

## The Bronchial Tree and Lobular Division of the Lung in the Striped Dolphin (*Stenella coeruleo-albus*)

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(Received 16 March 1994/Accepted 31 August 1994)

**ABSTRACT.** According to the fundamental structure of the bronchial ramification of the mammalian lung proposed by the present author [5, 6], the lung of the striped dolphin (*Stenella coeruleo-albus*) consists of the cranial and caudal lobes on either side. Both lobes are united to form a single one. The middle and accessory lobe bronchioles are lacking on either side.—**KEY WORDS:** bronchial tree, lung, striped dolphin.

*J. Vet. Med. Sci.* 56(6): 1209–1211, 1994

Anatomical interpretations of the left lung, especially the apical pulmonary lobe, differ among authors [1, 3, 4].

In veterinary anatomy, the lobular division of Ellenberger and Baum [2] was widely accepted for many years. This discriminated the apical, cardiac and diaphragmatic lobes in the left lung. However, Seiferle [8] pointed out that the left cardiac lobe of Ellenberger and Baum [2] is part of the apical lobe. At present, in veterinary anatomy, the left lung is discriminated into the cranial and caudal lobes. In this way, interpretations of the left lung have differed.

Therefore, the present author examined the lungs of many mammals, including man, to establish the fundamental structure of the bronchial ramification of the mammalian lung. The dorsal, ventral, medial and lateral bronchiole systems arise from the dorsal, ventral, medial and lateral sides of both bronchi, respectively. Furthermore, two pairs of bronchioles arise from the lateral sides of the trachea. The cranial lobe bronchioles are the first bronchiole of the dorsal bronchiole system (cranial lobe bronchiole I) and two bronchioles arising from the lateral side of the trachea (cranial lobe bronchioles II and III). In this way, three kinds of cranial lobe bronchioles can be differentiated. However, in general, 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 four bronchiole systems constitute the caudal lobe. However, in the caudal lobe, the numbers of bronchioles differ according to species, and among individuals [5, 6].

As the bronchial ramification of the striped dolphin lung is different from those of other mammalian lungs, and this lung shows important evidence to support the author's theory, the present paper describes the bronchial ramification and lobular division in this species on the basis of the above-mentioned theory of the present author.

The lungs of two striped dolphins (*Stenella coeruleo-albus*) were used. Various colored celluloid solutions were injected into the bronchial tree and blood vessels with the aid of a metal syringe. Then they were placed in water until the celluloid solutions had completely coagulated. The soft tissues were treated with hydrochloric acid, and the cast models were obtained after washing in running water.

**Bronchial ramification (Fig. 1):** In the striped dolphin lung, the right and left lungs each form a single lobe. The cardiac impressions are present on the medial side of the areas of the cranial lobe to the cranial portion of the caudal lobe on either side. From the viewpoint of bronchial ramification, the right cranial lobe is formed by the cranial lobe bronchiole III. This bronchiole arises from the dorsolateral side of the trachea, i.e. the so-called tracheal bronchiole (bronchus), and is divided into cranial (a) and caudal (b) branches. The tracheal bifurcation and the origin of the right cranial lobe bronchiole III are comparatively short. The cranial lobe bronchioles I and II are lacking. The right middle lobe bronchiole, i.e. the first bronchiole ( $L_1$ ) of the lateral bronchiole system, and the right accessory lobe bronchiole, i.e. the first bronchiole ( $V_1$ ) of the ventral bronchiole system, are lacking. The bronchioles of the dorsal, lateral and medial bronchiole systems arising from the right bronchus constitute the right caudal lobe, in which the lateral bronchiole system (L) is the most developed and has the second ( $L_2$ ) to eighth ( $L_8$ ) bronchioles. Each bronchiole further divides into dorsal and ventral branches, the latter being more developed than the former. The dorsal bronchiole system (D) has the second ( $D_2$ ) to seventh ( $D_7$ ) bronchioles, except for the fifth ( $D_5$ ) and sixth ( $D_6$ ). The origins of the third ( $D_3$ ) and fourth ( $D_4$ ) bronchioles are inclined to the medial side. The medial bronchiole system (M) has the fifth ( $M_5$ ) bronchiole only. In the right lower lobe, all the bronchioles of the ventral bronchiole system (V) are lacking. Externally, the cranial and caudal lobes are united to form a single lobe.

In the left lung, the cranial lobe bronchioles II and III are absent. The left cranial lobe is formed by 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 and divides into the cranial (c) and caudal (d) branches. The cranial branch (c) further divides into four branches, craniodorsal (e), cranioventral (f), caudoventral (g) and midcaudal (h). The former three branches are well developed, while the latter one is small. Consequently, the left cranial lobe bronchiole ( $D_1$ ) has five branches. The left middle lobe bronchiole, i.e. the first bronchiole of the lateral bronchiole, and the accessory lobe bronchiole, i.e. the first bronchiole of the ventral bronchiole system, are lacking. In the left caudal lobe, the lateral bronchiole system (L) is

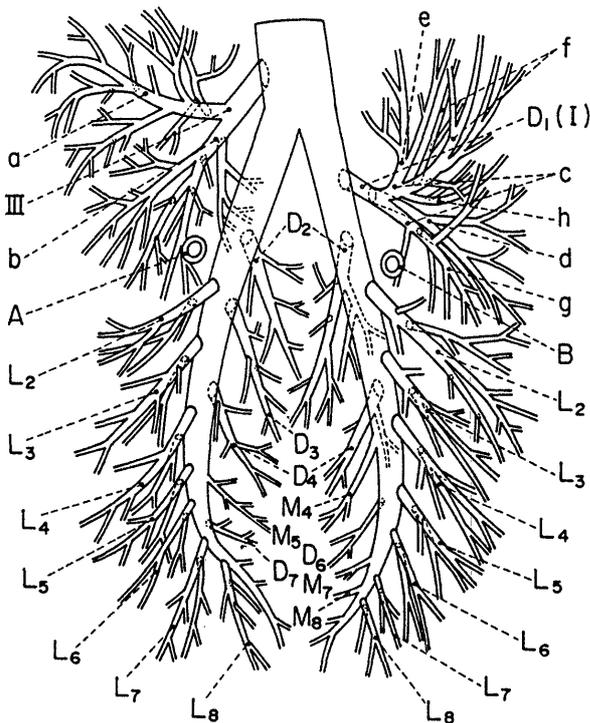


Fig. 1. Bronchial tree of the striped dolphin lung. Ventral aspect.

D—dorsal bronchiole system. L—lateral bronchiole system. M—medial bronchiole system. D<sub>1</sub>(I)—cranial lobe bronchiole I. III—cranial lobe bronchiole III. The remaining bronchioles constitute the caudal lobe. A—right pulmonary artery. B—left pulmonary artery.

the most developed and has the second (L<sub>2</sub>) to eighth (L<sub>8</sub>) bronchioles. Each bronchiole arises from the ventrolateral side of the left bronchus and divides into dorsal and ventral branches, as in the right caudal lobe. The dorsal bronchiole system (D) has the second (D<sub>2</sub>), fourth (D<sub>4</sub>) and sixth (D<sub>6</sub>) bronchioles. The medial bronchiole system has the fourth (M<sub>4</sub>), seventh (M<sub>7</sub>) and eighth (M<sub>8</sub>) bronchioles. All the bronchioles of the ventral bronchiole system (V) are lacking. The cranial and caudal lobes are united to form a single lobe.

The anatomical nomenclature of Ellenberger and Baum [2], namely the apical, cardiac and diaphragmatic lobes in the left lung correspond to the cranial part of the cranial lobe, caudal part of the cranial lobe and caudal lobe, respectively, is currently accepted in veterinary anatomy.

The right cranial lobe bronchiole of the striped dolphin lung corresponds to the right cranial lobe bronchiole III of the fundamental structure of the bronchial ramification of the mammalian lung [5, 6]. This bronchiole corresponds to the right cranial lobe bronchiole of the cow, goat, sheep and pig, respectively [5, 6]. However, the right cranial lobe bronchiole III of the striped dolphin seems to be the right cranial lobe bronchiole II, because the distance

between the origin of the former and the tracheal bifurcation is shorter than those of the cow, goat, sheep or pig [5, 6]. This is due to the fact tracheal bifurcation in the striped dolphin is more cranial than those of the above mammals.

In most mammals, except for having the tracheal bronchiole (bronchus) [6], the right cranial lobe bronchiole (cranial lobe bronchiole I) arises from the dorso-lateral side of the right bronchus and is the first bronchiole (D<sub>1</sub>) of the dorsal bronchiole system, being an epiarterial bronchiole. The right middle lobe bronchiole arises from the ventrolateral side of the right bronchus and is the first bronchiole (L<sub>1</sub>) of the lateral bronchiole system. Furthermore, it is one of the hypoarterial bronchioles. In this way, the cranial lobe bronchiole and the middle lobe bronchiole differ completely in their positions of origin, their bronchiole systems, and their relationships to the pulmonary artery. These features are also the same in the left lung [5, 6].

The left cranial lobe bronchiole, as designated by the present author, in the striped dolphin arises from the dorso-lateral side of the left bronchus and corresponds to the first bronchiole (D<sub>1</sub>) of the dorsal bronchiole system. Furthermore, it is an epiarterial bronchiole. Therefore, the features of this bronchiole are entirely different from those of the middle lobe bronchiole, and correspond to those of the cranial lobe bronchiole I as mentioned above. Therefore, the present author considers this to be the left cranial lobe bronchiole I. However, the left cranial lobe bronchiole of the striped dolphin lung and those of the cow, goat, sheep, pig and dog, currently accepted in veterinary anatomy, are not homologous, although both are called left cranial lobe bronchiole (bronchus). In the latter animals, the real left cranial lobe bronchioles are lacking, and the left cranial lobe bronchiole (bronchus) should be called the left middle lobe bronchiole, because it corresponds to the first bronchiole (L<sub>1</sub>) of the lateral bronchiole system, from the viewpoint of comparative anatomy [5, 6]. The left cranial lobe bronchiole of the striped dolphin and that of the horse are homologous, because both correspond to the first bronchiole (D<sub>1</sub>) of the dorsal bronchiole system (cranial lobe bronchiole I) [5–7].

In the striped dolphin lung, the middle lobe bronchiole, i.e. the first bronchiole (L<sub>1</sub>) of the lateral bronchiole system, is lacking on either side. This provides good evidence that the bronchioles lack not only the cranial lobe bronchioles but also the middle lobe bronchiole, thus supporting the present author's theory [5, 6].

The striped dolphin lung is different in the following respects from those of most other mammals which have been examined previously [6]. The striped dolphin lung has the cranial lobe bronchioles on either side, and the right cranial lobe bronchiole is a tracheal bronchiole. The tracheal bifurcation is more cranial than in most mammals. The middle lobe bronchioles are lacking on either side, and the accessory lobe bronchiole is also lacking. These features can be considered peculiar to the striped dolphin lung.

## REFERENCES

1. Aeby, C. 1880. Der Bronchialbaum des Säugetiere und des Menschen. W. Engelmann, Leipzig.
2. Ellenberger, W. und Baum, H. 1932. Handbuch der vergleichenden Anatomie der Haustiere. 17 Aufl. Julius Springer, Berlin.
3. Huntington, G. S. 1898. *Ann. New York Acad. Sci.* 11: 127-149.
4. Jackson, C. L. and Huber, J. F. 1943. *Dis. Chest* 9: 319-326.
5. Nakakuki, S. 1975. *Proc. Jpn. Acad.* 51: 342-346.
6. Nakakuki, S. 1980. *Bull. Fac. Agr., Tokyo Univ. Agr. Tech.* 21: 1-74.
7. Nakakuki, S. 1993. *J. Vet. Med. Sci.* 55: 435-438.
8. Seiferle, E. 1956. *Okajima's Folia Anat. Japonica* 28: 71-81.