

[Original Paper]

## Extrapulmonary morphological findings of the bronchial artery in the rat

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### Abstract

Although the rat is often adopted as the experimental model in investigations on the respiratory system, macroscopic findings of the bronchial arteries have not been described in detail satisfactorily. We dissected the extrapulmonary course of this artery from the origin to the pulmonary hilus in the rat. One right and one left bronchial arteries were observed. The right artery arose from the right highest intercostal artery, ran together with the right vagus nerve along the right side of the trachea and right principal bronchus, and reached the pulmonary hilus. The stem artery bifurcated into two main branches at the cranial border of the right principal bronchus. The left one arose from the left internal thoracic artery, ran along the left vagus nerve on the ventral surface of the thoracic aorta and reached the dorsal surface of the left principal bronchus. During their courses the right and left bronchial arteries gave off an ascending branch running along the course of the recurrent laryngeal nerve and several small branches to the trachea, esophagus, bronchus, and lymph nodes of the vicinity. The existence of species differences in the morphologic, pharmacologic, and physiologic characteristics of the bronchial arteries is implied by present and previous results as well as the need for caution in selecting laboratory animals if the results are to be applied to humans.

(J.Aomori Univ. Health Welf. 4(1):15–19, 2002)

Key words: bronchial artery, rat, gross anatomy

### Introduction

The lungs have two distinctive circulatory systems, that is, the pulmonary arteries and veins as the functional vessels of the lungs and the bronchial arteries and veins as the nutritive vessels for the lung tissues. Intra- and extrapulmonary relationships between these two bronchial and pulmonary circulations have been interesting from the viewpoints of the morphological and hemodynamic aspects (Harris and Heath<sup>1)</sup>).

The bronchial arteries have received increasing attention in human lung transplantation (Baudet et al.<sup>2)</sup>, Pettersson et al.<sup>3)</sup>) as well as experimentally (al Dossari et al.<sup>4)</sup>, Baile<sup>5)</sup>, Serikov and Fleming<sup>6)</sup>). The rat is often adopted as the experimental model in investigations on the respiratory system (Nakai et al.<sup>7,8)</sup>, Ferreira et al.<sup>9)</sup>), but macroscopic findings of the bronchial arteries of the rat have not been described in detail satisfactorily. Further studies have been needed to evaluate

fully the morphological meanings of this artery in the anatomy of rats. The purpose of this study was to improve an anatomical basis, particularly the extrapulmonary course of the bronchial arteries from the origin to the pulmonary hilus of the lung, for experimental studies of the rat bronchial branches.

### Materials and Methods

All animal experiments in this study followed the "Guidelines for animal experimentation" as laid down by the Animal Research Committee, Aomori University of Health and Welfare.

Five male Wistar rats at 2-3 months of age were used in this study. These rats were maintained under standard conditions of temperature ( $22 \pm 2^\circ\text{C}$ ) and light (LD 12:12) with free access to food and water. The animals were anesthetized and perfused with normal saline through a

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polyethylene tube inserted into the abdominal aorta at the level of its bifurcation, and injected through the tube with red colored latex gum. After fixation with 10% neutral formalin, the dissective procedures and observations of the bronchial arteries were performed by using fine forceps under a stereomicroscope.

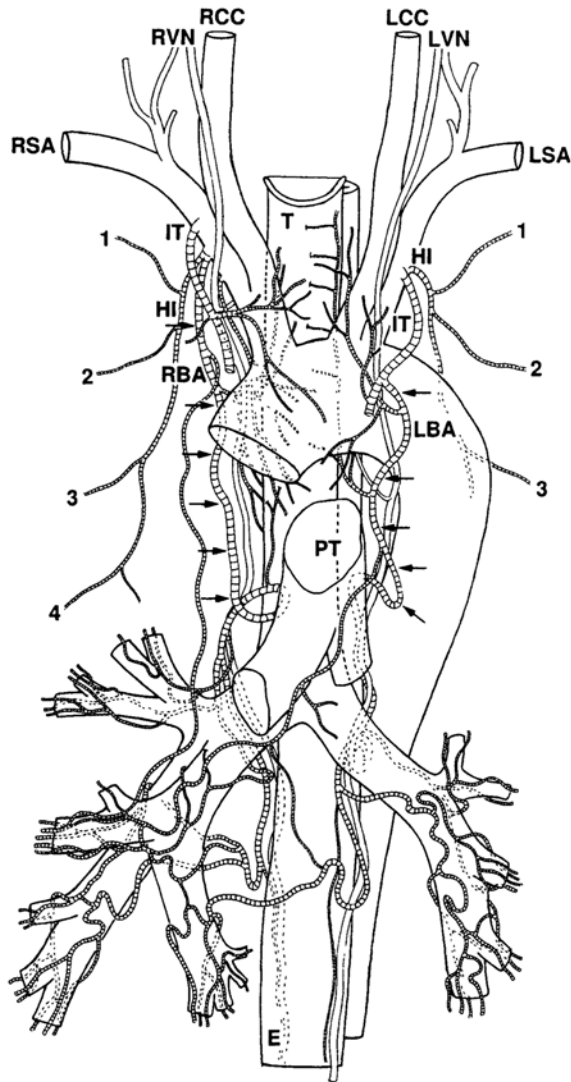


Fig. 1 Line drawing showing the origin and course of the right (RBA) and left (LBA) bronchial arteries (arrows) in the rat. RBA arose in common with the right highest intercostal artery (HI) from the right subclavian artery (RSA), ran together with the right vagus nerve (RVN) along the right side of the trachea and reached the dorsal surface of the right bronchus. LBA arose from the internal thoracic artery (IT), ran along the left vagus nerve (LVN) on the ventral surface of the thoracic aorta and reached the dorsal surface of the left bronchus. (E esophagus, LCC left common carotid artery, LSA left subclavian artery, RCC right common carotid artery, PT pulmonary trunk, T trachea, 1, 2, 3, 4 number of posterior intercostal artery)

## Results (Fig. 1)

### *Right bronchial artery*

The right bronchial artery arose in common with (2 cases) or from the original portion of (3 cases) the right highest intercostal artery, which is one of the branches of the right subclavian artery. After arising, the bronchial artery ran together with the right vagus nerve along the right side of the trachea and reached the dorsal surface of the right bronchus. During its course the bronchial artery gave off an ascending branch running along the course of the right recurrent laryngeal nerve of the vagus nerve and several small branches to the trachea, esophagus, bronchus, and lymph nodes of the vicinity. The stem artery bifurcated into two main branches at the cranial border of the right bronchus: the cranial branch coursed mainly along the cranial and middle lobar bronchi, and caudal branch along the middle, caudal, and accessory lobar bronchi, supplying them and the lung tissues.

### *Left bronchial artery*

The bronchial artery of the left side arose from the internal thoracic artery arising from the left subclavian artery in all cases. The bronchial artery ran along the left vagus nerve on the ventral surface of the aortic arch and thoracic aorta, reached the dorsal surface of the left bronchus, and coursed along the left principal bronchus. During its course the artery branched out an ascending branch along with the left recurrent laryngeal nerve. A few small branches of left bronchial artery were anastomosed with the branch of the right bronchial artery or directed toward the accessory lobar bronchus of the right lung. And the stem artery supplied the cranial, middle, and caudal lobes of the left lung.

## Discussion

Detailed morphological study on the bronchial arteries in the rat has not been reported, as far as we know, except for the brief mention made by Mizukami and Tanaka<sup>10</sup>. The description of this artery in textbooks of rat anatomy (Greene<sup>11</sup>, Hebel and Stromberg<sup>12</sup>) is not sufficient. The present study may be the first detailed report on the origin, course, and distribution of the bronchial arteries. In the rat, the morphological features of this artery were relatively constant on each right and left side.

On the other hand, there are many reports on the origin and extrapulmonary course of the bronchial arteries in man (Hovelacque et al.<sup>13</sup>, Cauldwell et al.<sup>14</sup>, Cudkowicz and Armstrong<sup>15</sup>, Liebow<sup>16</sup>, Kasai and Chiba<sup>17/19</sup>). Most

textbooks of human anatomy (Romanes<sup>20</sup>, Anson<sup>21</sup>, Hollinshed<sup>22</sup>, Clemente<sup>23</sup>, Woodburne and Burkel<sup>24</sup>, Williams<sup>25</sup>, Cornelius and Penelope<sup>26</sup>) have referred to the paper of Cauldwell et al.<sup>14</sup>, but in these textbooks the positional relations of the bronchial arteries to the surrounding structures have not been described in detail satisfactorily. The descriptions in the review articles (Lippert and Pabst<sup>27</sup>, Harris and Heath<sup>1</sup>) were no exception. Recently, Kasai and Chiba<sup>17,19</sup> reported more detailed macroscopical findings of this artery from the origin to the pulmonary hilus in 100 human adults. Summarizing the complexity in the origin and course of the bronchial arteries, they illustrated schematically all the feasible arrangements of the bronchial arteries on both sides in man.

Comparing the morphological characteristic features of the rat and human bronchial arteries, in man the right and left bronchial arteries usually arise from the thoracic aorta, but in rats such a bronchial artery does not present in both sides. Human bronchial arteries having similar features to those observed in rats were found in 29% on the right and in only 1% on the left (Kasai and Chiba<sup>18,19</sup>). It is very interesting to examine and elucidate the extra- and intrapulmonary morphological features of the mammalian bronchial arteries from the viewpoint of the comparative anatomical and functional significances (McLaughlin<sup>28</sup>, Magno<sup>29</sup>, Dyce et al.<sup>30</sup>). The anastomoses between the bronchial arteries and pulmonary, esophageal, coronary and intercostal arteries were followed by angiographic study in dog, porcine and human being (Jandik et al.<sup>31</sup>, Gade et al.<sup>32,33</sup>). The existence of species differences in the morphologic, physiologic, and pharmacologic characteristics of the bronchial arteries is implied by present and previous results as well as the need for caution in selecting laboratory animals if the results are to be applied to humans.

In conclusion, the extrapulmonary course, branching pattern and distribution of the rat bronchial arteries have been described. Each principal bronchus is followed by one bronchial artery. The present findings suggest that the rat is anatomically suited for experimental physiological and pharmacological studies on the bronchial circulation.

#### Acknowledgment

This work was supported in part by The Special Research Fund for Academic Research in Aomori University of Health and Welfare, Japan, granted to T. Suzuki.

(accepted: October 23, 2002)

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# ラットにおける気管支動脈の肺外形態について

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肺には2系統の循環路、すなわち、機能血管としての肺動・静脈と栄養血管としての気管支動・静脈が分布する。呼吸器循環の生理学的・薬理学的研究の実験動物としてしばしばラットが使用されるが、呼吸器循環と密接に関係する気管支動脈については、未だその形態学的所見は十分でない。

8～10週令のウイスター系ラット5体10側について、左心室より生理食塩水にて還流後、腹大動脈より着色したラテックスゴムを動脈系に注入し、気管支動脈の形態を実体顕微鏡下にて剖出・調査した。

ラットの気管支動脈は左右それぞれ1本認められた。右気管支動脈は、最上肋間動脈の起始部より起こるのが3側、共同幹を形成して起こるのが2側に観察された。いずれも右迷走神経と伴行しながら気管右側面を下行して右気管支後面に達し、頭側および尾側枝に2分した。頭側枝は主として上・中葉気管支に沿い、尾側枝は中・下・副葉気管支に沿って走り、肺門より右肺に侵入した。走行中、右反回神経と伴行して上行する枝、気管および気管支、食道、肺門周囲のリンパ節に分布する細枝を分枝した。左気管支動脈は5側全例で左内胸動脈より起こり、左迷走神経と伴行して大動脈弓および胸大動脈の腹側表層を下行して左気管支後面に達して2分した。一枝は右方に走行し、主として右副葉に分布した。もう一枝は左気管支腹側面を下行し、肺門より左肺に侵入した。走行中、左反回神経に沿って上行する細枝を分枝した。ヒトにおける気管支動脈は左右それぞれ2本存在し、主として胸大動脈より起こる。今回のラットの気管支動脈と同様の形態を持つ気管支動脈がヒトにおいても認められるが、右側で約30%、左側では1%以下に過ぎない。

ヒトで肺移植などの医療行為が行われているなか、一方で、呼吸器循環の生理学・薬理学的研究の実験のために、多種の動物が用いられている。これらの動物実験にあたっては、呼吸器循環と密接に関係する気管支動脈の形態についても十分な知識が必要と考えられる。また、各種実験動物における気管支動脈の形態の異同は、比較解剖学的にも非常に興味のある問題である。

(青森保健大紀要 4(1),15-19,2002)

キーワード：気管支動脈、ラット、肉眼解剖学