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Research Article

EXPLORATORY ANATOMY OF THE TRACHEO-BRONCHIAL TREE OF GOAT USING CORROSION CAST TECHNIQUE

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ABSTRACT

The pulmonary airways are organised in a complex branching pattern to facilitate gas exchange in the lungs. Information of this three dimensional branching pattern may help in better understanding of physiological and pathological condition of lung. Tracheo-bronchial tree of goat lung was prepared by injecting silicon sealant and digested by nitric acid. Cast produced through this method was flexible, resistant to acid and easy to handle. It provided complete information about the lung lobulation and aeration of different lobes of lung by different branches of bronchi and bronchioles. It also gave information about apical bronchus present in ruminants.

Keywords: Corrosion cast, Goat, Tracheo-bronchial tree

The respiratory system is the basic prerequisite for living organisms. So, a precise knowledge of normal anatomy and various dimensions of respiratory tract are inevitable. The pulmonary airways are organised in a complex branching arrangement to facilitate gas exchange in lungs. Information about this three dimensional branching pattern may help in better understanding of physiological and pathological condition of lung. Gross visualisation of this pathway is not possible. However, preparation of corrosion cast of tracheo-bronchial pathway provide an important contribution to the development of an animal model for study of normal anatomical, physiological as well as pathological condition of lung. Teaching and learning anatomy, as a process, has also changed. Today, technique such as corrosion casting is known to be a more effective way of achieving optimal results with the students (Rueda-Eastaben *et al.*, 2017). Corrosion cast of tracheobronchial tree acts as a well elaborative teaching aid for detailed understanding of lower respiratory passage. In present study, corrosion casts of goat lungs were prepared as it provide detailed information about the branching pattern of ruminant lungs and goats specifically which are more prone to respiratory distress in early age.

MATERIALS AND METHODS

Six [fresh] samples of goat lungs were collected from local meat shop of Rewa district of Madhya Pradesh. The samples were collected from 1- 2 year old goat during autumn season (January- February). The samples were thoroughly rinsed with normal saline solution and subjected to infusion of silicone sealant by injecting gun through the trachea. The injected silicone sealant was further pushed towards the caudal part of different lung lobes by manual pressure without puncturing the lung surface. After that the infused samples were kept in upright position by thread. The injected silicone sealant within the lung lobes and tracheal tube started solidifying once it was exposed to normal air contact at room temperature. This was left as such for 24 hours without altering its position further. After 24 hours interval, the solidified lungs samples were kept for acid digestion to remove the biological tissue except rubbery model of bronchial tree. The 50% diluted nitric acid was used just at the level of dipping of whole lung solidified specimens for 24-48 hrs. Thereafter, it was removed from acid digestion and placed under running tap water to remove the acid. It was then air dried and kept in room temperature for study of morphological pattern of trachea-bronchia lair passage (Menaka, 2015).

RESULTS AND DISCUSSION

A hand breadth long tracheal cast was obtained along with the ventral impression of cartilaginous rings. Two chief bronchi diverge from the line of trachea. In goat, a separate apical bronchus arose proximal to the tracheal bifurcation which separately aerated the apical lobe of right lung (Fig. 1) which was in confirmation with the findings of Singh *et al.* (2006) in buffalo calves, Monteiro and Smith (2014) in pigs and Menaka (2015) in goats. The structure of primary bronchi was similar to trachea. Variation in the diameter of bronchi and bronchiole was greater. The lobes were properly defined by ramification of bronchial tree which was in accordance with the reports of Viggiano *et al.* (2003) in sheep and pig. The right and left chief bronchi detached a bronchus to the cranial lobe before continuing caudally. Bronchial tree in goat followed "monopodial pattern", i.e., every secondary bronchus arose from each longitudinal main bronchus which resembled with the findings of Monterio and Smith (2014) and Autifi *et al.* (2015). The specific portion of lung was supplied by well identifiable bronchi. The right lung was divided in four lobes viz. apical, cardiac/middle, accessory and diaphragmatic (Fig. 1). The left lung was

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divided in apical and diaphragmatic lobes (Fig. 1). Several authors have also reported the lobulation pattern of lung in different species of animals with four identifiable lobes in right lung and two in left lung like Singh *et al.* (2006) in buffalo calves, Monteiro and Smith (2014) in pig and rat, Menaka (2015) in goats, Menaka *et al.* (2015) in equines and Autifi *et al.* (2015) in rabbits. The apical lobe of left lung was further divided into cranial (apical) and caudal (cardiac) parts by interlobar fissure. Corrosion cast prepared by the use of silicon sealant was flexible, strong and durable. Due to its durability and flexibility, preservation of tree for longer duration is possible as well as it maintain the integrity of very fine branches of tree (Temiselvan *et al.*, 2017).

RIGHT LUNG

The apical lobe of the right lung was further divided in to cranial and caudal division. The apical bronchus (Abr) which arose separately from the trachea and entered the apical lobe gave another branch, just after its origin, from its dorsal surface (Abr 1) and together supplied to the cranial division of the apical lobe (Fig. 2). The main branch (Abr 2) continued cranially and bifurcated to form secondary bronchi which further ramified to supply the cranial division of apical lobe. Just close to the opening of the apical bronchus, another branching occurred that was directed caudally (Abr 3). It gave off a branch caudo-ventrally (Abr 4) and the main branch (Abr 5) further ramified and supplied to the caudal division of the apical lobe.

The right principal bronchus after entering into the lungs through the hilus gave a branch (Cbr 1) from its ventral surface that supplied to the middle/cardiac lobe and was considered as middle bronchus. A small branch (Cbr 2) also arose from the dorsal aspect of the middle bronchus that supplied to the dorsal part of the cardiac lobe. Thereafter, the middle bronchus continued ventrally and ramified to supply the major portion of the middle/ cardiac lobe. The right principal bronchus gave an intermediate bronchus (Ibr 1) ventrally close to the origin of middle bronchus which further bifurcated into dorsal and ventral branches supplying to the intermediate lobe. Thus, two segmental bronchi, each for cardiac and intermediate lobe, were observed in the present study which was in accordance with the findings of Singh *et al.* (2006).

The right principal bronchus then continued caudally as diaphragmatic bronchus (Dbr) which gave off approximately 13-14 segmental bronchi which supplied to the diaphragmatic lobe of the right lung. The first branch (RD1) arose from the dorsal aspect of the right principal bronchus and ramified into minute branches (Fig. 3). The second branch (RD 2) originated from the right lateral surface of the right principal bronchus (Fig. 3). Just after its origin, it gave a small dorsal branch and then divided into cranial and caudal branches which further ramified and supplied towards the base of the diaphragmatic lobe. The third branch (RD 3) was left dorso-lateral in position and ran dorsally in to the parenchyma of the diaphragmatic lobe (Fig. 3). The fourth branch (RD 4) arose from the ventral surface of the principal bronchus, just opposite to the third branch which supplied ventrally. The fifth branch (RD 5) originated from the right lateral face, slightly dorsal to the second branch (Fig. 4). The sixth branch (RD 6) was again a dorsal branch (Fig. 4). The seventh branch (RD 7) originated from the ventral surface just opposite to the sixth. The eighth branch (RD 8) arose from the right lateral face of the principal bronchus caudal to the seventh branch. The ninth branch (RD 9) was ventral in position followed by a small left lateral tenth branch (RD 10). The eleventh branch (RD 11) was dorsally oriented and the twelfth branch (RD 12) originated from the left lateral face of the principal caudal bronchus. The thirteenth branch (RD 13) was ventrally present followed by a small dorsal placed fourteenth branch (RD 14) that arose just above the caudal bifurcation. After its origin, the caudal bronchus bifurcated and ramified in the region. All these branches after their origin further underwent divisions and ramifications and supplied the respective region of the diaphragmatic lobe.

LEFT LUNG

After branching of trachea, left principal bronchus entered into the left lung. It gave origin to apical bronchus which further divided in to cranio-dorsal branch (LA 1) supplying to the apical part and ventral branch (LA 2) supplying to the cardiac part of apical lobe, respectively. Thereafter, it continued as diaphragmatic bronchus that supplied to the diaphragmatic lobe of left lung. During its passage, it gave approximately 17 branches. The first branch (LD 1) originated dorsally from the main diaphragmatic bronchus (Fig. 3). The second branch (LD 2) originated from the left lateral aspect of the main trunk and ran towards the basal part (Fig. 5). It divided in to two branches which further ramified to supply the lung parenchyma. The third branch (LD 3) arose from the right dorso-lateral aspect of main trunk (Fig. 5). The fourth branch was given off from the ventral aspect of the trunk (LD 4). Another branch (LD 5) came from the left lateral aspect of the main trunk (Fig. 5). Two branches (LD 6 and LD 7) originated from the right dorso-lateral aspect and ventral aspect of main trunk, respectively, was identified only on the left side of tracheobronchial tree (Fig. 5). Another branch was dorsally situated (LD 8) while next

Fig. 1. Corrosion cast of goat lung showing Trachea (1), Right Apical bronchus (2), Right principal bronchus (3), Left Principal bronchus (4), Apical Lobe (i), Cardiac lobe/branch (ii), Diaphragmatic lobe (iii) and Right Intermediate lobe (iv). (Dorsal view)

Fig. 4. Corrosion cast of Tracheo-broncheal tree of goat showing branches of right diaphragnatic bronchus namely RDS (Right lateral), RD6 (dorsal branch) and further branching pattern of the candal part (arrow).

Fig. 2. Corrosion cast of Tracheo-broncheal tree of goat showing Trachea (1), Left principal bronchus (2), Right principal bronchus (3). Apical bronchus (Abr), Right canliac bronchus (Cbr1), Right intermediate bronchus (Ibr1) and Diaphragmatic bronchus (Dbr). (Ventral view).

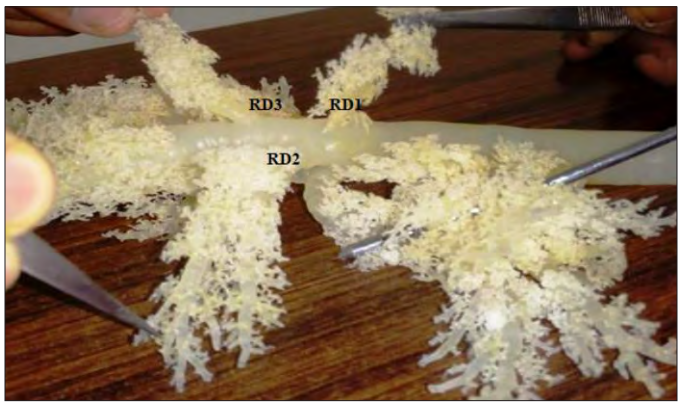

Fig. 3. Corrosion cast of Tracheo-broncheal tree of goat showing initial branches of right diaphragnatic bronchus namely RDI (dorsal branch), RD2 (Right lateral) and RD3 (Left dorso-lateral).

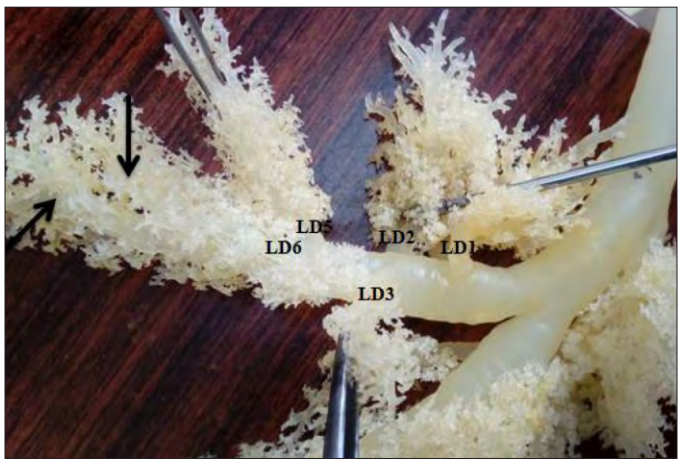

Fig. 5. Corrosion cast of Tracheo-broncheal tree of goat showing branches of left diaphragmatic bronchus namely LDI (Dorsal branch), LD2 (Left lateral branch) LD3 (Right dorso-lateral brnach), LDS (Left lateral), LD6 (Right dorso-lateral) and further branching pattern of the candal part (arrow).

branch (LD 9) originated from the ventral aspect of the trunk. Next branch originated from left lateral aspect (LD 10) and another branch from the right lateral aspect (LD 11). Twelfth branch (LD 12) was given off from the ventral aspect and was followed by the dorsal branch (LD 13). Fourteenth branch(LD 14) ran in right lateral aspect

followed by a left lateral branch (LD 15). Next branch (LD 16) originate in ventral aspect followed by a dorsal branch (LD 17). After origin of these branches, the main trunk divided in to two segments that further ramified to supply the caudal most part of diaphragmatic lobe of left lung.

Different authors have described the branching pattern of pulmonary airways that varied among species. Monteiro and Smith (2014) had described fourteen segmental branches from right principal bronchus and thirteen branches from left principal bronchus in case of pigs while in rat, it was fifteen from right and thirteen from left. Kamath *et al.* (2013) had enumerated 10 branches from each principal bronchus in sheep. Singh *et al.* (2006) had reported the presence of sixteen branches in right lung and thirteen branches in left lung of buffalo calves. So it can be inferred that branching pattern varies with species that depends upon the extent of ventilation required in order to meet the individual demand.

Each segmental bronchus after its origin, divided from the principal bronchi, further branched and ramified to form the bronchial tree which was well identified. The regionalization of lung lobe with typical segmental organization and ramification makes a clear cut understanding of the airways distribution pattern. The broncho-pulmonary division is somewhat arbitrary and varies with species. However, the prime motto lies in optimum ventilation of the lung to meet the demand of an individual organism for its survival.

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