BLOOD FLOW VELOCITY IN CEREBRAL CORTEX CAPILLARIES (MICROCINEPHOTOGRAPHIC STUDY)


The brain possesses very few reserve capillaries as compared with the muscles [1-4], and the oxygen supply to the nerve cells is regulated mainly by changes in the blood flow velocity in functioning capillaries. Studies on mathematical models of diffusion and utilization of oxygen in brain tissue [5] have shown this type of regulation to be highly effective, although there is virtually no direct experimental evidence of this because of the great technical difficulties involved. The only report in the world literature [6], so far as we are aware, concerning the direct measurement of blood flow velocity in cerebral capillaries was carried out on capillaries and larger vessels of the subarachnoid space in anesthetized animals. Naturally, the direct measurement of blood flow velocity in cerebral cortical capillaries and the limits of its physiologic variations are of exceptional interest.

In the study that we made on the blood flow velocity in individual capillaries of the cerebral cortex having a lumen diameter of 3-6 μ in conscious animals we developed a technic of microcinephotography followed by interpretation of the individual photographs. This involved the construction of a specially devised arrangement for observing and filming cerebral cortical vessels located both on the surface and at a depth of 10-30 μ with an effective magnification of 300×. New to motion picture filming was a 20×0.60 contact objective designed in the microscopy laboratory of the S. I. Vavilov State Optical Institute. This system has a number of advantages over the conventional technic of filming opaque biologic objects by means of contact objectives in polarized light [7]. It has a high resolving power enabling investigations

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**Fig. 1**

Schematic representation of apparatus for intravital microcinefilming of cerebral cortical capillaries. For 1-9, 11, see text; 10) motion picture camera; 12) brain surface.

**Fig. 2**

Showing alignment of erythrocytes while passing through tiniest vessels, a) in vessel with internal diameter of 5-6, b) 3-4. Arrows denote plasma-filled lumen.

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to be performed on the smallest vessels, and a good lighting performance in close-up illumination enabling one to make a serial film of moving blood in reflected light at a rate of 40 frames per sec.

Fig. 1 presents the theoretical optical design of the apparatus. The light beam from lamp 1 is directed by condenser 2 to the diaphragm with ring aperture 3. The elliptic mirror 4 deflects the circular light beam to the peripheral part of the objective 11. This ensures that the object to be examined is illuminated only at the site of contact of the frontal lens of the objective with the surface of the preparation. The lower layer of the specimen remains unilluminated. This system gives a dark field effect, which greatly enhances image contrast. The light divider 5 in the sight tube 6 enables one to monitor the preparation during filming. The ocular 7, prism 8, and correcting objective 9 direct and focus the image in the plane of the light-sensitive layer. The optical system is mounted on a NBB-1A microscope which has a fixed optic system and a solid plate on which the condenser is rigidly mounted. The light source used was a mercury quartz lamp having a bright-line spectrum with an emission peak in the region of maximal absorption of hemoglobin. A certain inconstancy of the actinic light beam was compensated by altering the opening of the diaphragm of the motion picture through 40-100°. Correction was applied during filming using a mirror diaphragm. To increase the contrast and the light sensitivity the negative was developed in a photographic developer for the maximal time; the positive was treated under standard conditions. This method of chemical photographic treatment provided a good image quality on film KN-3 with lighting from a mercury quartz lamp.

Experiments were carried out on conscious white rats weighing about 300 g. The operative intervention was described in our preceding report [7]. The skull was trephined in the temporal region (6×8 mm) and dura mater was removed under ether anesthesia. The brain surface was irrigated with physiologic solution at 37°. Under local anesthesia a catheter was inserted into the femoral artery to monitor the arterial pressure. By means of controllable heating the brain surface temperature was maintained constant at 35±0.5° and the rectal temperature at 37.5±0.5°. About 30-40 min after stopping the anesthesia the prepared animal was firmly fixed to a special bench and placed on the all-purpose examination table of a device whereby the brain surface was brought into contact with the frontal lens of the objective. In this way the image of the surface structures of the brain was located in the focal plane. Choice of visual field was made by displacing the animal on the examination table in a strictly horizontal plane [8]. Focusing at the requisite depth for inspection was done by altering the effective length of the microscope tube.