The Bronchial Tree and Blood Vessels of the Cow (Holstein) Lung

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(Received 29 November 1993/Accepted 3 March 1994)

ABSTRACT. In the lung of the cow (Holstein), the right and left bronchi have the dorsal, lateral, ventral and medial bronchiole systems, respectively. Furthermore, the right lung has a tracheal bronchiale (bronchus). From the standpoint of bronchial ramifications, a bilobed cranial lobe and the middle, caudal and accessory lobes can be discriminated in the right lung, whereas a bilobed middle lobe and a caudal lobe can be discriminated in the left lung. The left cranial lobe is lacking. The right pulmonary artery runs obliquely across the ventral side of the trachea caudally to the origin of the cranial lobe bronchiale. It then runs across the dorsal side of the right middle lobe bronchiale, and thereafter along the dorsolateral side of the right bronchus. During its course, it gives off arterial branches running mainly along the dorsal or lateral side of each bronchiale. The left pulmonary artery runs the same course as that in the right lung. The pulmonary veins run mainly along the ventral or medial side of the bronchiale.—KEY WORDS: bronchial tree, cattle, lung, pulmonary artery, pulmonary vein.

Interpretations of the left lung of mammals have differed among authors, especially with regard to the left apical pulmonary lobe [1, 3, 4].

In veterinary anatomy, Ellenberger and Baum [2] considered the right lung to consist of the apical, cardiac, diaphragmatic and intermediate lobes, and the left lung to consist of the apical, cardiac and diaphragmatic lobes, except for the horse lung. This interpretation was widely accepted for many years. Later, however, Seiferle [8] pointed out that the left cardiac lobe of Ellenberger and Baum [2] is, in fact, part of the apical lobe.

In this way, interpretations of the left lung have differed among authors.

Therefore, the present author examined many mammalian lungs to establish the fundamental structure of the bronchial ramifications of the mammalian lung: It was concluded that the dorsal, lateral, ventral and medial bronchiole systems arise from the dorsal, lateral, ventral and medial sides of both bronchi. 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 the two bronchioles arising from the lateral side of the trachea (cranial lobe bronchioles II and III). However, in general, the cranial lobe can be formed by any one of them. The middle lobe bronchiole is formed by the first bronchiole of the lateral bronchiole system. The accessory lobe bronchiole is formed by the first bronchiole of the ventral bronchiole system. The remaining bronchioles of the four bronchiole systems constitute the caudal lobe [5, 6].

In this report, the cow lung will be described on the basis of the above-mentioned theory of the author [5, 6], from the viewpoint of comparative anatomy.

MATERIALS AND METHODS

Three cow lungs were used. The lungs were injected with various colored celluloid solutions into the bronchial tree and blood vessels through the trachea and heart, and then were placed in water until the celluloid had completely coagulated. The soft tissues were treated with hydrochloric acid (HCl), and celluloid cast models were obtained after washing in running water (Fig. 1).

RESULTS

Bronchial ramification and lobular division (Figs. 1, 2): The right cranial lobe bronchiole (cranial lobe bronchiole III) arises from the right side of the trachea, i.e. the tracheal bronchiole (bronchus). This bronchiole divides into the cranial (a) and caudal (b) branches. The cranial branch (a) further gives off two side branches from its dorsal side. The caudal branch (b) divides into two branches, dorsal and ventral. The cranial (a) and caudal (b) branches each form a lobule, respectively. Both lobules are united in their dorsal portions. These areas constitute the right cranial lobe. The right middle lobe bronchiole corresponds to the first bronchiole (L1) of the lateral bronchiole system and arises from the ventrolateral side of the right bronchus and forms a right middle lobe. The right accessory lobe bronchiole is the first bronchiole (V1) of the ventral bronchiole system, and arises from the ventromedial side of the right bronchus, dividing into three branches. This bronchiole forms the right accessory lobe. The remaining bronchioles of the lateral, dorsal and ventral bronchiole systems and a bronchiole of the medial bronchiole system constitute the right caudal lobe. In the
right caudal lobe, the lateral bronchiole system is the most well developed and has the second (L₂) to fifth (L₅) bronchioles. Each branch divides into two branches, cranial and caudal, in its distal portion, except for the fifth bronchiole (L₅). The dorsal bronchiole system has the second (D₂) to sixth (D₆) bronchioles. The ventral and medial bronchiole systems are poorly developed and lack bronchioles in some portions. The ventral bronchiole system has the second (V₂) to fourth (V₄) bronchioles. The fourth bronchiole (V₄) has two bronchioles. The medial bronchiole system has the sixth bronchiole (M₆) only. The right cranial and caudal lobes are united in their dorsal portion, and the middle lobe is separated from the cranial and caudal lobes. Part of the accessory lobe is united with the right caudal lobe.

In the left lung, the cranial lobe bronchioles are lacking. Therefore, the left middle lobe bronchiole, i.e. the first bronchiole (L₁) of the lateral bronchiole system, is well developed. This bronchiole arises from the ventrolateral side of the left bronchus and divides into the cranial (a) and caudal (b) branches. The cranial branch (a) further divides into the dorsal and ventral branches. The cranial (a) and caudal (b) branches each form a lobule, respectively. Parts of these two lobules are united each other and constitute the bilobed left middle lobe. The left accessory lobe bronchiole, i.e. the first bronchiole (V₁) of the ventral bronchiole system, is lacking. The remaining bronchioles of the lateral bronchiole system, and all the bronchioles of the dorsal, ventral and medial bronchiole systems constitute the left caudal lobe. In the left caudal lobe, the lateral bronchiole system has the second (L₂) to fifth (L₅) bronchioles, and the dorsal bronchiole system has the second (D₂) to sixth (D₆) bronchioles. The ventral bronchiole system has the third (V₃) to fifth (V₅) bronchioles, and the fourth bronchiole (V₄) has two bronchioles. The medial bronchiole system has the fourth (M₄) to sixth (M₆) bronchioles. In the left lung, the middle and caudal lobes are united in their dorsal portions.

In each bronchiole system, the distance between the origins of the bronchioles becomes shorter in a more cranial direction in both bronchi.

Distribution of the pulmonary artery (Figs. 3, 4): The right pulmonary artery runs obliquely across the ventral side of the trachea caudally to the origin of the right cranial lobe bronchiole III. Then it runs across the dorsal side of the right middle lobe bronchiole, and thereafter along the dorsolateral side of the right bronchus, between the dorsal (D) and lateral (L) bronchiole systems. The right cranial lobe artery arises from the cranialateral side of the right pulmonary artery and divides into two branches. The first branch runs along the medial side of the main trunk of the cranial branch (a) in its initial portion and gives off two branches. One branch runs along the ventromedial side of the first side branch, and the other along the dorsomedial side of the second side branch. Then, the first branch appears at the lateral side of the main trunk and runs along its dorsolateral side. The second branch runs along the medial side of the dorsal branch of the caudal branch (b), whereas in the ventral branch, it runs along its lateral side. The right middle lobe artery arises from the ventrolateral side of the right pulmonary artery and runs along the lateral side of the bronchiole. The right accessory lobe bronchiole arises from the ventromedial side of the right pulmonary artery and runs along the ventral side of the bronchiole. Thereafter, the right pulmonary artery gives off arterial branches running along each bronchiole of the right caudal lobe. In the lateral bronchiole system (L), arterial branches arise from the ventrolateral side of the right pulmonary artery and run along the cranialateral side of each bronchiole. In the dorsal bronchiole system (D), arterial branches arise from the dorsal or dorsomedial side of the right pulmonary artery and run along the dorsolateral side of each bronchiole. In the ventral bronchiole system (V), arterial branches arise from the ventral or ventromedial side of the right pulmonary artery and then run obliquely across the ventral side of the right bronchus and run along the ventrolateral side of each bronchiole. In the medial bronchiole system (M), an arterial branch arises from the cranial side of the right pulmonary artery and runs along the dorsal side of the bronchiole after running across the dorsal side of the right bronchus. In the left lung, the left middle lobe artery has two branches. The first branch arises from the dorsolateral
Fig. 2. Bronchial tree of the cow lung, ventral aspect.

Fig. 3. Bronchial tree and blood vessels of the cow lung, dorsal aspect.

Fig. 4. Bronchial tree and blood vessels of the cow lung, ventral aspect.

Abbreviations

Figs. 2-4:

D — dorsal bronchiole system
L — lateral bronchiole system
V — ventral bronchiole system
M — medial bronchiole system
III — cranial lobe bronchiole III
L1 — middle lobe bronchiole
V1 — accessory lobe bronchiole

The remaining bronchioles constitute the caudal lobe.

1 — right pulmonary artery
2 — right cranial lobe artery
3 — right middle lobe artery
4 — right accessory lobe artery
5 — right cranial lobe vein
6 — right middle lobe vein
7 — right accessory lobe vein
8 — right caudal lobe pulmonary venous trunk
9 — left pulmonary artery
10 — left middle lobe artery
11 — left middle lobe vein
12 — left caudal lobe pulmonary venous trunk

The other arteries and veins are distributed in the caudal lobe.
side of the left pulmonary artery and divides into two branches, one running along the medial side of the dorsal branch of the cranial branch (a), and the other along the lateral side of the ventral branch of the cranial branch (a). The second branch arises from the ventrolateral side of the left pulmonary artery independently, or forming a short common trunk with the arterial branch running along the lateral side of the second bronchicle (L₂) of the lateral bronchicle system, then running along the caudo-lateral side of the caudal branch (b). In the left caudal lobe, the distributional pattern of branches of the pulmonary artery is the same as in the right caudal lobe.

Distribution of the pulmonary vein (Figs. 3, 4): In the right cranial lobe, pulmonary veins run along the medial side in the cranial branch (a). In the caudal branch (b), pulmonary veins run along the lateral side of the dorsal branch, whereas, in the ventral branch, a pulmonary vein runs along its medial side. The above pulmonary veins form a short common trunk, i.e. the trunk of the right cranial lobe vein. The right middle lobe vein runs along the craniomedial side of the right middle lobe bronchicle and is in contact with the trunk of the right cranial lobe vein, or independent before entering the left atrium. The right accessory lobe vein runs along the dorsal side of the bronchicle and enters the base of the right caudal lobe pulmonary venous trunk. In the right caudal lobe, in the lateral bronchicle system (L₁), pulmonary veins run along the caudomedial side of each bronchicle. In the dorsal bronchicle system (D), the pulmonary veins run along the caudal or ventral side of each bronchicle. In the ventral bronchicle system (V), pulmonary veins run along the dorsal side of the bronchicle. In the medial bronchicle system (M), a pulmonary vein runs along the caudoventral side of the bronchicle. The above pulmonary veins enter the right caudal lobe pulmonary venous trunk, running closely along the ventromedial side of the right bronchus, respectively.

In the left lung, the left middle lobe vein runs along the lateral side of the dorsal branch of the cranial branch (a), whereas in the ventral branch, a pulmonary vein runs along the medial side. In the caudal branch (b), the pulmonary vein runs along the craniomedial side. These veins form a short common trunk before entering the left atrium. The distributional pattern of the pulmonary veins in the left caudal lobe is the same as in the right caudal lobe.

DISCUSSIONS

The bronchial tree and the distribution of the pulmonary blood vessels are similar to those of the Japanese deer (Cervus nippon) lung [7].

The left middle lobe bronchicle, as designated by the present author, corresponds to the common trunk of the apical and cardiac lobe bronchioles (bronchi) of Ellenberger and Baum [2] and the apical lobe bronchicle of Seiferle [8]. However, the right cranial lobe bronchicle of the cow arises from the right side of the trachea. This bronchiole corresponds to the cranial lobe bronchiole III in the fundamental structure of the bronchial ramification of the mammalian lung [5, 6], and is an epiarterial bronchiole. The right cranial lobe bronchiole II, arising from the right side of the trachea, is usually lacking in the cow. However, it has been found as a variation [6]. The right cranial lobe bronchiole I, arising from the dorsolateral side of the right bronchus, i.e. the first bronchiole (D₁) of the dorsal bronchicle system, is also lacking in the cow. These two cranial lobe bronchioles, if present, also belong to the epiarterial bronchiole. The right middle lobe bronchicle is the first bronchiole (L₁) of the lateral bronchicle system and arises from the ventrolateral side of the right bronchus, being one of the hypoarterial bronchioles. In this way, the cranial and middle lobe bronchioles differs completely in their origins, their bronchiole systems and their relationships to the pulmonary artery.

The left middle lobe bronchicle, as designated by the author, is the first bronchiole (L₁) of the lateral bronchicle system and arises from the ventrolateral side of the left bronchus, being one of the hypoarterial bronchioles. The origin of this bronchiole is at the same level as that of the right middle lobe bronchicle. Therefore, the left middle lobe bronchicle, as designated by the author, does not correspond to any right cranial lobe bronchiole, but to the right middle lobe bronchicle. This bronchiole corresponds to the left cranial lobe bronchicle (bronchus) of the dog or pig in terms of accepted veterinary anatomy. The well-developed nature of the left middle lobe bronchicle is a compensatory development for the absence of the left cranial lobe bronchioles. The left cranial lobe bronchioles II and III arising from the left side of the trachea are apparently lacking in the cow. The left cranial lobe bronchicle I, i.e. the first bronchiole (D₁) of the dorsal bronchicle system, is also lacking. Consequently, all of the left cranial lobe bronchioles are lacking in the cow lung.

Thus, it is important to take into consideration the four bronchiole systems and pulmonary artery in order to identify the bronchial tree and lung lobes.

The right cranial lobe bronchiole divides into cranial (a) and caudal (b) branches, each of which forms a lobule. The cranial lobule corresponds to the cranial part of the right cranial lobe, and the caudal one corresponds to the caudal part of the right cranial lobe in veterinary anatomy. In the left lung, the left middle lobe bronchiole, as designated by the present author, also divides into the cranial (a) and caudal (b) branches, and each branch forms a lobule. The cranial lobule corresponds to the cranial part of the left cranial lobe, and the caudal one to the caudal part of the left cranial lobe in veterinary anatomy.

REFERENCES


