Functional Morphology of Blind and Other Processes in the Lymph Capillary System

M. R. Sapin and G. G. Aminova

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"Blind" lymph capillaries of the diaphragmatic tendon center were studied in normal rabbits and after injections of India ink, yellow cadmium, chicken erythrocyte suspensions, and whole chicken blood into the abdominal cavity. Three groups of blind capillaries differing by morphological and functional signs were distinguished. Some blind capillaries can deposit foreign particles. The process of intracapillary endothelial growth is described.

Key Words: *lymph capillary; "blind" process; endothelial bridges*

"Blind" lymph capillaries (BLC) were found by all investigators of the lymph system [3,4,6]. However, these capillaries attracted little attention, because they were believed to belong to the total complex of the lymph system roots [2,5]. We investigated the morphology, location, and functional characteristics of BLC.

MATERIALS AND METHODS

The lymph bed of the tendon center was examined in 30 normal rabbits and 35 rabbits injected intraperitoneally (under ether narcosis) under the xiphoid process with different suspensions (10% India ink or yellow cadmium in normal saline), chicken erythrocytes or whole blood (20 cm^3 per animal). The experiment was carried out for 1-30 min. Narcotized animals were sacrificed by pneumothorax at the moment of sample collection. BLC were detected using the method of Ranvier. The material was fixed in 10% neutral formalin.

RESULTS

Our findings indicate that BLC can be divided into 3 groups.

Laboratory of Functional Anatomy, Institute of Human Morphology, Russian Academy of Medical Sciences, Moscow; Department of Human Anatomy, I. M. Setchenov Moscow Medical Academy

Group 1 includes capillaries with even contour (finger-shaped) or with narrowed mouth (club-shaped). Ball-shaped capillaries or capillaries of complex configuration are rare. They are usually located individually or form small groups. These capillaries are situated in tissues and adsorb tissue fluid with metabolites in the zone of their location forming a peculiar structural and functional unit together with blood capillaries (module) [5,6]. The size of BLC varies. Longer capillaries can have small folds resembling a valve. BLC can be seen not only within the network of lymph capillaries and postcapillaries, they can directly join the lymph vessels. The walls of this group of capillaries are more often represented by scalloped endotheliocytes (Fig. 1), which indicates their high functional activity [1].

Finger-shaped BLC little differ from the network capillaries by their function. Their wide mouth cannot prevent the discharge of resorbed tissue fluid, particularly in small capillaries. Fluid discharge will be impeded in capillaries with narrow mouth, and hence, accumulation of the resorbed material in their dilated cavities is possible. Since the endothelium is an actively functioning structure [2-4,6,8,9], favorable conditions for modification of physicochemical characteristics of tissue fluid are created in the capillary lumen. Cells and products of their degradation can also be stored here.

Group 2 BLC are associated with serous membranes. Lymph capillaries in the diaphragmatic peri-

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toneum have small conic processes directed towards the mesothelium. The majority of the processes reaches the mesothelium and participates in resorption of intraperitoneal fluid [1]. High functional activity of endothelial cells in these processes is determined by activity of their apical zone located in immediate proximity to the mesothelium. Other parts of these capillaries (middle and mouth) are mainly short vessels through which the intraperitoneal fluid collected under the effect of the respiratory excursions of the diaphragm enters the common lymph bed. The wide mouth of the processes promotes rapid outflow of the lymph.

The endothelium in processes consists of spindle or irregularly shaped cells.

Experiments with resorption of various materials showed that they were not retained in processes directed toward the mesothelium, but were immediately transported to the deeper network of lymph capillaries and postcapillaries. The major part of resorbed par-

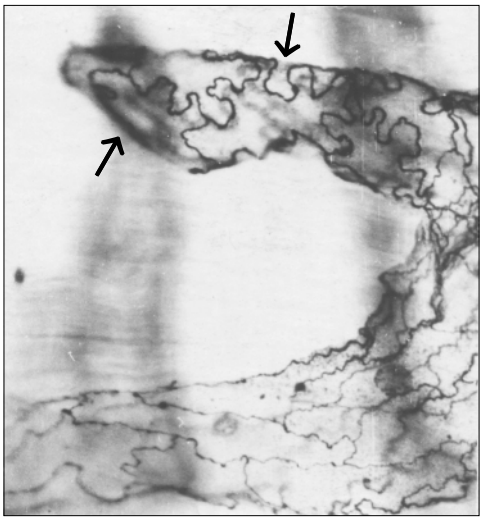

Fig. 1. "Blind" lymph capillary (arrows) in tendon center of the rabbit diaphragm. Scalloped endothelial cells. Total preparation, impregnation by the Ranvier method, ×200.

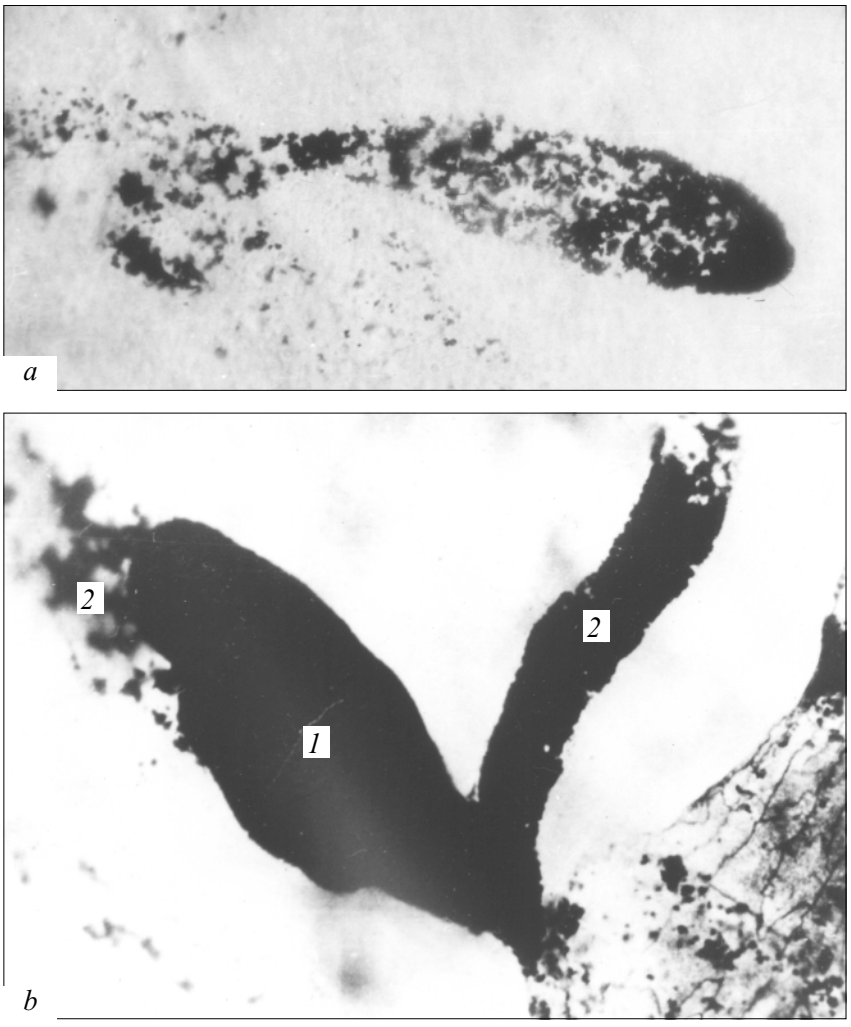

Fig. 2. "Blind" processes of lymph capillaries in the tendon center of the rabbit diaphragm. *a*) "blind" processes with few resorbed yellow cadmium particles; *b*) blind excrescence (*1*) and lymph capillaries (*2*) filled with yellow cadmium particles. Three minutes after intraperitoneal injection of yellow cadmium suspension. Total preparation, impregnation by the Ranvier method, ×200.

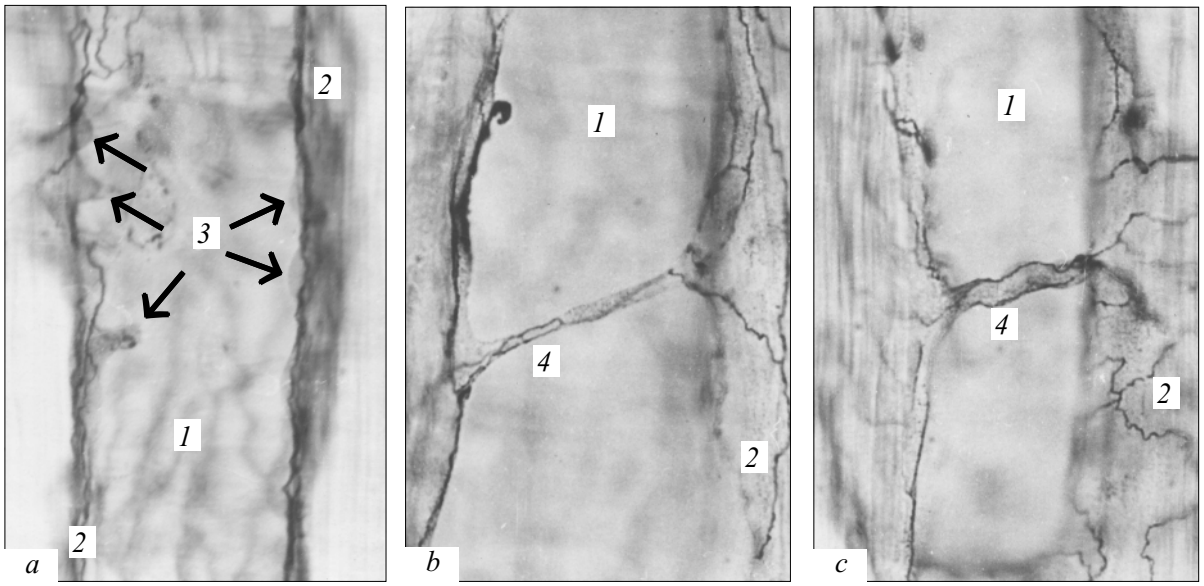

Fig. 3. Formation of bridges in lymph capillaries in tendon center of the rabbit diaphragmatic. *a*) endotheliocyte swelling; *b*, *c*) bridges in lymph capillary. *1*) lymph capillary lumen; *2*) lateral walls of lymph capillary; *3*) swollen endotheliocytes; *4*) endothelial bridge in the lumen. Total preparations, Ranvier impregnation, ×280.

ticles got into the lymph vessels, but some compactly packed particles remained in the club-shaped BLC or in capillaries with narrow mouth (Fig. 2). Many resorbed particles accumulated in small lymph vessels, forming sort of obstruction.

The presence of contractile protein (microfilaments) in endotheliocytes [10] creates the possibility of partial or complete obstruction of the club-shaped capillaries after endotheliocyte thickening. Often seen club-shaped structures filled with resorbed material indicated high contractility of the capillaries situated near the mouth. Narrowing of the BLC lumen at the site of their fusion with the total network of lymph capillaries impeded evacuation of resorbed material into the common lymph discharge system. Presumably, pathogenic microorganisms can be thus retained under natural conditions.

Group 3 BLC are mainly ball-shaped. These processes are formed under conditions of lymph congestion and reflect high adaptation capacity of capillaries to pathological conditions (tissue hypoxia). The ball shape of BLC is explained by the necessity of enlarging the area of resorbed surface, but the remaining narrow mouth can prevent the lymph outflow. The same is true for ball-shaped processes appearing in humans with age [7,8]. On the other hand, these ball-shaped structures in the lymph system indicate preserved reactive potential of the lymph capillary endotheliocytes.

All the above described BLC are products of endothelial wall growth into the adjacent tissue. Endothelial cells can grow inside the BLC lumen, which was observed in young (1-4 week-old) and adult animals with aseptic inflammation.

This process starts with remarkable swelling and elongation of the endotheliocyte cytoplasm (Fig. 3, *a*). A thin thread-like cytoplasmatic process forms at the apex of the thickened part of endotheliocyte; this process grows longer and adheres to capillary wall at some distance from the site of its origination or reaches the contralateral wall of the capillary, forming a sort of a bridge. The number of endotheliocytes in the wall of this bridge increases and the bridge becomes thicker and larger (Fig. 3, *b*, *c*); connective-tissue fibers can penetrate into it. These bridges appear primarily in narrow BLC located in narrow spaces between the bundles of connective tissue fibers. The bridges forming inside BLC modify its lumen and can decelerate lymph outflow. Loop-shaped bridges are sometimes seen in the lumens of lymph vessels. Presumably, the formation of intracapillary bridges leads to regional rearrangement of lymph vessels.

Hence, our findings demonstrate adaptive morphological restructuring of the lymph bed in health and experimental disease and functional peculiarities of its individual elements.

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