

# MORPHOLOGY AND PATHOMORPHOLOGY

## LYMPHO-VEINOUS SHUNTS AFTER OBSTRUCTION OF THE LYMPH DRAINAGE FROM THE HEART

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The formation of lympho-venous shunts following complete obstruction to the lymphatic drainage from the heart has been demonstrated. Lymph is shunted directly into the veins of the heart along the new channels. The formation of direct connections between lymphatics and veins is the result of growth of lymphatic capillaries under the conditions of severe lymph stasis.

The formation of lympho-venous shunts has been reliably demonstrated only after experimental obstruction of the thoracic duct [1-6]. So far as intramural lympho-venous shunts are concerned, this phenomenon has not previously been demonstrated.

### EXPERIMENTAL METHOD

Experiments were carried out on adult mongrel dogs anesthetized by intravenous injection of 1% thiopental sodium. The anesthetized animal was intubated and maintained on controlled respiration. Good access to the base of the heart was obtained by thoracotomy in the fourth intercostal space. The pericardium was opened 1.5 cm anteriorly to the phrenic nerve. Lymphatic drainage in dogs in most cases is effected by two large collectors: right and left. Insufficiency of the lymphatic circulation of the heart was produced by creating a mechanical obstruction to the flow of lymph along these collectors. Each of them was ligated (the right at the level of the ascending aorta, the left on the left surface of the pulmonary trunk) by two silk ligatures tied 1-1.5 cm apart. The segments of the vessels between the ligatures were excised together with the perivascular cellular tissue. The animals were sacrificed 5, 10, 15, 20, and 30 days after operation (20 cases altogether). Immediately after death, modified blue Gerota's mass was injected into the lymphatic vessels of the heart. Total tangential sections of the epicardium together with the stumps of the efferent lymphatic vessels were then fixed in 10% neutral formalin, dehydrated, and cleared in methyl salicylate. These sections were examined stereoaangioscopically by means of the MBS-1 binocular stereoscopic microscope.

### EXPERIMENTAL RESULTS

Macroscopic and microscopic control tests confirmed the absence of restoration of the lymph drainage in the zone of resection of the lymphatic vessels.

Changes discovered in the lymphatic system of the heart consisted of dilatation of lymphatic vessels of all calibers, dilatation of preexisting subepicardial capillary networks with the formation of lacunae at places where the capillaries merged, deformation of the outlines of the lymphatic vessels, the formation of varicose swellings of their walls, growth of lymphatic capillaries, and the formation of lympho-venous shunts.

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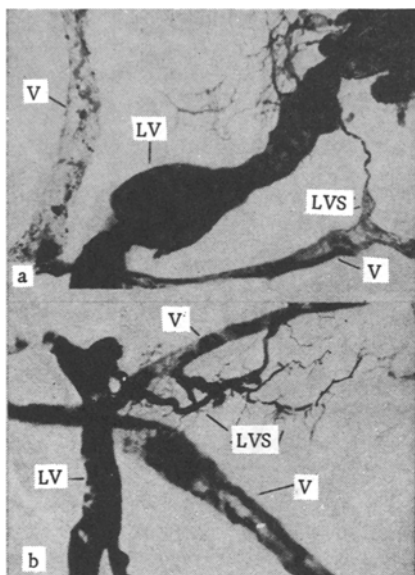


Fig. 1. Lympho-venous shunts 15 (a) and 20 (b) days after operation. LV—lymphatic vessel; V—vein; LVS—lympho-venous shunts. Combined injection of lymphatics (with Gerota's mass, 1:100) and veins with ink with mixing of injection media, 32  $\times$ .

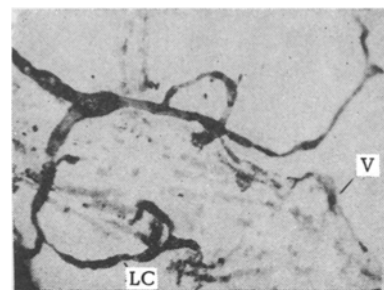


Fig. 2. Formation of lympho-venous shunt from the paravenous plexus of lymphatic capillaries (10 days after operation). V) Vein; LC) lymphatic capillary. Injection with Gerota's mass, 56  $\times$ .

The investigation showed that changes in the lymphatic system of the heart were subject to individual variations, although they were similar within the limits of one series.

Of all the adaptive changes following obstruction of the lymphatic drainage described above, special attention must be paid to growth of lymphatic capillaries. This began from the subepicardial plexuses, but with time it spread everywhere. The

formation of new lymphatic capillaries took place most intensively from the stumps of the divided collectors, and also from lymphatic vessels accompanying veins. This process was completed by the appearance of direct connections between the lymphatic and venous systems of the heart.

Four types of shunts between lymphatics and veins were detected (Fig. 1a). The first type consisted of communications between lymphatic capillaries and veins through long or short, but thin capillaries, deformed in shape, with numerous small bends along their course, sometimes helical in shape. As a rule communications of this type occurred between newly formed lymphatic capillaries and very small branches of veins. The second type consisted of lympho-venous anastomoses in the form of small trunks (Fig. 1b), of varying diameter, with funnel-shaped ends, one arising from the wall of a lymphatic collector close to or alongside the stump of the divided lymphatic vessel or from a large efferent lymphatic, the other arising from the wall of a relatively wide venous trunk. The possibility is not ruled out that both these types of lympho-venous shunts are different phases or stages of the same process. The third type of shunt was observed only in the zone of the perivascular plexuses of lymphatic capillaries (paravenous lymphatic capillaries and vessels). In such regions (Fig. 2), projections from lymphatics located in the adventitia of a blood vessel (vein) lie in very close proximity to the vessel, apparently adherent to it and perforating its wall. Contacts between veins and lymphatics in these areas also vary in size. Finally, the fourth type of connection (Fig. 3) between lymphatics and veins takes place through a capillary plexus, small in area and resembling the rete mirabile. Structural changes in the architectonics of the lymphatic system of the heart in the presence of lymphatic stasis are interconnected and, to some extent, interdependent.

A direct relationship is clearly observed between the degree of dilatation and deformation of the lymphatic vessels and the intensity of growth of the lymphatic capillaries. Meanwhile, the relationship between the degree of these adaptive changes and the state of the lympho-venous anastomoses is equally constant, but opposite in character. The more intensively growth of the lymphatic capillaries takes place in the early period, the more rapidly lympho-venous shunts develop and, consequently, the more highly developed they are. Extensive contacts between veins and lymphatics reduce the severity of stasis in the latter vessels, leading to a subsequent decrease in activity of growth of the lymphatic capillaries and cessation of further deformation of efferent vessels and capillaries. In cases when the formation of lympho-venous shunts was still in its early stages, changes in the lymphatics were more marked, and proliferation of the capillaries took place for a longer period, so that the volume of newly formed structures was greater than in the preceding cases.

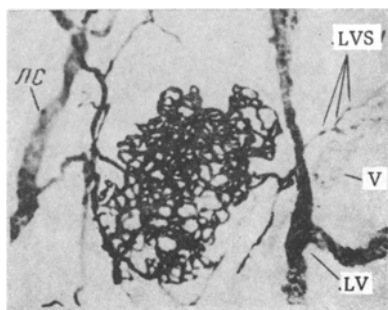


Fig. 3. Passage of Gerota's injection mass from lymphatic into vein through newly formed network of lymphatic capillaries and lympho-venous shunt. Legend as in Fig. 1, 32  $\times$ .

To verify the existence of direct communications between lymphatics and veins, in a series of cases the method of simultaneous injection of lymphatics and veins with different injection media was used. As is usual, the lymphatic system was injected with Prussian blue in chloroform (1 g/100 ml), while the veins were injected with Stefanis's yellow mass or with black ink. These combined injections confirmed the presence of lympho-venous shunts, because the injection mass crossed from the veins into the lymphatics and vice versa.

A combination of ligation and resection of part of the main efferent collector with the perivascular cellular tissue irreversibly disturbed the drainage of lymph from the heart and led to severe regional stasis of lymph in the organ. This was responsible for the development of a series of compensatory and adaptive changes, in the form of dilatation and deformation of all the components of the intramural lymphatic system of the heart, with the formation of secondary varicose changes and induction of the proliferation of lymphatic capillaries.

Growth of lymphatic capillaries, the most universal and demonstrative morphological manifestation of failure of the lymphatic circulation, assumed special importance in these cases because it gradually led to the formation of direct connections between the lymphatics and veins, which normally do not exist. The formation of lympho-venous shunts must be regarded as a qualitatively new and important stage leading ultimately to the more or less complete resolution of the lymphatic stasis.

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