

# The Bronchial Tree and Lobular Division of the Horse Lung

Shoichi NAKAKUKI

*Department of Veterinary Anatomy, Faculty of Agriculture, Tokyo University of Agriculture and Technology, 3-5-8 Saiwai-cho, Fuchu-shi, Tokyo 183, Japan*

(Received 13 November 1992/Accepted 8 March 1993)

**ABSTRACT.** The lungs of five horses were examined. At present, in veterinary anatomy, the horse lung is divided into the cranial and caudal lobes by the cardiac notch on either side. In addition to these lobes, in the right lung, the accessory lobe is present. However, from the viewpoint of the bronchial ramifications, the horse lung can be divided into the cranial, middle, caudal and accessory lobes bilaterally. The horse lung has four bronchiole systems on either side, dorsal, lateral, ventral and medial. The cranial lobe is formed by the first bronchiole of the dorsal bronchiole system. The middle lobe is formed by the first bronchiole of the lateral bronchiole system. The accessory lobe is formed by the first bronchiole of the ventral bronchiole system. The remaining bronchioles of the dorsal, lateral and ventral bronchiole systems and all bronchioles of the medial bronchiole system constitute the caudal lobe. These features were compared with those of the lungs of other domestic animals.—**KEY WORDS:** bronchial tree, horse, lobular division, lung.

*J. Vet. Med. Sci.* 55(3): 435–438, 1993

Aeby [1] examined the lungs of many mammals including man, and classified the bronchioles into the dorsal and the ventral bronchiole systems. Furthermore, he classified the bronchioles into the epiarterial and hypoarterial bronchioles according to the course of the pulmonary artery, and considered that the left epiarterial bronchiole, i.e. the left upper lobe bronchiole, is lacking in the human lung. Huntington [3] also examined many mammalian lungs and considered that the left cranial and middle lobe bronchioles have a common trunk from the left bronchus. Jackson and Huber [4] divided the human lung into ten pulmonary segments for the convenience of surgery, and considered that the left upper lobe corresponds to the right upper and middle lobes from the viewpoint of pulmonary segments.

On the other hand, in veterinary anatomy, the lobular division of Ellenberger and Baum [2] was widely accepted for many years. They considered that the right lung comprises the apical, cardiac, diaphragmatic and intermediate lobes, and that the left lung comprises the apical, cardiac and diaphragmatic lobes, except in the horse. In the horse lung, they considered that the right lung contains the apical, diaphragmatic and intermediate lobes, and that the left lung has the apical and diaphragmatic lobes. However, Seiferle [7] considered that the left cardiac lobe of Ellenberger and Baum [2] is a part of the apical lobe, except for the horse lung in which the lobular division of Ellenberger and Baum [2] is accepted. Thus, the way of interpretations of the left lung have differed among authors.

Therefore, the present author has examined the lungs of many mammals including man to establish the fundamental structure of the bronchial ramifications. From these examinations, it has been proposed as follows: The dorsal, lateral, ventral and medial bronchiole systems arise from the dorsal, lateral, ventral and medial sides of the bronchus on either side, respectively. Furthermore, two pairs of bronchioles arise from the lateral sides of the

trachea. The cranial lobe bronchioles are composed of the first bronchiole of the dorsal bronchiole system (cranial lobe bronchiole I), and the two bronchioles arising from the lateral side of the trachea (cranial lobe bronchioles II and III). Thus three kinds of cranial lobe bronchioles can be enumerated. Generally, however, the cranial lobe can be formed by any one of them. The middle lobe bronchiole is the first bronchiole of the lateral bronchiole system, and the accessory lobe bronchiole is the first bronchiole of the ventral bronchiole system. The remaining bronchioles of the dorsal, lateral and ventral bronchiole systems and all bronchioles of the medial bronchiole system constitute the caudal lobe [5, 6].

The present paper describes the structure of the horse lung, on the basis of the fundamental structure of the bronchial ramifications of the mammalian lung [5, 6].

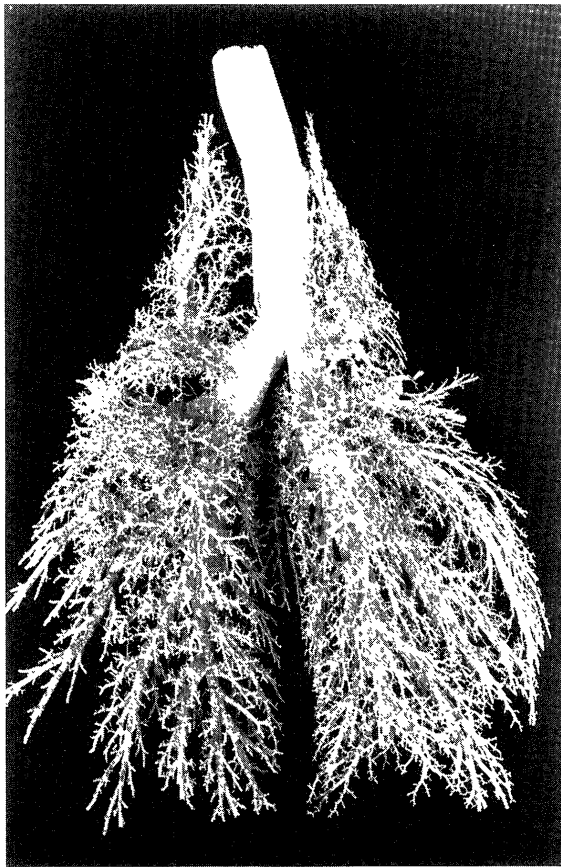
## MATERIALS AND METHODS

The lungs of five horses were used. The lungs of three horses were injected with celluloid solutions with different colors into the bronchial tree through the trachea and into the pulmonary blood vessels through the heart using a metal syringe. The other one was injected with a celluloid solution into the bronchial tree and pulmonary artery. The remaining one was injected only into the bronchial tree. After injection the lungs were placed in water until the injected materials coagulated completely. The soft tissues were then treated with hydrochloric acid (HCl) to obtain celluloid cast models after washing in running water.

## RESULTS

*Bronchial ramifications and lobular division (Figs. 1–4):* Systematically, bronchioles can be classified into four systems: dorsal (D), lateral (L), ventral (V) and medial (M) bronchiole systems on either side.

The right cranial lobe bronchiole arises from the

**Fig. 1.**

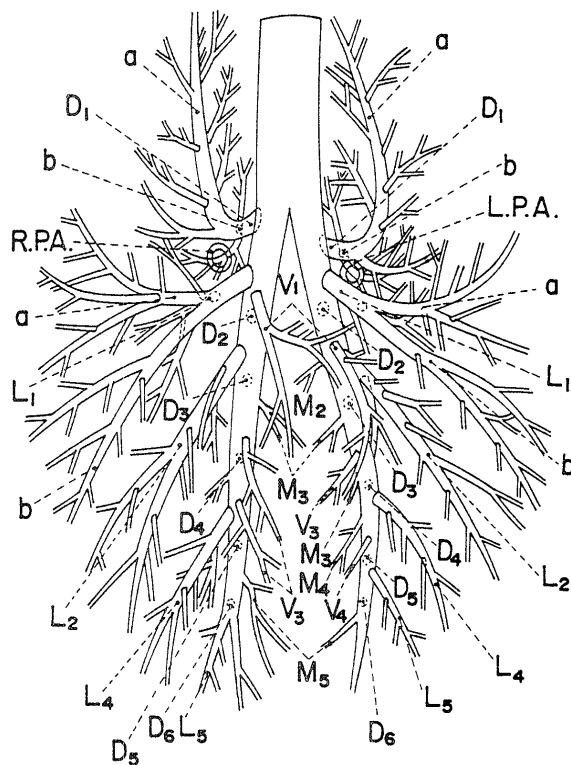
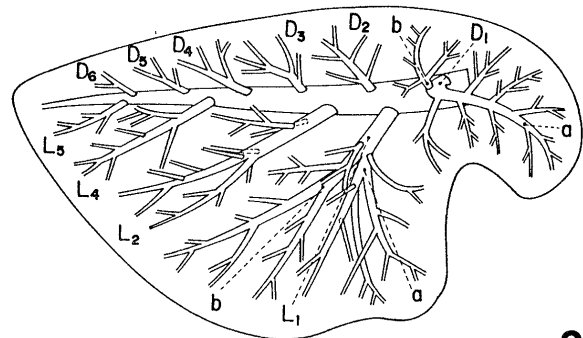
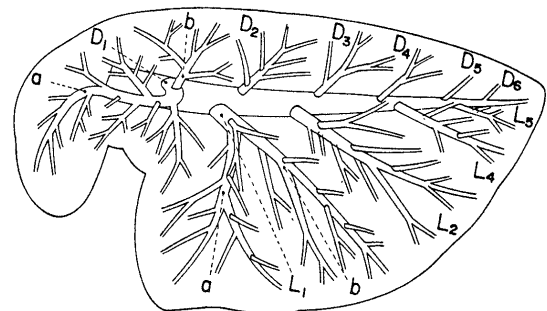
dorsolateral side of the right bronchus. This bronchiole is the first bronchiole ( $D_1$ ) of the dorsal bronchiole system (cranial lobe bronchiole I) and divides immediately into two branches, cranial (a) and caudal (b), the former branch being larger. This bronchiole forms the right cranial lobe. The right middle lobe bronchiole is the first bronchiole ( $L_1$ ) of the lateral bronchiole system. This bronchiole arises from the ventrolateral side of the right bronchus and divides into two branches, cranial (a) and caudal (b), the latter branch being more developed. This bronchiole forms the right middle lobe and is well developed. However, this lobe is united with both the cranial and the caudal lobes. The right accessory lobe bronchiole is the first bronchiole ( $V_1$ ) of the ventral bronchiole system, and arises from the ventromedial side of the right bronchus, dividing into two branches, lateral and medial. The area formed by this bronchiole is the right accessory lobe, and a part of this lobe is united with the right caudal lobe. The remaining bronchioles of the dorsal, lateral and ventral bronchiole systems and all bronchioles of the medial bronchiole system constitute the right caudal lobe. In this lobe, the dorsal and lateral bronchiole systems are well developed, especially the

Fig. 1. Celluloid cast model of the bronchial tree of the horse lung, dorsal aspect.

Fig. 2. Bronchial tree of the horse lung, ventral aspect.

Fig. 3. Lateral aspect of the right lung.

Fig. 4. Lateral aspect of the left lung.

**2****3****4**

latter. The dorsal bronchiole system has the second ( $D_2$ ) to the sixth ( $D_6$ ) bronchioles. The lateral bronchiole system has the second ( $L_2$ ), the fourth ( $L_4$ ) and the fifth ( $L_5$ ) bronchioles without the third bronchiole ( $L_3$ ). The second ( $L_2$ ) and the fourth ( $L_4$ ) bronchioles are divided into two branches, in the distal portion. The ventral and medial bronchiole systems are poorly developed. The ventral bronchiole system has the third bronchiole ( $V_3$ ) only. This bronchiole is represented by two bronchioles. The medial bronchiole system has the third ( $M_3$ ) and the fifth ( $M_5$ ) bronchioles. These bronchioles constitute the right caudal lobe. Accordingly, the right lung consists of the cranial, middle, caudal and accessory lobes.

The left cranial lobe bronchiole is the first bronchiole ( $D_1$ ) of the dorsal bronchiole system (cranial lobe bronchiole I). This bronchiole arises from the dorsolateral side of the left bronchus, somewhat more caudal than the origin of the right cranial lobe bronchiole. This bronchiole divides into two branches, cranial (a) and caudal (b), as in the right lung. The area formed by this bronchiole is the left cranial lobe. The left middle lobe bronchiole is the first bronchiole ( $L_1$ ) of the lateral bronchiole system. This bronchiole arises from the ventrolateral side of the left bronchus and divides into two branches, cranial (a) and caudal (b). This bronchiole forms the left middle lobe and is well developed. However, this lobe is united with both the cranial and the caudal lobes, as in the right lung. Thus, the horse lung has the middle lobe bronchiole on either side. The left accessory lobe bronchiole, i.e. the first bronchiole ( $V_1$ ) of the ventral bronchiole system, arises from the ventral side of the left bronchus. This bronchiole is smaller than the right accessory lobe bronchiole, and is more caudal in origin. The area formed by this bronchiole is the left accessory lobe, which is united with the left caudal lobe. The remaining bronchioles of the dorsal, lateral and ventral bronchiole systems and all bronchioles of the medial bronchiole system constitute the left caudal lobe. The dorsal bronchiole system has the second ( $D_2$ ) to the sixth ( $D_6$ ) bronchioles. The lateral bronchiole system has the second ( $L_2$ ), the fourth ( $L_4$ ) and the fifth ( $L_5$ ) bronchioles without the third bronchiole ( $L_3$ ), as in the right lung. The second bronchiole ( $L_2$ ) is divided into two branches in its distal portion. The ventral bronchiole system has the third ( $V_3$ ) and the fourth ( $V_4$ ) bronchioles. The medial bronchiole system has the second ( $M_2$ ), the

third ( $M_3$ ), the fourth ( $M_4$ ) and the fifth ( $M_5$ ) bronchioles. The third bronchiole ( $M_3$ ) is represented by two bronchioles. Accordingly, the left lung also consists of the cranial, middle, caudal and accessory lobes.

#### DISCUSSION

The anatomical terms used in this paper, the cranial lobe, middle lobe, caudal lobe and right accessory lobe correspond to the upper lobe, middle lobe, lower lobe and the right medial basal segment ( $S^7$ ) in human anatomy, respectively. However, in the human left lung, the upper lobe and the medial basal segment ( $S^7$ ) are absent, and the left upper lobe should be called the left middle lobe from the viewpoint of comparative anatomy [5, 6]. The term bronchiole corresponds to a lobar bronchus arising from the right and left bronchi, or a segmental bronchus arising from the caudal (lower) lobe bronchi in veterinary or human anatomy.

The author considers the cranial, middle, caudal and accessory lobes to be sub-lobes, respectively, since in the horse and some other mammals, these lobes are united with one another and form a larger lobe on one or either side. For this reason, the author used the term lobular division.

The horse lung has four bronchiole systems, as in most other mammalian lungs [5, 6]. The right cranial lobe bronchiole corresponds to the first bronchiole ( $D_1$ ) of the dorsal bronchiole system, and arises from the dorsolateral side of the right bronchus. This bronchiole is situated on the cranial side of the right pulmonary artery. Accordingly, it is the epiarterial bronchiole. The right middle lobe bronchiole corresponds to the first bronchiole ( $L_1$ ) of the lateral bronchiole system, and arises from the ventrolateral side of the right bronchus. This bronchiole is hypoarterial, since it is located on the caudal side of the right pulmonary artery. Thus the right cranial lobe bronchiole and the right middle lobe bronchiole are completely different, with regard to the bronchiole system to which they belong, the site of their origins and the relationship to the pulmonary artery. Furthermore, in the horse lung, the main bronchial ramifications are bilateral, as mentioned in Results. Therefore, in the horse lung, the left cranial lobe bronchiole and the left middle lobe bronchiole can also be clearly discriminated. At the same time, the right and left

#### Abbreviations

Figs. 2-4:

D — dorsal bronchiole system

L — lateral bronchiole system

V — ventral bronchiole system

M — medial bronchiole system

$D_1$  — cranial lobe bronchiole

$L_1$  — middle lobe bronchiole

$V_1$  — accessory lobe bronchiole

The remaining bronchioles of the dorsal, lateral and ventral bronchiole systems and all bronchioles of the medial bronchiole system constitute the caudal lobe.

R.P.A. — Right pulmonary artery

L.P.A. — Left pulmonary artery

middle lobes can be discriminated from the large diaphragmatic (caudal) lobes of Ellenberger and Baum [2] and Seiferle [7].

The right cranial lobe bronchiole (cranial lobe bronchiole I) of the horse lung does not correspond to the right cranial lobe bronchiole of the cow, goat or pig lung, which arises from the right lateral side of the trachea. These bronchioles correspond to the right cranial lobe bronchiole III in the fundamental structure of the bronchial ramifications of the mammalian lung. The right cranial lobe bronchiole of the horse is the first bronchiole ( $D_1$ ) of the dorsal bronchiole system i.e. the cranial lobe bronchiole I [5, 6], and corresponds to the right upper lobe bronchiole of the dog.

The right middle lobe bronchiole of the horse lung corresponds to the right middle lobe bronchiole of the cow, goat, pig or dog lung, because in all these animals, including the horse, the right middle lobe is formed by the first bronchiole ( $L_1$ ) of the lateral bronchiole system, as in the lungs of other mammals [5, 6].

The left cranial lobe bronchiole (cranial lobe bronchiole I) of the horse does not correspond to that of the cow, goat, pig or dog. The left cranial lobe bronchiole of the cow, goat, pig or dog corresponds to the left middle lobe bronchiole of the horse, from the viewpoint of comparative anatomy, because the bronchiole of the cow, goat, pig or dog is the first bronchiole ( $L_1$ ) of the lateral bronchiole system, whereas that of the horse is the first bronchiole ( $D_1$ ) of the dorsal bronchiole system [5, 6]. In the cow, goat, pig or dog, the true left cranial lobe bronchioles, i.e. the first bronchiole ( $D_1$ ) of the dorsal bronchiole system (cranial lobe bronchiole I) and the two bronchioles arising from the lateral side of the trachea (cranial lobe bronchioles II and III), are lacking. Therefore, the left cranial lobe bronchiole of the cow, goat, pig or dog should be called the left middle lobe bronchiole from the viewpoint of comparative anatomy [5, 6].

The present author considers that the third bronchiole ( $L_3$ ) of the lateral bronchiole system is lacking on either

side, because the distance between the origins of the second ( $L_2$ ) and the fourth ( $L_4$ ) bronchioles is greater than the other distances between the two bronchioles in the same bronchiole systems.

In veterinary anatomy, it has been accepted the horse lung consists of the cranial and caudal lobes on either side. In addition to these lobes, in the right lung, the accessory lobe is present. On the other hand, the present author discriminates the cranial, middle, caudal and accessory lobes on either side. Such difference in the lobular division of the horse lung is probably due to the difference in viewpoint. Anatomy, at present, is based on the external features, especially the presence of the cardiac notch. The present author, however, takes into consideration not only the external features but also the bronchial ramifications and the course of the pulmonary artery, with special emphasis on the bronchial ramifications from the viewpoint of comparative anatomy.

#### REFERENCES

1. Aeby, C. 1880. Der Bronchialbaum der Säugetiere und des Menschen. W. Engelmann, Leipzig.
2. Ellenberger, W. and Baum, H. 1932. Handbuch der vergleichenden Anatomie der Haustiere, 17 Aufl., Julius Springer, Berlin.
3. Huntington, G. S. 1898. The epiarterial bronchial system of the mammalia. *Ann. New York Acad. Sci.* 11: 127-149.
4. Jackson, C. L. and Huber, J. F. 1943. Correlated applied anatomy of the bronchial tree and lungs with a system of nomenclature. *Dis. Chest* 9: 319-326.
5. Nakakuni, S. 1975. The new interpretation of the bronchial tree. *Proc. Jpn. Acad.* 51: 342-346.
6. Nakakuni, S. 1980. Comparative anatomical studies on the mammalian lung. *Bull. Fac. Agr., Tokyo Univ. Agr. Tech.* 21: 1-74.
7. Seiferle, E. 1956. Grundsatzliches zu Bau und Benennung der Haussäugerlunge. *Okajima's Folia Anat. Jpn.* 28: 71-81.