Studies on the Primitive Lymphatic Apparatus in the Blood Vascular System of the Lungs of *Macaca cyclopis**

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Introduction

The defense mechanism against foreign invaders is the most important physiological function of the lymphatic tissue and lymphocytes produced in it. From developmental viewpoint the respiratory system is the one which first and most easily subjects to invasions of noxious factors.

The subepithelial lymphatic apparatus of the bronchial system in mammals and human beings have been reported by Hase¹⁾, Yano²⁾, Kashima³⁾, Toda⁴⁾...etc. A survey of literature also revealed that the study of the lymphatic apparatus in the blood vascular system of mammalian lungs was reported only in rabbits (Nishikawa,⁵⁾) and that no information was available in primates.

As a part of the consecutive morphological and developmental work of lymphatic tissue in mammals, the development and distribution of the lymphatic apparatus in the walls of vascular branches in lungs of *Macaca cyclopis* were studied.

Materials and Methods

Nine monkeys (*Macaca cyclopis*) were used. They were approximately 24 and 48 hours, 1, 3, 5, 6, 11, 20 and 60 months of postnatal ages at the time of sacrifice.

Under ether anesthesia, a 10% formalin solution was perfused through the abdominal aorta, and whole animals were preserved in the same solution. After fixation, the whole left lungs were removed and embedded in celloidin. Thirty micron serial sections roughly

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perpendicular to main branches of the pulmonary artery were cut for microscopical examination.

Results

Case 1. *Macaca cyclopis* (0.35 kg), female. 24 hours after birth.

Case 2. *Macaca cyclopis* (0.45 kg), male. 48 hours after birth.

Case 3. *Macaca cyclopis* (0.48 kg), male. 1 month old.

No lymphatic apparatus was found in the vascular system of lungs in these three cases.

Case 4. *Macaca cyclopis* (0.58 kg), female. 3 months old.

In this case, the lymphatic apparatus started to appear in the form of lymphatic infiltrations in the wall of the functional vascular system of lungs. But no lymphatic apparatus was observed in the nutritive vascular system.

Upper lobe: Of the six lymphatic infiltrations found (about 280×120 – $120 \times 80 \mu$ in size) one occurred in the tunica adventitia of the pulmonary artery 250μ in caliber at the site of bifurcation and was seen to be associated with lymphatic vessels. Five were found in the tunica media or tunica adventitia of pulmonary veins 270μ (one), 120μ (three) and 80μ (one) in caliber, of which three showed an intimate association with lymphatic vessels.

Lower lobe: Five lymphatic infiltrations about 220×130 – $170 \times 80 \mu$ in size were found. Three of them were located in the tunica adventitia of pulmonary arteries at the site of bifurcation, respectively, 260μ , 160μ and 120μ in caliber. Two were accompanied by lymphatic vessels and were found in the tunica adventitia of pulmonary vein, respectively, 500μ and 400μ in caliber.

Case 5. *Macaca cyclopis* (0.83 kg), female. 5 months old.

Sixteen lymphatic infiltrations were discerned in the functional vascular system. Most of them occurred in the tunica adventitia of the blood vessels at bifurcation and a few apparatus showed infiltration of lymphocytes into the tunica media of the vascular walls. About a half of lymphatic apparatus appeared to be in contact with lymphatic vessels.

Upper lobe: Seven lymphatic infiltrations about 280×200 – $120 \times 80 \mu$ in size were found. Two of them were located in pulmonary arteries, respectively, 160μ and 120μ in caliber. The other five spreaded into the walls of pulmonary veins 340 – 120μ in caliber.

Lower lobe: Nine lymphatic infiltrations about 360×180 – $160 \times 140 \mu$ in size were found. Three of them were located in the wall of pulmonary arteries, respectively, 280μ , 200μ and 170μ in caliber. The other six occurred in the wall of pulmonary veins, respectively.

350 μ , 200 μ , 160 μ , 150 μ , 100 μ and 80 μ in caliber.

Case 6. *Macaca cyclopis* (1.0 kg), male. 6 months old.

Fifteen lymphatic infiltrations were located along the functional vessels of the lungs. They were about 210×150 – 80×60 μ in size. Most of them were distributed in the tunica adventitia of the blood vessels, and some were seen in the muscular layers. No lymphocytes were seen to infiltrate into the endothelium. In general, there were some relationships between the lymphatic apparatus and lymphatic vessels.

Upper lobe: Six lymphatic infiltrations were found. Two of them were located at the bifurcation of pulmonary arteries 100 μ in caliber. The others occurred in the wall of pulmonary veins 210–70 μ in caliber.

Lower lobe: Nine lymphatic infiltrations were observed. Two of them appeared to surround the bifurcation of pulmonary arteries 100 μ in caliber. The other seven were seen to circumscribe the site where tributaries of pulmonary veins 300–80 μ in caliber joined.

Case 7. *Macaca cyclopis* (1.5 kg), male. 11 months old.

In this case, the lymphatic apparatus were rather poorly developed. Only seven lymphatic infiltrations about 320×200 – 150×110 μ in size were observed along the functional vascular system of the lungs. Most of these apparatus were located in the tunica adventitia of blood vessels. They were occasionally seen in the tunica media, but were never seen to extend into the tunica intima. Each lymphatic apparatus was accompanied by lymphatic vessels.

Upper lobe: Four lymphatic infiltrations occurred. One of them was found in the wall of a branch of the pulmonary artery 120 μ in caliber. The others were located in the angle formed by tributaries of the pulmonary veins 150–110 μ in caliber.

Lower lobe: Three lymphatic infiltrations were found. Two of them were seen at the bifurcation of pulmonary arteries, respectively, 500 μ and 120 μ in caliber. The other was found in the wall of a tributary of the pulmonary vein 180 μ in caliber.

Case 8. *Macaca cyclopis* (2.0 kg), male. 20 months old.

In this case, lymphatic apparatus were much more abundant than the previous cases, particularly, in the lower lobe. The total of lymphatic infiltrations in the functional vascular system was ninety. Most of them were located in the tunica adventitia of the diverging or converging parts of blood vessels. Most of the apparatus were in close contact with lymphatic vessels. In spite of numerous lymphatic apparatus along the functional vascular system, none was found in the wall of the nutritive vascular system.

Upper lobe: Thirty-six lymphatic infiltrations about 550×180 –

120×80 μ in size were observed in this lobe. Five of them were found along branches of the pulmonary arteries 130–100 μ in caliber. In the wall of pulmonary veins many lymphatic infiltrations were found. Of these one was found in the wall of a 400 μ caliber vein, eleven in the wall of 300–180 μ , sixteen in the wall of 170–100 μ and three in the wall of 80 μ caliber veins.

Lower lobe: Of the fifty-four lymphatic infiltrations found (about 510×100–80×60 μ in size) only six were observed in pulmonary arteries 250–70 μ in caliber. The others were all found in the wall of pulmonary veins 350–180 μ (twenty four), 170–100 μ (twenty) and 90–70 μ (four) in caliber.

Case 9. *Macaca cyclopis* (5.3 kg), female. 60 months old.

In this adult monkey, the frequency of appearance of the lymphatic apparatus was about a half of case 8. Only fifty lymphatic infiltrations were found along the functional vascular system of the lung. Most of them were accompanied by lymphatic vessels and mainly appeared in the tunica adventitia of the diverging or converging parts of the blood vessels.

Upper lobe: Twenty-seven lymphatic infiltrations were found. Five of them (about 280×220–150×140 μ in size) were observed in the wall of pulmonary arteries 320–80 μ in caliber. The other twenty-two (about 610×210–140×70 μ in size) were found in the wall of pulmonary veins 300–70 μ in caliber. About a half of the latter were in the wall of veins 170–100 μ in caliber.

Lower lobe: Twenty-three lymphatic infiltrations about 320×170–130×70 μ in size were found. Only five of them were observed in the wall of pulmonary arteries 160–80 μ in caliber. The others were located in the wall of pulmonary veins 260–70 μ , mostly (eleven) 170–100 μ , in caliber.

Discussion and Conclusion

A few comments and conclusion about the structure, distribution and the development of lymphatic apparatus in the blood vascular system of the lungs of nine monkeys (*Macaca cyclopis*) with different ages will be given in the following sections.

1) In the blood vascular system of the lungs in *Macaca cyclopis*, the occurrence of the primitive lymphatic apparatus was detected. The distribution of the apparatus was confined to the functional vascular system (A. pulmonalis, V. pulmonalis) only. No lymphatic apparatus was observed in the nutritive vascular system (Rr. bronchiales, Vv. bronchiales) of the monkeys at any ages examined.

2) There was no lymphatic apparatus formation in the suckling

period. They started to appear in the form of lymphatic infiltrations at the beginning of the middle of the infant period (3 months after birth). They never differentiated into solitary nodules.

3) Most of the lymphatic apparatus were in close contact with lymphatic vessels located in the tunica adventitia of diverging or converging parts of the functional blood vessels. Therefore, they belonged to the subendothelial lymphatic apparatus of lymphatic vessels. Nevertheless, a few of them were found in the media or intima of blood vessels.

4) The developmental situations of the lymphatic apparatus in the functional vascular system of the lungs were as follows:

a) A. pulmonalis: The lymphatic infiltrations were first found in the middle of infant period (3 months after birth). Afterward, they increased gradually with age until the maximum development was reached in the middle of the juvenile period. The development of lymphatic apparatus was gradually declined until the adult period.

b) V. pulmonalis: The developmental situation of the lymphatic apparatus in the wall of the pulmonary veins was essentially similar to that of the pulmonary arteries. However, lymphatic infiltrations were far more developed in the venous than in the arterial system in all cases, especially in the juvenile ones.

There was a prominent tendency that the development of the lymphatic apparatus of the functional vascular system was much more advanced along the pulmonary vein than along the artery.

5) Distribution of primitive lymphatic apparatus in the functional vascular system of lungs was intimately related to the caliber of the blood vessels. The primitive lymphatic apparatus were usually located in the wall of the blood vessels 0.07-0.50 mm in caliber, and were mostly assembled in those 0.10-0.17 mm in caliber, which mainly supplied terminal bronchioles.

From the developmental viewpoint the occurrence of the lymphatic apparatus in the functional vascular system of the lungs exhibited a definite tendency. The lymphatic apparatus appeared frequently along the terminal portions of the pulmonary arteries and much more frequently in the initial portions of the pulmonary veins. From the functional point of view this arrangement of the lymphatic apparatus might be significant, because the blood flow in these terminal and initial segments of the vessels is much slower than in larger caliber vessels. This situation might provide the lymphatic apparatus aggregated there to have more opportunities to contact with the noxious agents.

Abstract

The development and distribution of the primitive lymphatic apparatus in the blood vascular system of the lungs in nine *Macaca cyclopis* were studied. There was no lymphatic apparatus formation in the suckling period. Toward the beginning of the infant period the lymphatic apparatus started to occur in the form of lymphatic infiltrations. They were mostly located in the wall of functional blood vessels 0.07-0.50 mm in caliber (Vasa pulmonalia) and were especially numerous in those 0.10-0.17 mm in caliber. However, the lymphatic apparatus was never found in the nutritive vascular system (Rr. bronchiales, Vv. bronchiales).

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Table 1. Distribution of primitive lymphatic apparatus (LI) in the blood vascular system of the lungs of *Macaca cyclopiis*

Materials (Age)	Blood vessels	Caliber of blood vessels (mm)										Total	
		x-0.51		0.50-0.36		0.35-0.18		0.17-0.10		0.09-0.07		0.06-x	
		Upp.	Low.	Upp.	Low.	Upp.	Low.	Upp.	Low.	Upp.	Low.	Upp.	Low.
I (24 hours)													
II (48 hours)													
III (1 month)													
IV (3 months)	A. p.					1	1		2			1	3
	V. p.			2	1			3		1		5	2
V (5 months)	A. p.						2	2	1			2	3
	V. p.					3	2	2	3	1		5	6
VI (6 months)	A. p.							2	2			2	2
	V. p.			1	2				4	3	1	4	7
VII (11 months)	A. p.		1					1	1			1	2
	V. p.					1		3				3	1
VIII (20 months)	A. p.						2	5	3		1	5	6
	V. p.	1		11	24	16	20	3	4			31	48
IX (60 months)	A. p.					2		1	3	2	2	5	5
	V. p.					4	3	11	11	7	4	22	18
Total	A. p.		1	1	3	5	11	12	2	3		16	21
	V. p.			1	3	8	23	62	5	14		37	
				1	2	20	32	35	14	10		70	82
				3	52	34	73	48	24	16		152	
													189

LI: Lymphatic infiltration A. p.: A. pulmonalis V. p.: V. pulmonalis Upp.: Upper lobe Low.: Lower lobe

Explanation of figures (Plate I and II)

- Fig. 1. Lymphatic infiltration discerned in the converging part of the pulmonary vein. Upper lobe of case 4. $\times 100$
- Fig. 2. Lymphatic infiltration in a branch of the pulmonary vein. Lower lobe of case 4. $\times 100$
- Fig. 3. Lymphatic infiltration found in the tunica adventitia of pulmonary vein. Upper lobe of case 5. $\times 100$
- Fig. 4. Lymphatic infiltration located in the converging part of the pulmonary vein. Lower lobe of case 5. $\times 100$
- Fig. 5. Lymphatic infiltration observed in the tunica adventitia of the diverging part of the pulmonary artery. Upper lobe of case 5. $\times 100$
- Fig. 6. Lymphatic infiltration occurring in the tunica adventitia of the pulmonary vein. Upper lobe of case 6. $\times 50$
- Fig. 7. Lymphatic infiltration found in the tunica adventitia of converging part of the pulmonary vein. Lower lobe of case 6. $\times 100$
- Fig. 8. Lymphatic infiltration found in the tunica media and adventitia of the pulmonary artery. Upper lobe of case 7. $\times 100$
- Fig. 9. Lymphatic infiltration seen in the tunica adventitia of pulmonary vein. Lower lobe of case 7. $\times 100$
- Fig. 10. Lymphatic infiltration occurring in the tunica adventitia of diverging part of the pulmonary artery. Upper lobe of case 8. $\times 100$
- Fig. 11. Lymphatic infiltration discerned in the tunica adventitia of pulmonary artery. Lower lobe of case 8. $\times 100$
- Fig. 12. Lymphatic infiltration occurring in the tunica adventitia of pulmonary artery. Lower lobe of case 9. $\times 100$

Fig. 1

Fig. 2

Fig. 3

Fig. 4

Fig. 5

Fig. 6

Fig. 7

Fig. 8

Fig. 9

Fig. 10

Fig. 11

Fig. 12