

ORIGINAL PAPER

Venous circulation of the bronchial wall

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Abstract

Bronchial supply plays an important role in both the protecting mechanisms and the pathogenic ones of many chronic inflammatory, infections or ischemic diseases of the lung. However, little is known regarding the bronchial supply development; the appearance of the connections to the functional pulmonary supply; the territory supplied by the bronchial veins. In this study, we follow the distribution of the pulmonary veins branches at the level of the subcarinal airways and their relationship to the bronchial veins in the human lungs. For studying the venous supply of the airways, we used the corrosion and colored gelatin injection methods followed by microdissection by means of an operator microscope. Venous circulation of the intrapulmonary airways is mainly tributary to the pulmonary vein branches. Venous circulation of the extrapulmonary airways is tributary to both the pulmonary and the bronchial veins. Taking into account the difference of sizes, we consider that, under physiologic conditions, the main venous collector is represented by the pulmonary veins.

Keywords: bronchial circulation, pulmonary veins, vascular casting, dissection.

Introduction

Bronchial supply plays an important role both in the protecting mechanisms and the pathogenic ones of many chronic inflammatory, infections or ischemic diseases of the lung [1–2]. The complex anatomy of the vasculature supplying the subcarinal airways has been known for many years.

Miller WS [3] described the unique arrangement of parallel vascular plexus of the bronchial circulation. However, the bronchial supply development, the appearance of the connections to the functional pulmonary supply, the territory supplied by the bronchial veins and the precise route for blood flow through this vasculature are still unknown [4–6].

In this study, we follow the distribution of the pulmonary veins branches at the level of the airways and their relationship to the bronchial veins in the human lungs.

Material and methods

In order to perform this study we used human lungs collected during necropsy of cases of sudden death (accidents, suicide, etc.) from the Necropsy Service of the Emergency County Hospital of Craiova. Normal human lungs were used and during their removal care was taken to leave the stems of the pulmonary artery and veins and of the bronchus as long as possible.

We have used the vascular castings and microscopic

dissection coupled with tracers to define detailed anatomy of the venous supply of the airways.

As to achieve vascular castings we used a modified washing method of Pump KK [7] to clean the lung vascular system: after the lung had been removed, trachea was cannulated and distilled water was injected through it at a pressure of 40 cmH₂O; a blood emptiness of the pulmonary vascular system occurred through the free pulmonary arteries and veins once the lungs had been expanded; after the total lung expansion, as much as possible of the fluid was removed by gently compressing the lung and forcing the fluid out through the airways and pulmonary vessels; the filling up – clearing maneuver was repeated until the pulmonary parenchyma assumed a grayish or grayish pink color, which was characteristic for a good clearing of the pulmonary vascular bed.

Vascular castings were made by injection of the polyacrylic resin at the level of the airways and pulmonary veins according to Weiger T *et al.* [8] and Lametschwandtner A *et al.* [9].

Briefly, lungs were prepared by manual injection with a 65% solution of duracryl (Duracryl® Spofa-Dental) at the level of the airways and pulmonary veins. In order to isolate the vascular casts, lung tissue was digested by incubation in 25% sodium hydroxide at 30°C for 3–4 days. The resin cast were further cleaned in 5% formic acid for 10 minutes and rise in distilled water. Further on, the vascular casts was studied by means of a dissection magnifying glass to which a digital photo camera was added.

Colored gelatin injections of the pulmonary veins were made using a modified method of Ferreira PG *et al.* [10].

We slowly made a 30% gelatin (marked with a 2% China ink tracer and 15% barium sulphate) injection until the pulmonary parenchyma was uniformly colored.

Before and throughout the injection of the mixture, the lungs were warmed by immersion in a water bath (50°C). The lungs were then placed in a cool water bath (0–4°C) to induce solidification of the gelatin. The lungs were fixed by immersion in 10% buffered formalin.

In these vascular casts, the anatomy of the pulmonary veins was studied under a dissecting microscope and by light microscopy.

For light microscopy, lung samples were processed for paraffin embedding by standard methods and 5 µm sections were stained with Hematoxylin–Eosin.

☞ Results

Extrapulmonary airways venous circulation

Microscope dissection of the extrapulmonary airways, upon the colored gelatine injected preparations could reveal the following aspects:

- after penetrating the lung hilum, pulmonary veins branches with recurrent trajectory along the main bronchia detached, coming over the trachea and reached at its lower portion; those branches were revealed upon each preparation studied by us and they had a relatively constant arrangement (Figure 1);
- from the upper root of the pulmonary right vein, a branch with a trajectory on the lateral side of the right upper lobar bronchia separated; that branch penetrated the lower portion of trachea wall and going on with descendent branches in a winding arrangement, into the thickness of the right main bronchial wall;
- from the right lower pulmonary vein, a branch disposed on the inferior side of the medial lobar bronchia detached, crossing anteriorly the lower lobar bronchia and it had an ascendant trajectory on the medial side of the intermediary bronchia just below the carina where it would bifurcate, going on with a sizable branches on the anterior side of the carina and the lower part of the trachea and a ramus anteriorly crossing the main left bronchia;
- from the left upper pulmonary vein, a branch-rams disposed on the inferior side of the lobar bronchia detached, crossing anteriorly the lower lobar bronchia and ascendant on the medial side of the left main bronchia up to the proximity of the carina where it anastomosed with the rams came from the right lower pulmonary vein.
- along their trajectory those branches give two types of collaterals: the former ones with circular disposition around the cartilaginous rings; the latter penetrated into the bronchia wall and got a winding descendent trajectory accompanying the bronchial artery and nervous plexus branches;
- at the level of the posterior sides of the main bronchia, the right bronchial vein goes on directly with

a collateral of the tributary rams to the right upper pulmonary vein and the left pulmonary vein goes on with a collateral rams tributary to the right inferior pulmonary vein (Figure 1, square); the bronchial vein had diameters less than those of the pulmonary vein branches, which were distributed to the extrapulmonary airways.

Intrapulmonary air pathway venous circulation

Both preparations of corrosion and the dissection on the colored gelatin injected preparations revealed that the venous drainage of the intrapulmonary airways is tributary to the pulmonary veins.

The pulmonary vein branches have a sectorial distribution (Figure 2) and, at the bronchial wall and bronchioles they are winding-trajected, accompanying the nervous and the bronchial artery branches. In addition, at that level they form both the peribronchial venous and the subepithelial venous plexus (Figure 3).

☞ Discussions

Many previous studies revealed the presence of some anastomosis between the bronchial and pulmonary circulations at the arterial, capillary and venous levels [11].

Studies upon the bronchial circulation showed many connections at the intrapulmonary level between the bronchial venous circulation and the pulmonary veins [12–13].

Charan NB [14] showed that the venous blood flow of the intrapulmonary bronchovascular structures is mostly taken by the pulmonary veins. The bronchial vascular bed consists of two interconnecting capillary networks: a peribronchial plexus and a subepithelial plexus [15–17].

By dissecting the pulmonary vein branches injected with colored gelatin we noticed that both the plexus in the bronchial wall thickness were sectorially drained by the same rams of the pulmonary vein; we also noticed that the same bronchia has sectors drained by the branches of different pulmonary veins. Preparations of corrosion showed that one intrapulmonary vein could join the venous blood sectorially from bronchia of different generations.

The dimension of the communications between the pulmonary and the bronchial veins of the sheep was quantified by measurement of bronchial venous occlusion pressure and bronchial venous blood flow. Those experiments showed that under normal condition, only 13% of the airways venous supply was taken by the bronchial veins, all the rest having been taken by the pulmonary veins [18].

Microscope dissection of the human lungs showed that mainly the pulmonary vein branches, which directly anastomosed with the bronchial veins, drain venous circulations of the extrapulmonary airways. We noticed that those branches of pulmonary veins received venous collectors from the pericardium, esophagus, lymph nodules and mediastinal pleura level.

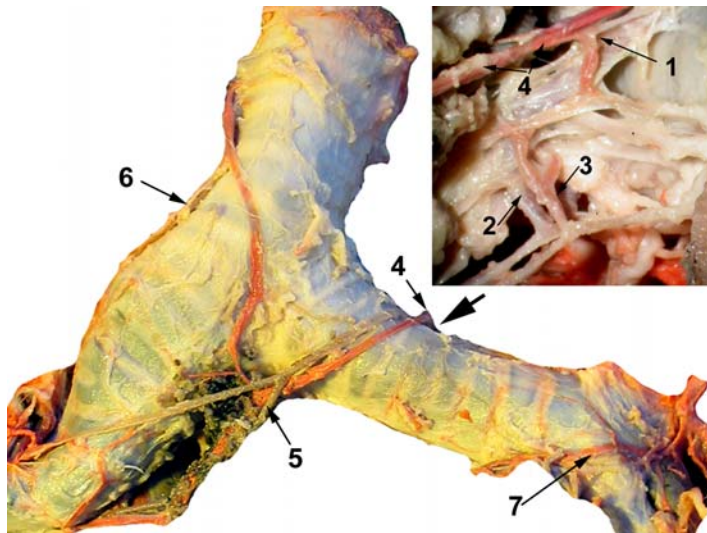


Figure 1 – Distribution of the pulmonary vein branches at the level of trachea and main bronchia. Dissection on a piece injected with colored gelatin. Square: detail dissection of anastomosis between the left bronchial vein and the recurrent branches of the right lower pulmonary vein: 1 – anastomosis area; 2, 5 – left bronchial artery; 3 – left bronchial vein; 4 – right lower pulmonary vein branch; 6 – right upper pulmonary vein branch; 7 – left upper pulmonary vein branch

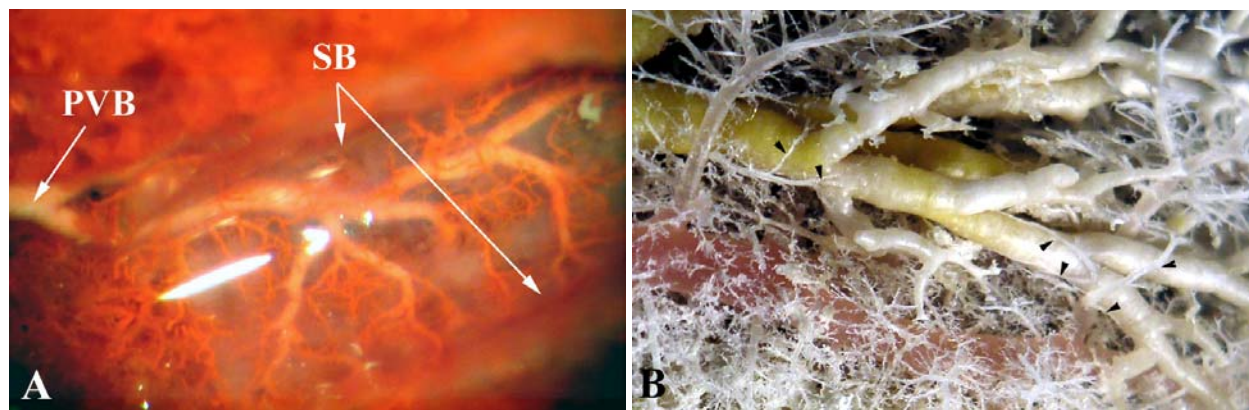


Figure 2 – Sectorial distribution of the pulmonary veins branches (black arrow) to the bronchial wall. Vascular casting with colored gelatin (A) and polyacrylic resin (B): PVB – pulmonary venous branch; SB – segmentary bronchia

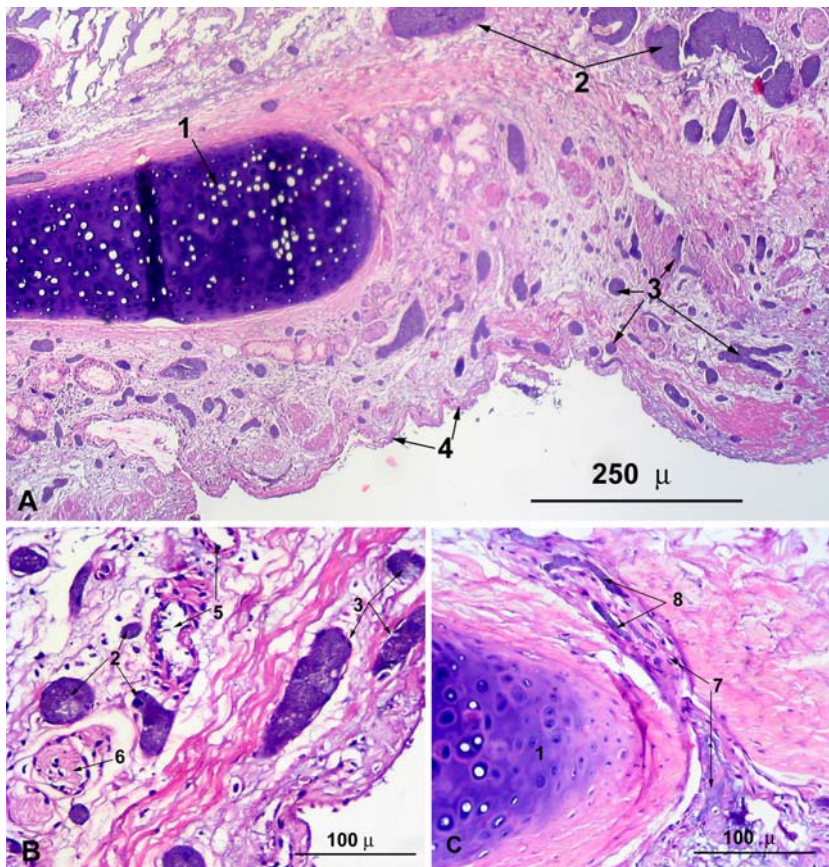


Figure 3 – Bronchial wall microvascularization. Piece injected with colored gelatin and processed by usual histological techniques (HE stain): 1(A) – bronchial cartilage; 2(A, B) – peribronchial venous plexus; 3(A, B) – subepithelial venous plexus; 4(A) – bronchial lumen; 5(B) – bronchial arteries; 6(B), 7(C) – peribronchial nervous plexus; 8(C) – vassa nervosum

☐ Conclusions

Venous circulation of the intrapulmonary airways is tributary to the pulmonary vein branches.

Venous circulation of the extrapulmonary airways is tributary to both the pulmonary and the bronchial veins.

Taking into account the difference of sizes, we consider that under physiologic conditions, the main venous collector is represented by the pulmonary veins.

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