These two quantitative parameters, which are mutually complementary, thus enable a wider estimation to be given both of possible hypertrophy or dystrophy of the vessel wall, and also of the vasoconstrictor, functional state which, as this example clearly shows, was low, i.e., virtually absent.

LITERATURE CITED

1. I. K. Esipova and L. L. Kapuller, Some Problems in Pathology of the Lungs in the Light of the Most Recent Data on Their Normal Structure, Development, and Regeneration [in Russian], Novosibirsk (1962), p. 177.
2. P. M. Mazhuga, Zool. Zh., 37, No. 11, 889 (1958).
3. V. M. Khayutin, Byull. Éksp. Biol. Med., 54, No. 11, 22 (1962).
4. V. P. Shafranova, Arkh. Patol., No. 4, 76 (1967).
5. M. Furuyama, J. Exp. Med., 76, 388 (1962).
6. C. Nordborg and B. B. Johansson, Stroke, 11, 266 (1980).

ECOLOGICAL DIFFERENCES IN STRUCTURAL ORGANIZATION OF THE RESPIRATORY REGIONS OF THE LUNGS

R. I. Valitskaya, G. S. Shishkin, and T. V. Voevoda

UDC 611.233.08:599.742

KEY WORDS: lobe of the lung; acinus; segment.

The respiratory system of Arctic animals is adapted to breathing air at low temperatures, and the adaptive mechanisms are genetically consolidated. The study of these mechanisms in endemic Arctic species may help to assess the possible directions of individual physiological adaptation in animals and man. However, only a few details of the structure of the air passages and of the air–blood barrier have so far been described in endemic Arctic animals [1-5]. The morphological and functional basis of ecological differences in the respiratory portions of the lungs has not hitherto been studied.

The aim of this investigation was to study the structural features of the respiratory regions of the lungs in an endemic Arctic animal, namely the Arctic fox *Alopex lagopus* L. and to compare them with those of the dog.

EXPERIMENTAL METHOD

The lungs of 35 mature Arctic foxes (weight 6 kg), kept in open sheds in the Magadan Game Farm, and the lungs of 15 dogs (weight 8-9 kg), living in an animal house in Novosibirsk, were investigated. The Arctic foxes were well adapted to breathing air at low temperatures and could tolerate a frost down to −50°C. Material for investigation was taken during the winter. The animals were killed by electrocution. The lungs were divided into segments and the segments into lobules by dissection of freshly eviscerated complexes and by the use of corrosion preparations of the bronchial tree. The acrylic glue Protakril was used as plastic material. The plastic mass was prepared immediately before injection by mixing the monomer and polymer in the ratio of 1:1. In this way the Protakril was of the correct viscosity for filling the peripheral segments of the air passages as far as the terminal bronchioles. Polymerization was carried out for 3-4 h at 70-80°C. Fifteen lung lobules were reconstructed by a graphic method from serial preparations obtained from three Arctic foxes and three dogs.

EXPERIMENTAL RESULTS

The lobes of the lungs of the animals investigated were divided into segments, isolated from each other to some degree by intersegmental septa. In the cranial, middle, and accessory

Laboratory of Functional Morphology of the Lungs, Institute of Physiology, Siberian Branch, Academy of Medical Sciences of the USSR, Novosibirsk.

(Presented by Academician of the Academy of Medical Sciences of the USSR V. A. Matyukhin.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 106, No. 7, pp. 122-124, July, 1988. Original article submitted October 27, 1987.

0007-4888/88/0007-1059$12.50

TABLE 1. Number of Segments, Lobules, and Acini in Right Lung of Arctic Fox and Dog (min — max)

Lobe of lung	Dog			Arctic fox		
	segment	lobules	acini	segment	lobules	acini
Cranial	3	240—260	1800—1950—	3	410—440	1750—1850
Middle	1	160—180	1120—1260	1	370—400	1900—2100
Caudal	5	500—600	3600—4320	7	1250—1350	5100—5300
Accessory	1	40—60	290—430	1	220—230	850—950
Total in lung	10	940—1000	6800—7960	12	2200—2500	9,5—10,2 тыс.

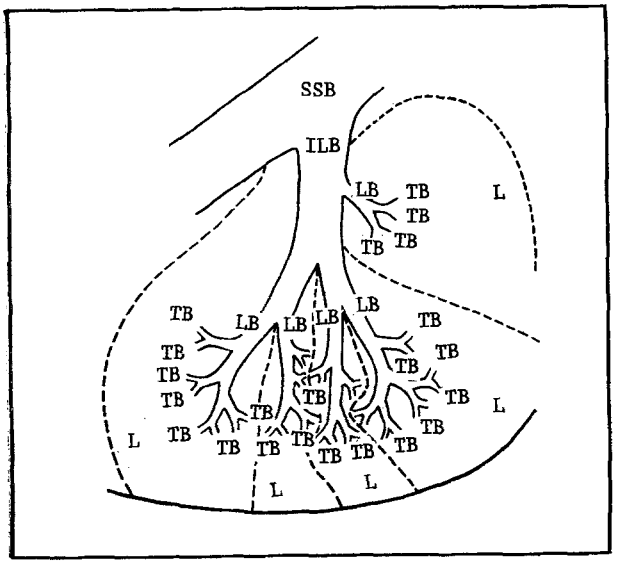

Fig. 1. Diagram showing three-dimensional reconstruction of part of a subsegment in the caudal lobe of a dog's lung. SSB) Subsegmental bronchus; ILB) interlobular bronchiole; LB) lobular bronchiole; TB) terminal bronchiole; L) lobule.

lobes the number of segments and their topography completely coincided. In the caudal lobes of each lung, however, the Arctic foxes had two segments more. Altogether, 12 segments were counted in the right lung of the Arctic fox and only 10 in the dogs.

Segments of the lungs consisted of lobules the boundaries between which were readily visible in histological preparations. The segments differed greatly in their number of lobules. In dogs 30 to 50 lobules were counted in each of the five dorsal segments and 150-180 lobules in each of the five ventral segments. Altogether the dog's right lung contains 940-1000 lobules, and both lungs about 1700 lobules (Table 1). In the lungs of the Arctic foxes, although the volume of the organ was the same or a little less, the number of lobules was twice as great: in each of five dorsal segments 60-100 lobules were counted, and 200-300 in the seven ventral segments. Altogether in the right lung of the Arctic fox there were 2250-2450 lobules, and in both lungs — 4000.

The lobule of the lung in the animals studied consisted of primary morphological and functional units (acini), number of which corresponded to the number of terminal bronchioles conducting air into them.

Diagrams of branching of the interlobular and intralobular bronchioles in the dogs and Arctic foxes, obtained by graphic reconstruction, are illustrated in Figs. 1 and 2. The lobular bronchioles branch from the interlobular bronchiole mainly consecutively, and in 70% of cases they branch asymmetrically. The number of branches of the intralobular bronchioles and the number of terminal bronchioles for one branch were usually twice as great as for the other, i.e., along one branch only one ramification is found or often there are no intralobular bronchioles whatsoever, and the terminal bronchiole leaves directly from the lobukar, whereas along the other branch there may be two to four ramifications.

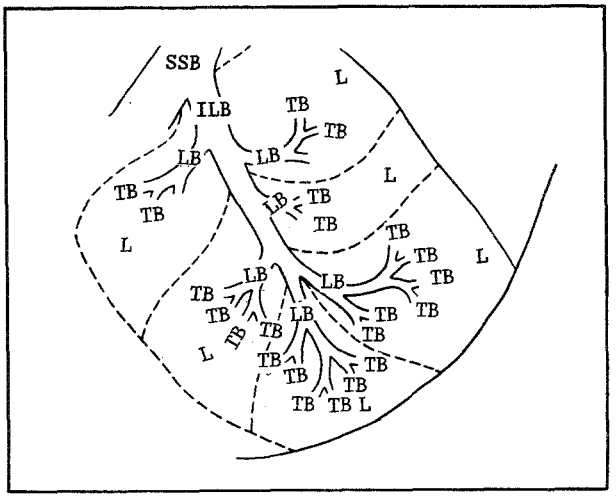

Fig. 2. Diagram of three-dimensional reconstruction of part of a subsegment of the caudal lobe of the Arctic fox lung. Legend as to Fig. 1.

On average the lobular bronchioles of dogs ramified 2-4 times, to form 1-3 generations of intralobular bronchioles and one generation of terminal bronchioles. In Arctic foxes they branch 1-3 times, i.e., they give rise to one intralobular generation fewer.

Because of the inconstant number of ramifications of the bronchial tree within the lobules the number of acini in them varies considerably. In dogs it varies from four to ten, although in fact it is the same in all lobes. The average number of acini in one lobule of the dog's lung is 7.2 ± 2.2. In Arctic foxes the lobule has a simpler structure and corresponds to about half of the lobule of the dog's lung. The number of acini in the lobules varies from three to six and, in addition, in all the lobes up to 20% of rudimentary lobules can be found, in which there are only two acini, and the terminal bronchioles are given off directly from the lobular bronchiole. On average a lobule of the lung consists of 4.5 ± 1.7 acini. The number of acini in the lobules of the cranial lobe varies from four to six (without rudimentary lobules), in the caudal lobe from three to six, and in the middle lobe it is fairly constant, namely six.

Since in Arctic foxes the smaller number of acini in the lobule is compensated by a larger number of the latter in segments and lobes, the total number of acini in the lungs of these animals does not differ significantly. As regards the number of acini in the animals of these two species the caudal lobes predominate considerably (53-58%; Table 1). It will be evident that these possess the greatest functional capacity.

The fact that the Arctic fox has twice as many pulmonary lobules as the dog whereas the volume of each lobe is reduced almost by half, enables the former to exert stronger control over local ventilation by the central mechanisms of regulation. Each lobular bronchiole regulates ventilation of a smaller volume of respiratory tissue, which ensures greater uniformity of ventilation and increases the precision of adaptive involvement of reserve tissue when the inspired air temperature falls. This also enables pathological processes of an inflammatory character to be localized in a smaller volume.

LITERATURE CITED

1. T. A. Belousova and A. P. Milovanov, Fiziol. Cheloveka, 3, No. 1, 97 (1977).
2. A. P. Milovanov and T. A. Belousova, Physiology and Pathology of Human Adaptation under Conditions of the Far North [in Russian], Novosibirsk (1977), pp. 11-13.
3. A. K. Serditykh, Collection of Scientific Works of Students of Omsk Veterinary Institute [in Russian], No. 4, 10 (1961).
4. A. D. Soboleva, G. S. Shishkin, and N. V. Ustyuzhaninova, The Reaction of Homeostatic Systems in Individual Adaptations [in Russian], Novosibirsk (1976), pp. 81-106.
5. A. N. Shakutin, T. V. Voevoda, and G. S. Shishkin, Biological Problems of the North [in Russian], Part 2, Magadan (1983), pp. 416-417.