

EFFECT OF RADIAL ACCELERATION ON THE TERMINAL BLOOD VESSELS

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In dogs trained to undergo exposure to radial acceleration of a centrifuge and to the action of maximal tolerable overloads, dilatation of the venules and of the blood and lymphatic capillaries and a decrease in the distance between valves of the lymphatics of the diaphragm, pericardium, and kidney capsule were observed. All these changes disappeared after 3-4 days. No morphological disturbances were found in the investigated blood vessels. In some cases hypertrophy of muscle fibers of the precapillary sphincters was observed in dogs which had undergone training.

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In animals exposed to intensive radial acceleration, hemorrhages and marked structural disturbances develop in the heart, lungs, liver, adrenals, and other organs [3, 5, 6], and also in the walls of blood vessels [2, 7, 8].

In this investigation we studied changes in the terminal blood vessels of dogs exposed to radial accelerations.

EXPERIMENTAL METHOD

The state of the intramural blood vessels and lymphatics of the pericardium, the fibrous capsule of the kidney, and the diaphragm with the pleura and peritoneum lining it, was studied by impregnation of the preparations with silver nitrate [4]. This method, unlike the injection method of revealing blood vessels, does not produce artificial changes in the vascular pattern.

Tissues of 47 adult male dogs, 24 of which had been trained on a centrifuge by V. I. Stepantsov's scheme [8], were investigated. Training was carried out on alternate days. To detect the effect of training, before and after the experiment the maximal tolerable overload for each dog was determined, i.e., the overload under the influences of which the duration of the cardiac pause was increased to twice its initial value [1]. Twelve dogs subjected only to maximal tolerable overloading and 7 intact animals were used as controls. Besides these, the organs of 4 dogs rotated on the centrifuge until the appearance of grouped extrasystoles, i.e., beyond the limit of tolerable overloading, also were investigated. One of these dogs developed ventricular fibrillation when the centrifuge was stopped, and died. The dogs were killed with ether vapor at various times (30 min, 1, 3, and 7 days) after exposure to overloading.

EXPERIMENTAL RESULTS

Hemorrhages of considerable size were found during macroscopic investigation in the lungs and beneath the endocardium of the left ventricle only in cases when the dogs had been exposed to overloads exceeding the upper limit of tolerance. No macroscopic changes were found in any of the other experiments, with the exception of congestion of the dorsal diaphragmatic portions of the lungs in animals sacrificed 30 min after the end of spinning.

The capillary network, arterioles and venules, the blind beginnings of lymphatic capillaries, and many lymphatic vessels of different caliber, equipped with valves, could be clearly seen on preparations impregnated with silver. Numerous arteriolo-venous anastomoses were found in the vascular system of the pericardium and, in particular, in the fibrous capsule of the kidney.

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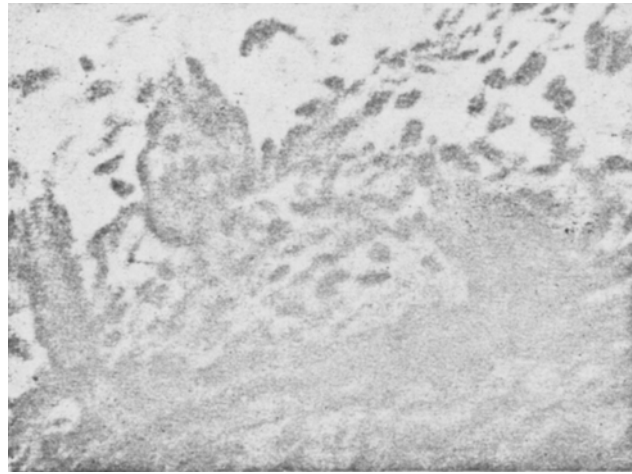


Fig. 1. Photomicrograph. Congestion of lymphatic capillary in pericardium (dog sacrificed 26 min after overloading). Impregnation with silver, 48 \times .

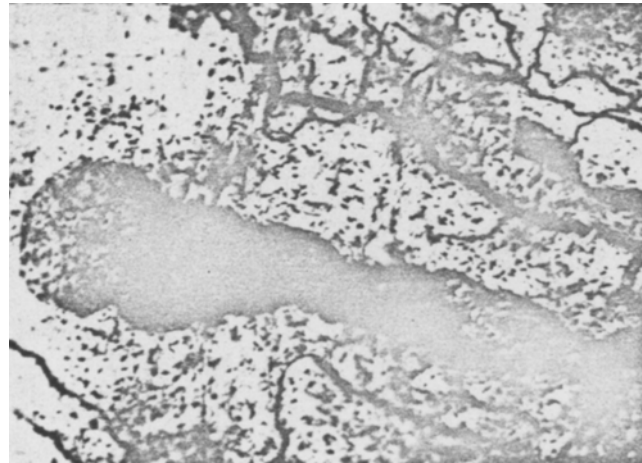


Fig. 2. Photomicrograph. Microvaricose dilatations of precapillaries in tendinous center of diaphragm (dog sacrificed 12 min after overloading). Impregnation with silver, 120 \times .

Untrained dogs exposed to maximal tolerable overloading were characterized by marked congestion of the capillaries and veins with blood, and also by marked lymphostasis in the substance of the pericardium, peritoneum, and fibrous capsule of the kidney (Fig. 1). Microvaricose dilatations were found in the arterioles of the tendinous center of the diaphragm (Fig. 2), the diaphragmatic peritoneum, and the fibrous pericardium (Fig. 2). The diameter of the varicose arteriole or precapillary was three times greater than normal ($55\ \mu$ compared with $18\ \mu$ outside the region of dilatation). The caliber of the capillaries increased to $18\text{--}19\ \mu$ compared with a normal value of $8.3\text{--}12.4\ \mu$. The distance between venulae comitantes was reduced to $40\ \mu$ from a normal $120\ \mu$ (Fig. 3), so that the anastomoses between the venae comitantes were shorter and wider.

Changes in the lymphatics were particularly distinct. Their congestion with lymph produced a well-marked beading of their outline and stretching of their walls. Measurement of the intervals between the valves showed that the mean distance between them decrease relative to the caliber of the vessels as a result of overloading, and the valves appeared to be closer together. This index for the lymphatics from 37 to $150\ \mu$ in diameter was 463.84 ± 23.36 for the experimental dogs and 870.61 ± 33.13 for the controls.

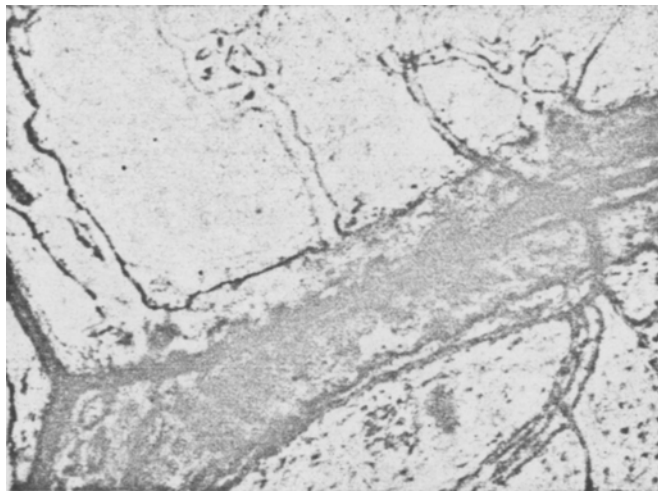


Fig. 3. Photomicrograph. Fibrous capsule of kidney. Dilatation of venae comitantes as a result of congestion with blood (dog sacrificed 24 h after overloading). Impregnation with silver, 48 \times .

The results indicate a higher coefficient of elasticity of the walls of the lymphatics in width compared with their elasticity in length.

The most marked changes were observed in animals sacrificed 30 min after overloading. In dogs sacrificed 3-7 days after exposure the signs of stasis had disappeared, the microvaricose dilatations of their arterioles and veins had disappeared, and the normal state of the lymphatics was restored. No structural disturbances in the vessel walls were found, even in animals exposed to overloads exceeding the upper limit of tolerance, although the signs of stasis in these dogs were very marked.

In animals systematically trained on the centrifuge, overloads not exceeding the upper limit of tolerance and following training caused no significant changes in the terminal blood vessels of the pericardium, fibrous capsule of the kidneys, and diaphragm, such as were found in the untrained dogs. In animals trained on the centrifuge and sacrificed 30 min after the end of the experiments, signs of congestion of the lymphatics and venules were dominant and changes in capillaries and, in particular, in the arterioles were less marked, in contrast to the findings in untrained dogs. In trained dogs sacrificed 3 days after the end of spinning, dilated lymphatics and venules could still be found. Meanwhile in animals sacrificed 3 and 7 days after spinning, signs of spasm of arterioles and even of hypertrophy of the muscle fibers in their walls could sometimes be seen, which never happened in untrained dogs.

The results of investigation of the microcirculation of the internal membranes of dogs trained on a centrifuge and of untrained animals, after exposure to radial accelerations at the upper limit of tolerance demonstrate that, despite considerable disorders of the general hemodynamics inevitably arising during the action of overloads, the morphological changes in the blood vessels do not extend beyond the bounds of normal physiological adaptability.

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