EFFECT OF CLOSED HEAD INJURIES ON DEVELOPMENT OF THE VASCULAR SYSTEM OF THE BRAIN

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Infliction of closed head injuries on rabbits 5 days old delays development of the superficial venous system in the region of the trauma.

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In this paper we describe the results of a study of the reaction of the superficial blood vessels of the brain in rabbits subjected to closed head injuries at the age of 5 days (15 animals) and 1.5 months (21 animals). Of the total number of animals 28 were experimental and 8 control.

EXPERIMENTAL METHOD

The experimental rabbits were tied to a special frame, and their heads were fixed. A closed head injury was inflicted by means of a weight falling down a vertical metal tube. The tube was placed above the occipito-parietal region of the skull of the experimental animal and pressed firmly against it. For each age the strength of the blow was chosen so as to produce transient loss of "consciousness," but the possibility of an open head injury was excluded because disturbance of hermetic closure of the skull influences the cerebral circulation [1]. The blood vessels of the brain were injected intravitally with 3% gelatin solution in ink 1 and 4 h and 6 and 21 days after trauma, and also in the control animals of the same age, using a method developed in the authors' department. The brains of the experimental and control rabbits were removed from the skull 2-3 h after injection and cooling, and fixed in 10% formalin solution. The vessels were studied in whole brain preparations under the MBS-2 binocular microscope.

EXPERIMENTAL RESULTS

Our investigations showed that 1-4 h after injury, the arteries and veins over the whole surface of the cerebral hemispheres of the 5-day old rabbits were considerabley constricted. Vasoconstriction was particularly marked in the occipital and parietal regions, i.e., in the areas of maximal injury to the skull. Small vessels were constricted most, their lumen becoming impermeable to ink particles. Even in animals surviving 6 days after injury inflicted at the age of 5 days, the diameter of the arteries of the brain surface, although it had increased, remained less than in normal animals. Meanwhile the veins draining the blood from the brain substance became wider than in rabbits aged 11 days (Fig. 1).

Injury delayed formation of the large veins, especially in the occipital regions of the brain. In normal animals formation of the large venous trunks in these regions is completed by the 11th day of life (Fig. 1a). Conversely, in rabbits subjected to trauma at the age of 5 days, on the 11th day of life active processes of formation of large veins and of their branches of the first order by the merging of small veins into lacunae followed by conversion of these lacunae into venous trunks draining blood into the venous sinus, were still taking place (Fig. 1b).

In the animals surviving 21 days after head injury the diameter of the arteries was even less than in the control rabbits aged 26 days. Constriction of the small arteries and arterial anastomoses was particularly noticeable. In the experimental animals the tone of the arterial wall was less marked, so that the lumen of the arteries varied along their course. Conversely, the veins were much wider over the surface of the brain than in control animals of the same age. Meanwhile, delay in development of the veins was clearly visible in the animals subjected to trauma. In the control rabbits aged 26 days, for instance, merging of the small veins in the venous system on the surface of the occipital lobes was complete, the process

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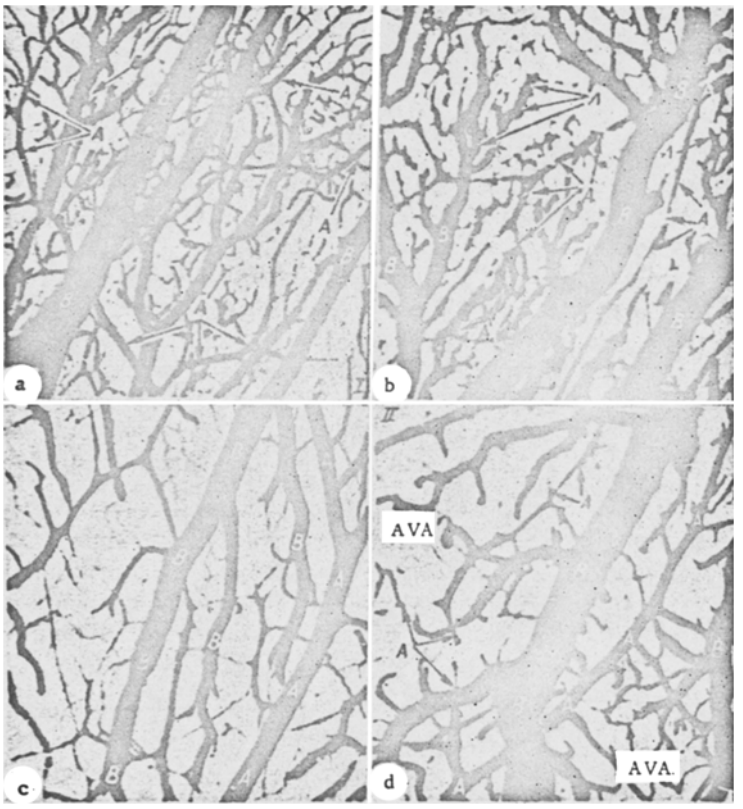

Fig. 1. Reaction of superficial vessels of the occipital lobe 6 and 21 days after closed head injury at the age of 5 days. I) Constriction of arteries (A), dilatation of veins (B), active merging of small veins and formation of lacunae (Λ) 6 days after head injury; II) constriction of arteries, marked dilatation of veins, and active atrophy of venous anastomoses (AVA) 21 days after head injury; a and b) control and experiment (age of animals 11 days); c and d) control and experiment (age of animal 26 days). Here and in Fig. 2: intravital injection of cerebral vessels with ink. 32 ×.

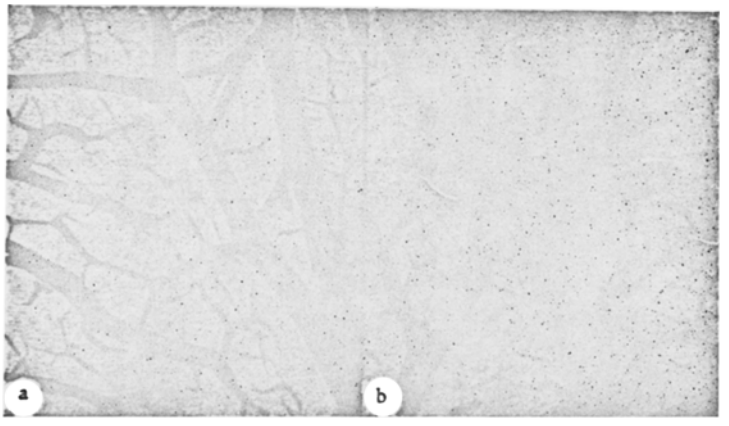

Fig. 2. Reaction of superficial vessels of the occipital lobe 21 days after closed head injury to a rabbit aged 1.5 months. Dilatation of arteries and veins; a and b) control and experiment (age of animals 66 days).

of atrophy of the venous anastomoses was ill-defined, and as a result, the structure of the venous network was essentially the same as in the adult animal. In the experimental 5-day old rabbits, 21 days after injury, merging of small veins into lacunae and of lacunae into larger veins was still proceeding, and atrophy of the anastomoses continued, leading to the creation of straight, wide veins from the network of small loops (Fig. 1, c and d).

Closed head injury inflicted on animals aged 1.5 months caused marked constriction of arteries and veins on the surface of the occipital lobes of the brain; but the trunks of some arteries were not uniformly constricted, as in the animals aged 5 days, but the constriction was of "hourglass" type. In contrast to the young animals, in these rabbits 6 days after injury the arteries and veins on the brain surface remained constricted. Meanwhile, in rabbits aged 1.5 months surviving 21 days after trauma, dilatation not only of veins, but also of arteries, was observed (Fig. 2). Marked venous hyperemia on the surface of the hemispheres at the site of injury was particularly characteristic. Considerable dilatation of the principal venous trunks draining into the sinus and of all their branches was found in this region. This suggests the passive dilatation of the arteries as a result of the severely retarded outflow of venous blood from the brain substance, in which large amounts of carbon dioxide and breakdown products, formed in the zone of maximal trauma, accumulated.

We consider that the arteries became constricted by a reflex mechanism as a result of the concussion and displacement of the brain produced by the blow in the region of the occipital and parietal lobes. The strength and duration of the effect on the arterial system increased with age. Whereas in animals aged 5 days the arteries were uniformly constricted 4 h after trauma, in animals subjected to injury at the age of 1.5 months some arteries acquired an "hourglass" appearance.

It can be concluded from the study of the reaction of the vascular system of the brain to closed head injury that when the developing brain is exposed to harmful influences the severest disturbances are found in processes which are most active at that particular moment. In fact, as the results of our previous investigations [2, 3] showed, at birth of the animal the arterial system on the brain surface is largely formed, and after birth the vessels increase in length and in diameter. Conversely, in the venous system of the brain active processes of vein formation continue to take place for 17-20 days after birth, and only when these processes are complete does the character of the oxygen supply to the nerve cells and the removal of metabolic products and carbon dioxide from them become the same as in the adult. In our experiments, therefore, the harmful action of closed head injury affected primarily the formation of the venous sytem, causing considerable delay in its development, and thus delaying development of the brain as a whole.

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