the cranial (a) and a branch to the middle lobe (b), arising from a trunk (t); B: Right lung of a cat indicating a branch to the cranial (a) and a branch to the middle lobe (b), in different origins.

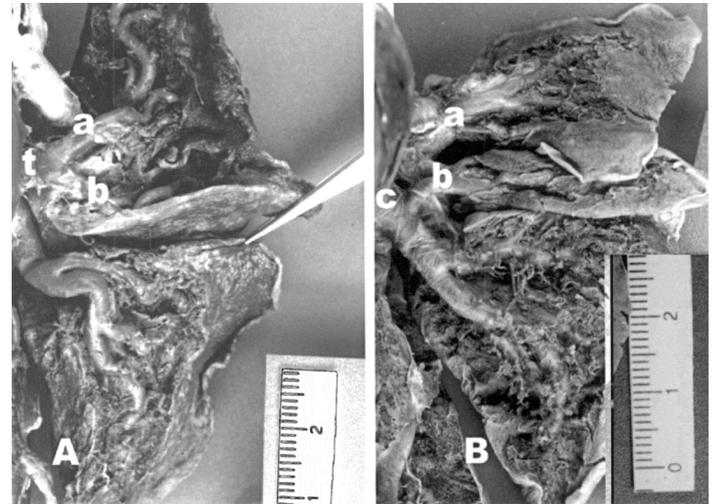


Figure 3

A: Left lung of a cat indicating a branch to the cranial part (a) and a branch to the caudal part of the cranial lobe (b), arising from a trunk (t); B: Left lung of a cat indicating that the branch to the caudal part of the cranial lobe (b) is originated from the arterial trunk of the caudal lobe (c).

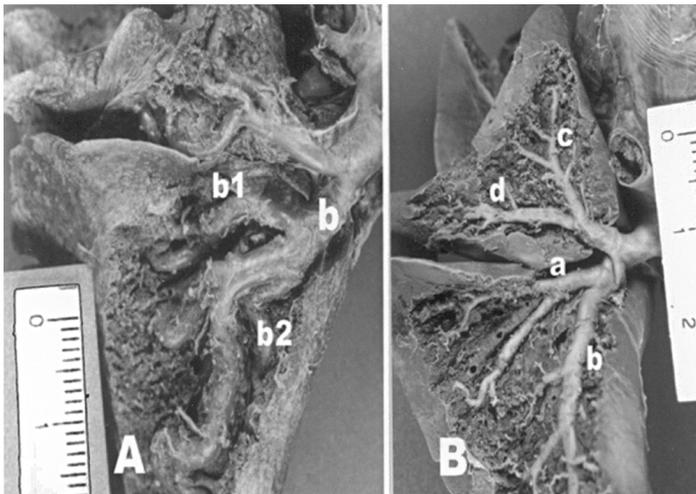


Figure 2

A: Right lung of a cat indicating a branch that irrigates the caudal lobe (b) emitting collateral branches during its course (b1, b2); B: Right lung of a cat indicating two main branches that irrigate the caudal lobe (a,b); two branches supply the accessory lobe (c,d).

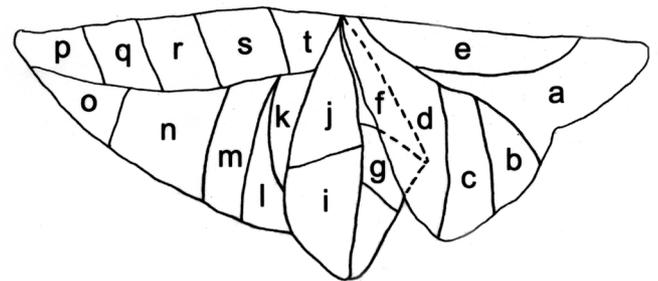


Figure 4

Line drawing of the anatomicosurgical arterial segmentation of the cat lungs (left lateral view). Segments of the cranial part of the left cranial lobe: dorsoventral cranial (a), ventrocranial (b), ventrocaudal (c), dorsocaudal (d), dorsocranial (e); Segments of the caudal part of the left cranial lobe: dorsocranial (f), middlecranial (g), ventrocranial (h), ventrocaudal (i), dorsocaudal (j); Segments of the left caudal lobe: ventrocranial proximal (k), ventrocranial distal (l), ventromiddle (m), ventrocaudal proximal (n), ventrocaudal distal (o), dorsocaudal distal (p), dorsocaudal proximal (q), dorsomiddle (r), dorsocranial distal (s), dorsocranial proximal (t).

Schematically, the pulmonary segmentation, made according to the distribution of the pulmonary arteries in cats, is expressed in Fig. 4 - 6. Dorsoventral cranial, ventrocranial, ventrocaudal, dorsocaudal and dorsocranial are the anatomicosurgical segments of the cranial part of the left cranial lobe. In the caudal part of the left cranial lobe there are dorsocranial, middlecranial, ventrocranial, ventrocaudal and dorsocaudal segments and, in the left caudal lobe, there are ventrocranial proximal, ventrocranial distal, ventromiddle, ventrocaudal proximal, ventrocaudal distal, dorsocaudal distal, dorsocaudal proximal, dorsomiddle, dorsocranial distal and dorsocranial proximal segments. Craniodorsal, craniomiddle, craniocaudal, caudodorsal,

caudomiddle and caudoventral are the segments in the right cranial lobe and craniodorsal, craniomiddle, craniocaudal and caudal are the segments in the right middle lobe. Dorsocranial, dorsomiddle, dorsocaudal, ventrocaudal, ventromiddle and ventrocranial are the segments of the right caudal lobe. Left lateral, right lateral and middle are the segments of the accessory lobe.

DISCUSSION

The pulmonary lobation of cats observed in the present work is similar to that described by Adrian¹, Bruni; Zimmerl², Dyce et al.⁴, Light⁶, Hare⁷ and Nickel et al.¹⁰. The right lung is formed

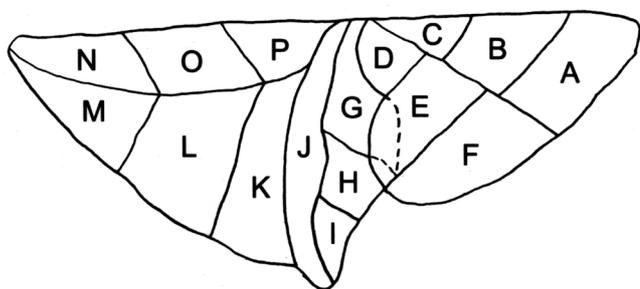


Figure 5

Line drawing of the anatomicosurgical arterial segmentation of the cat lungs (right lateral view). Segments of the right cranial lobe: craniodorsal (A), craniomiddle (B), craniocaudal (C), caudodorsal (D), caudomiddle (E), caudoventral (F); Segments of the right middle lobe: craniodorsal (G), craniomiddle (H), cranioventral (I), caudal (J); Segments of the right caudal lobe: dorsocranial (K), dorsomiddle (L), dorsocaudal (M), ventrocaudal (N), ventromiddle (O), ventrocranial (P).

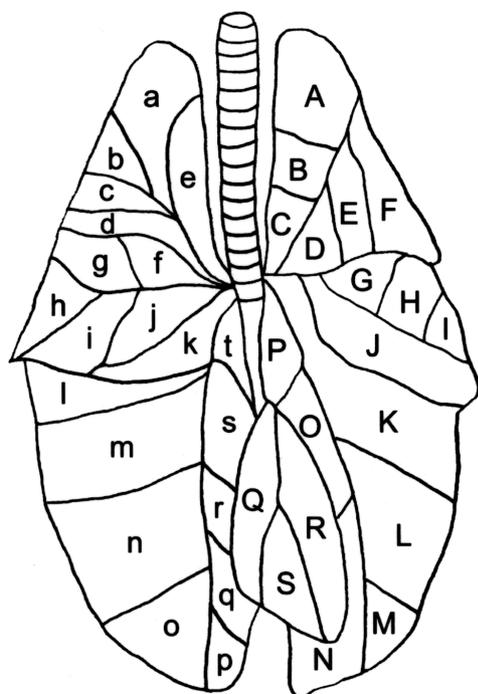


Figure 6

Line drawing of the anatomicosurgical arterial segmentation of the cat lungs (ventral view). Segments of the accessory lobe: left lateral (Q), right lateral (R), middle (S). Other segments are shown in the captions of figures 6 and 7.

by four lobes (cranial, middle, caudal and accessory) and the left lung by two (cranial, which is subdivided, and caudal).

However, our observations differ from those of Ellenberger; Baum *apud* Nakakuki⁸, who divided the left lung of the domestic animals in apical (cranial), middle (cardiac) and

diaphragmatic (caudal) lobes. The authors affirm that just the equine lungs differ from those of other species, since the right lung is formed by apical (cranial), diaphragmatic (caudal) and intermediate (accessory) lobes, and the left lung is composed by apical (cranial) and diaphragmatic (caudal) lobes. Our observations also differ from those of Nakakuki⁹, who related in research using 33 pigs, that the left lung is constituted by a subdivided middle lobe and a caudal lobe, not making allusion to the cranial lobe.

The pulmonary trunk bifurcates, in the left side of the tracheal bifurcation, into right and left pulmonary arteries that ramify in the right and left lungs, being us in agreement with Hare⁷ in carnivorous. The first branching of the pulmonary arteries happens before they enter the lungs, going us along with Dyce et al.⁴ in carnivorous.

The right pulmonary artery, in most of the cases, gave off a branch to the cranial and a branch to the middle lobe arising from a trunk, and a branch to the caudal lobe, besides two branches that arose in common origin in the arterial trunk of the caudal lobe to irrigate the accessory. These results are in disagreement with Adrian¹, who checked out that the right pulmonary artery of cats originated two branches to the right apical lobe and two branches to the right middle lobe, besides arterial branches to the caudal and accessory lobes.

The left pulmonary artery gives off two branches to the cranial lobe: one to the cranial and one to the caudal part, going the 75% of our observations along with those of Adrian¹, in cats. However, the author's statements disagree from 25% of ours, as long as the branch to the caudal part of the cranial lobe is originated from the left pulmonary artery, together with the branch to the cranial part of this lobe, and not from the arterial trunk of the caudal lobe, as noticed by us. As for the left caudal lobe, our observations are in agreement with Adrian¹, who related the occurrence of just one arterial branch in this lobe.

As for the broncoarterial relation, we adopted a ventral, dorsal, medial and lateral classification of the pulmonary arteries in relation to the bronchi, differing from Hare⁷, who used the lateral, medial, cranial and caudal surfaces. The pulmonary arterial branches lie ventral to the bronchus in the right cranial lobe and cranial part of the left cranial lobe, medial in the right middle lobe and caudal part of the left cranial lobe, and dorsal in the right caudal, left and accessory lobes. However, according to Hare⁷, the pulmonary arterial branches may be found in the cranial surface of the bronchi that run transversally or obliquely in relation to the longitudinal axis of the lung, in the lateral surface of the bronchi that run caudally parallel to this axis and in the medial surface of the bronchi that run cranially parallel to the same axis.

A model of anatomicosurgical segmentation in lungs was established according to the distribution of the pulmonary arteries in cats. There are nineteen segments in the right lung and twenty in the left lung, indicating a great branching of these arteries inside the lungs of cats.

RESUMO

O objetivo desta pesquisa foi estabelecer os segmentos anátomo-cirúrgicos arteriais, através da lobação e ramificação intralobar arterial, em pulmões de gato. Após a dissecação de vinte pulmões, notou-se que a artéria pulmonar direita geralmente emite um ramo para o lobo cranial e um ramo para o lobo médio, sendo originados juntos em um tronco. Um grande ramo irriga o lobo caudal na maioria dos casos. Dois ramos com origem comum no ramo arterial do lobo caudal irrigam o lobo acessório. A artéria pulmonar esquerda origina um tronco que, na maioria dos casos, emite um ramo para a porção cranial e um ramo para a porção caudal do lobo cranial esquerdo. Pode-se concluir que o pulmão direito é formado por quatro e o esquerdo por dois lobos, ocorrendo variações na ramificação arterial pulmonar.

UNITERMOS: Segmentação arterial; Gatos; Pulmões.

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