

## BRONCHO-PULMONARY TREE AND SEGMENTS OF THE LUNGS OF BUFFALO CALVES

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### ABSTRACT

The study revealed that the main bronchi emanating from trachea and principal bronchus on the right side gave off nineteen branches while on the left, these were fifteen in number. The branching of pulmonary arteries and veins followed the same pattern as that of the bronchial tree. However, crossing over of fine arteries and veins from one segment to other was evident which was absent in the bronchial tree.

**Key words:** Broncho-pulmonary segments, bronchial tree, pulmonary veins, pulmonary artery

The anatomy of the bronchial tree has been described by Aeby (1880) but till-date, the classification of the broncho-pulmonary segments is not clear. The accurate information on this aspect will be of great help to the pathologists, surgeons and physicians aiding in diagnosis and treatment of respiratory disorders. Thus the present work was undertaken to study the broncho-pulmonary tree and the segments of lungs in the buffalo calves.

### MATERIALS AND METHODS

The study was conducted on 20 buffalo calves which had been used by the students for myology practicals. Piecemeal removal of the lung parenchyma starting from the apical bronchus was done in 5 out of 20 lungs, so as to expose the branching pattern of this bronchus. The same technique was applied for other main branches emanating from the principal bronchus. For the purpose of clarity, at places minute branches were severed. The margins of the lungs were left undissected, so that the bronchi remain fixed. After having dissected the bronchial tree, the line diagram was drawn.

In five pairs of lungs, saturated solution of lead oxide prepared in a mixture of soap solution

and water was injected into the trachea. Immediately after the filling, the lungs were radiographed in dorso-ventral position. Similarly, five pairs of lungs were injected with the contrast material for studying the pattern of pulmonary arteries and so also the pulmonary veins. All these lungs, injected with contrast material and being radiographed, were again dissected after removal of the contrast material through excessive washing with water.

### RESULTS AND DISCUSSION

**Right lung:** The numbers or alphabets given hereafter are marked on the line diagrams viz. Figs 1-5). The trachea gives off the tracheal bronchus at the level of 3<sup>rd</sup> or 4<sup>th</sup> rib which enters the cranial lobe of the right lung. The tracheal bronchus just after its origin gives out a branch from its dorsal surface. This branch (RCr-1) is directed dorsally and supplies the central and the dorsal part of the cranial lobe. The main branch (RCr-2) then continues cranially and supplies the cranial part of the cranial lobe. Just close to the origin of the tracheal bronchus another branch is given out which is directed caudally. At times this branch and the tracheal bronchus have a common opening into the trachea. This caudally directed branch further gives a branch that is directed caudo-ventrally (RCr-3) and the main

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trunk continues dorsally. This main trunk then divides into two branches supplying the dorsal (RCr-4) and middle (RCr-5) part of the caudal part of the cranial lobe. Guzsal (1952) in cattle, sheep, pig and dog and Nanda and Patel (1967) in goat reported four segmental bronchi in right apical lobe while Hare (1955) in sheep and Talanti (1959) in pig had reported two segmental bronchi of right apical lobe. However, Ishq (1980) in dog reported six branches of right apical lobar bronchus. Where as, Tucker and Krunentz (1957) in dog had earlier pointed three branches only.

The trachea then continues caudally and divides into left (LB) and right (RB) principal bronchi at the level of 5<sup>th</sup> or 6<sup>th</sup> rib. The right bronchus then enters the right lung through the hilus and gives out a branch (RMI) from its ventral surface, which is directed into the middle lobe as the middle bronchus. Just after its origin, it gives out a small branch from its dorsal aspect, which runs towards the dorsal part of the middle lobe. The main bronchus of the middle lobe then continues ventrally towards the ventral most tip of the middle lobe.

Thereafter, from the right bronchus the intermediate bronchus (RI-1) arises ventrally close to the origin of middle bronchus. On entering the intermediate lobe it gives out dorsal intermediate branch and a ventral intermediate branch. The dorsal branch is smaller than the ventral branch and it supplies to about one-fourth of the lobe. The ventral branch is the continuation of the lobar bronchus and it supplies to about three – fourths of the intermediate lobe. However, Nanda and Patel (1968) observed two segmental bronchi each for the cardiac (middle) and accessory (intermediate) lobes in goat. While Guzsal (1952) described three segmental bronchi status to cardiac lobe and only one to the intermediate lobe in cattle, sheep, pig and horse.

The principal bronchus then continues as the caudal bronchus. The first branch (RCd-1) takes its origin from the dorsal aspect of the main right caudal bronchus. It runs dorsally and then divides into two equal branches running cranially and caudally. The second branch (RCd-2) from the right caudal bronchus arises from the lateral surface and runs laterally towards the base of caudal lobe. It also divides into two branches,

approximately at a distance of two inches from the main right bronchus, running in the cranial and caudal directions. Just ahead of its origin, it gives out few branches from its dorsal surface, which supplies the mid part of the caudal lobe in this particular region. The third branch (RCd-3) arises from the dorsal surface of the right caudal bronchus but is placed slightly medial to the origin of 1<sup>st</sup> dorsal branch (RCd-1) and it runs dorsally into the parenchyma of the caudal lobe. Just opposite to the RCd-3 the fourth branch (RCd-4) is given out from the ventral surface of the right caudal bronchus, which runs ventrally. Caudal to this is the fifth branch (RCd-5) which arises from the lateral surface of the right bronchus but is placed slightly dorsal to the origin of second branch and after giving few dorsally directed branches it continues towards the ventro- lateral part of the caudal lobe. The sixth branch (RCd-6) is again a dorsal branch, which runs dorsally. Opposite to its origin is the seventh branch (RCd-7) which originates from the ventral surface and is directed towards the ventral part of the caudal lobe. Caudal to the seventh branch is the eighth branch (RCd-8) which arises from the lateral surface of the right principal caudal bronchus. On its way it gives out few dorsally directed branches. The ninth branch (RCd-9) is ventrally directed and is followed by the tenth branch (RCd-10), which is given out, from the dorsal surface of the right caudal bronchus. Just caudal to the tenth branch, is given out the eleventh branch (RCd-11) which arises from the lateral surface of the right caudal bronchus and is directed caudally. The twelfth branch (RCd-12) arises from the ventral surface and thereafter the right caudal bronchus divides into two, although it gives out two or three minor branches which are directed caudally, dorsally and ventrally.

Hare (1955) in sheep, Talanti (1959) in pig and Nanda and Patel (1967) in goat reported that the diaphragmatic lobar bronchus gave rise to six segmental bronchi. Ishaq (1980), however, reported thirteen segmental branches ventilating diaphragmatic lobe in dog. Taking this into account, the total number of broncho-pulmonary segments in the right lung of buffalo calves came out to be nineteen.



**Left lung:** In the left lung, the first branch is given out from the lateral surface of the left principal bronchus that enters the cranial lobe. It divides into two main branches. One of the branches is directed cranio-dorsally into the cranial part. This branch gives out a main offshoot directed dorsally (LCr-1) and thereafter it divides into two branches (LCr-2 and 3) directed cranially. The second branch (LCr-4) is directed laterally which goes into cardiac part of the cranial lobe.

The left principal bronchus thereafter enters the caudal lobe as the left caudal bronchus and gives the branches similar to the right caudal bronchus except that the twelfth branch, which arises from the ventral aspect, is absent. However, in some of the lungs, the number of branches is constant but their origin is different. Hare (1955) in sheep and Getty (1975) in ox and horse reported that apico-cardiac lobar branches of the left lung gave off apical and cardiac segmental bronchi. Talanti (1959), however, reported three in pig and Guzsal (1952) had pointed six segmental bronchi in cattle, sheep, horse, pig and dog. Ishq (1980) observed total nine number of branches in this and left middle lobe of dog while Tucker and Kremenz (1957) had reported three segmental bronchi in left apical and two in the middle lobe of dog. Eleven main branches were observed in the present study in the caudal lobe and hence the total number is fifteen. In the left lung, six segmental bronchi have been reported in the caudal lobe of ruminants and horse (Getty, 1975). However Talanti (1959) reported five in pig and so also Tucker and Kremenz (1957) in dog.

From the earlier observations and the present findings it is still debatable as to how many broncho-pulmonary segments in reality do exist. Although Guzsal (1952) and Hare (1955) worked extensively on sheep yet their findings did not corroborate with each other. Ishq (1980) clearly negated as arbitrary division of the lungs into broncho-pulmonary segments. Appleton (1944) defined the broncho-pulmonary segment as a large portion of lung which is ventilated by bronchi that have orifices into one of the lobar bronchi. Going by this norm, the branches from the tracheal bronchus in the present study can be

reduced from five to two in the right cranial lobe and from four to two in the left cranial lobe thereby reducing the total number from nineteen to sixteen in the right lung and from fifteen to thirteen in the left lung.

**Pulmonary artery:** The pulmonary trunk (Figs 6-8) divides into right and left branches slightly left to the median plane. The right pulmonary artery passes towards the right side from the ventral surface of the trachea. It gives out its first branch, which is placed ventral to the trachea, and it moves towards the cranial lobe. The right pulmonary artery then takes a curve and comes to lie on the dorsal surface of the principal right bronchus. Just at its curvature it gives off a branch, which is directed laterally into the middle lobe. Just opposite to the middle branch but from the ventral surface, it gives off a branch, which moves into the intermediate lobe. After coming out on the dorsal surface of the right principal bronchus, it gives off the first branch, which runs dorsally along with the cranial (RCd-1) branch of the right caudal bronchus. Thereafter, it gives off the branches, which follow the same pattern as that of the bronchial tree of the right side. Although the branching pattern of the artery is similar to the bronchial tree, yet from the main stem of the pulmonary artery a few branches are given off from its medial surface that run ventrally into the parenchyma of the lung. The left pulmonary artery also follows the same branching pattern as that of the left bronchus.

**Pulmonary veins:** The pulmonary veins (Figs 9-11) from the left and right caudal lobes get their tributaries, which are similarly placed as the bronchial tree and the left and right pulmonary arteries. The right caudal pulmonary vein just before it merges with its counterpart from the left caudal lobe receives a branch from the intermediate lobe. Thereafter, both the left and right veins from the caudal lobes join together and open through a common opening on the caudal aspect of the left auricle. Just cranial to this opening, there are two openings present on either side of the wall of the left auricle which are the openings of pulmonary veins which bring blood from the (1) right cranial and middle lobe and the (2) the left cranial lobe.

Although it is seen that the arteries and veins





Fig 1. Dorsal view of the bronchial tree.



Fig 2. Ventral view of the bronchial tree.

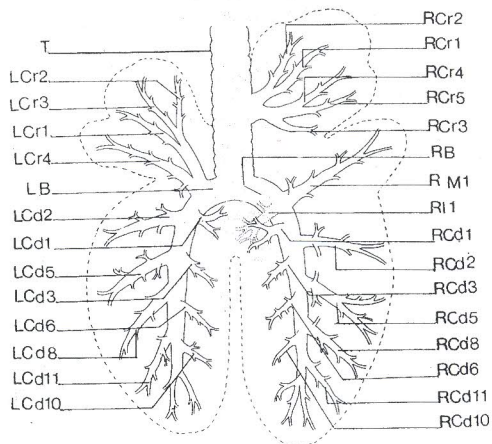


Fig 3. Line diagram of the bronchial tree as seen from the dorsal aspect. T-Trachea, RCr-1 to RCr-5-Branches from tracheal bronchus, RB-Right bronchus, RM-1-Right middle branch from right bronchus, RI-1-Right intermediate branch from right bronchus, RCd-1, 2, 3, 5, 6, 8, 10 and 11-Branches from right caudal bronchus, LCr-1 to LCr-4-Cranial branches of left bronchus, LB-Left bronchus, LCd1, 2, 3, 5, 6, 8, 10 and 11-Branches from left caudal branches.

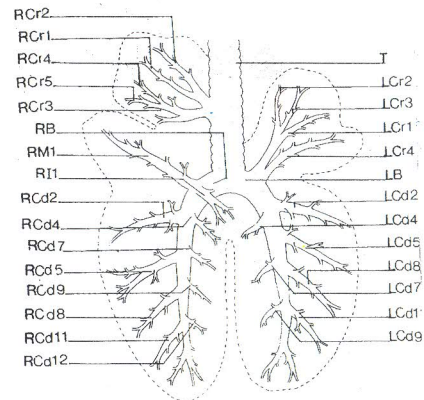


Fig 4. Line diagram of the bronchial tree as seen from the ventral aspect. T-Trachea, RCr-1 to RCr-5-Branches from tracheal bronchus, RB-Right bronchus, RM-1-Right middle branch from right bronchus, RI-1-Right intermediate branch from right bronchus, RCd-2, 4, 5, 7, 8, 9, 11 and 12-Branches from right caudal bronchus, LCr-1 to LCr-4-Cranial branches of left bronchus, LB-Left bronchus, LCd-2, 4, 5, 7, 8, 9 and 11-Branches from left caudal branches.

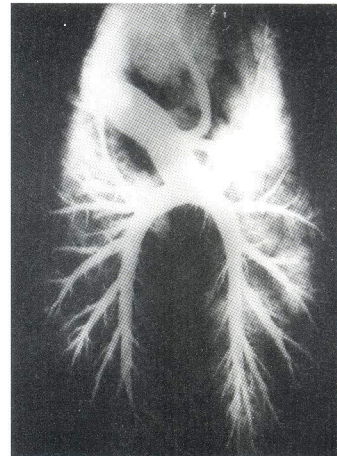


Fig 5. Radiograph of the bronchial tree, injected with saturated solution of lead oxide.



Fig 6. Dorsal view of the bronchial tree (white) and pulmonary arteries (red).



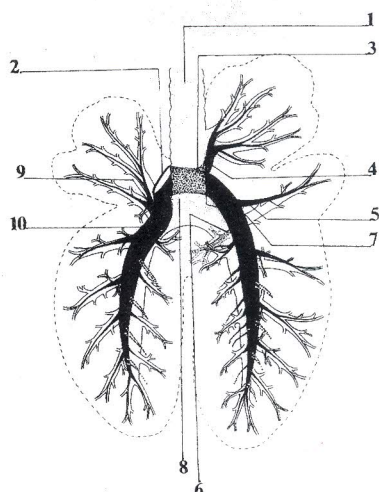


Fig 7. Line diagram showing the relationship of pulmonary arteries with the bronchial tree. (1) Trachea, (2) Pulmonary trunk, (3) Right pulmonary artery, (4) Branch to cranial lobe, (5) Branch to middle lobe, (6) Branch to intermediate lobe, (7) Right caudal lobular artery, (8) Left pulmonary artery, (9) Branch to left cranial lobe and (10) Left caudal lobular artery.

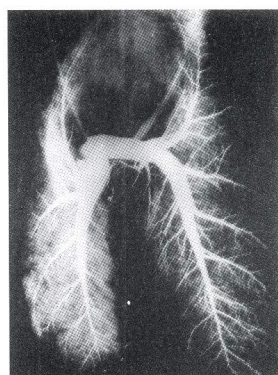


Fig 8. Radiograph of the pulmonary artery injected with saturated solution of lead oxide.



Fig 9. Ventral view of the bronchial tree and pulmonary veins (blue).

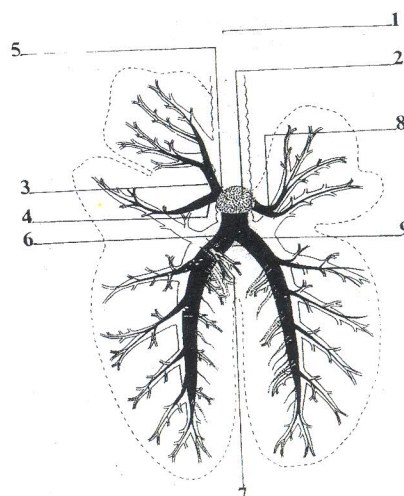


Fig 10. Line diagram showing the relationship of pulmonary veins with the bronchial tree. (1) Trachea, (2) Left auricle, (3) Right cranial lobular vein, (4) Right middle lobular vein, (5) Right common cranial vein, (6) Right caudal lobular vein, (7) Intermediate lobular vein, (8) Left cranial lobular vein and (9) Left caudal lobular vein.

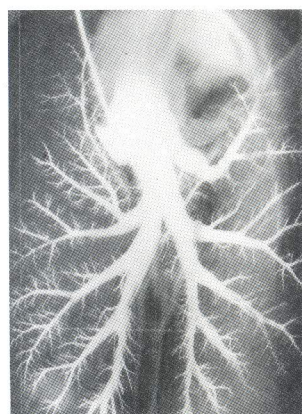


Fig 11. Radiograph of the pulmonary veins injected through left auricle, with saturated solution of lead oxide.

follow the pattern of the bronchial tree, yet some branches of the arteries and the tributaries of the veins do not strictly adhere to it. The observations of the present study regarding the branching pattern of pulmonary artery and tributaries of pulmonary veins is in consonance with the observations of Tucker and Kremetz (1957) who reported that an individual lobe is supplied by one arterial branch from the pulmonary artery, but commonly the venous drainage from a lobe also receives tributaries from other lobes and enters by a common channel into the left atrium. It was also observed in the present

study that the bronchi are generally centrally located with the pulmonary artery on one side and pulmonary vein on the other. Same observations were also made earlier by McLaughlin *et al.* (1961) in ox. However, it was also seen that tributaries for the veins and the branches from the arteries do penetrate into the adjoining broncho-pulmonary segments. This clearly indicates that the main branch arising from the lobar bronchus can not be deduced to form a separate broncho-pulmonary segment as the blood vessels are not only confined to that small unit thereby making difficult the resection of a broncho-pulmonary segment from the lung without affecting the tissue form adjoining areas. It is therefore opined that a broncho-pulmonary segment should be one, which has an independent bronchus and arterial branch and a venous tributary. It is felt that in the present study, the last three branches can be grouped into one broncho-pulmonary segment, thereby reducing the number from sixteen to fourteen in the right lung and from thirteen to eleven in the left lung. It also seems that probably the ventral branches which were emanating from the ventral aspect of the caudal lobar bronchi were not taken into account in the previous studies due to which their numerical number in the caudal lobes is less as compared to the cranial lobe.

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