THE CONDITION OF THE VASCULAR-CAPILLARY SYSTEM OF THE BRAIN IN ANIMALS OF DIFFERENT AGES DURING ASPHYXIA

Article II

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This work is part of a research project studying the effects of different physiological and pathological body conditions on the blood supply and the vascular-capillary system of the cerebral hemispheres in animals of different ages.

The preceding article [2] presented data regarding change in the blood supply of the cerebral hemispheres due to asphyxia in cats of various ages. By quantitatively determining the amount of blood supplying the brain, we showed that the blood supply to the cerebral hemispheres increased after lethal asphyxiation in kittens 1-2 days old, 25-45 days and 2-3 months old, and in adult cats as well. Only in kittens which had died from asphyxia when 3-10 days old was there no change in the blood supply to the cerebral hemispheres. In this age group, the amount of blood going to the cerebral hemispheres increased at the start of asphyxia, but after the death of the animal, the amount of blood supplied to the cerebral hemispheres was reduced to normal.

EXPERIMENTAL METHODS

The animals were asphyxiated by being put into a hermetically sealed chamber twice the volume of the animal. As soon as respiration ceased, the animals were withdrawn from the chamber and decapitated. The skull was opened and the brain removed; the right hemisphere was isolated – it was used for the quantitative blood determination; the left hemisphere and the rest of the brain were placed in 7-10% formalin for subsequent histological processing. Sections from the frontal-parietal and occipital regions of the cerebral hemispheres were used for the histological study. The brains of healthy animals of the same age were processed concurrently by the same method as those of the animals which had been asphyxiated.

By histologically processing the brains of these animals and using one of the cerebral hemispheres for quantitative blood determination, we could compare data concerning the quantitative blood determination with that concerning the morphological condition of the vascular-capillary system of the brain from the same animal.

The sections were histologically processed by the Eros method, which stains erythrocytes with acid fuchsin, by the Masson method, which stains both plasma (with aniline blue) and erythrocytes (with acid fuchsin), and by the Klosovsky method, which is based on silver impreganation of the vascular wall. To stain preparations by the Eros method, paraffin blocks were cut into sections 60 microns thick. The sections stained according to Masson were 7 and 20 microns thick. Sections 150 microns thick were made from celloidin blocks of the brain, processed by the Klosovsky method.

EXPERIMENTAL RESULTS

On brain preparations processed by the Eros method from normal kittens, a weak acid fuchsin coloring of the hyaloplasm was noted; in some places, the nerve cells were also stained. A small number of capillaries containing erythrocytes, which were arranged in the form of a few sparse chains (Fig. 1) were observed in the cortex and white matter. A somewhat different picture was seen in the subcortex. Here, there were considerably more blood-filled capillaries than in the cortex of the cerebral hemispheres. It is a known fact that the subcortex is more mature than the cortex of the cerebral hemispheres in young animals born prematurely. This could explain the greater vascularization of the subcortex as compared with the cortex of the cerebral hemispheres.

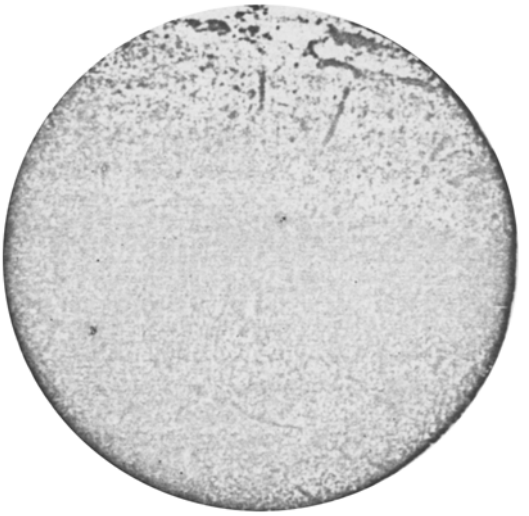

Fig. 1. Vascular-capillary system of the cerebral hemisphere cortex in the brain of a one-day old healthy kitten. Eros method of staining. Magnification 15 x 10.

Studying the preparations processed by Masson's method, we noted that a large part of the capillaries of the cortex and white matter were filled with plasma and contained few erythrocytes. The fact that a relatively small number of blood-filled capillaries was observed on the preparations stained according to the Eros method (which only shows erythrocytes) is explained by the large quantity of plasma present in the capillaries and in some of the larger vessels.

On the preparations impregnated with silver according to the Klosovsky method, many constricted capillaries were evident in the cortex, and a lesser number in the white matter. Many of the capillary lumina were not uniform in diameter. The tonicity of the vascular wall was poor, causing the capillary network forming the vascular-capillary system of the cortex to be misshapen.

The same condition of the vascular-capillary system of the cerebral hemispheres in kittens a few days old was also noted by Z. N. Kiseleva [3], who showed that the brains of healthy kittens are edematous during the first few days of life.

In the previous article, we showed that the amount of blood in the cerebral hemispheres of normal kittens 3-10 days old is slightly greater than that in 1-2 day old kittens; the cerebral hemispheres of normal kittens 1-2 days old contain an average of 0.81% blood, while those of normal kittens 3-10 days old contain an average of 0.88% blood. Such a slight change in the cerebral hemisphere blood supply is almost imperceptible on histological preparations. Therefore, the condition of the cerebral hemisphere vascular-capillary system in normal 3-10 day old kittens is practically the same as that in normal kittens 1-2 days old. However, one must note that, after the 3rd day of life, an increase in the number of growing capillaries was observed.

We have established that the blood supply to the cerebral hemispheres of animals increases as the body of the animal grows and develops. Only in animals aged from $1\frac{1}{2}$-2 months does it approximate the amount characteristic to the mature body. The morphological condition of the vascular-capillary system of the cerebral hemispheres also changes accordingly. Studying histological preparations made from the vascular-capillary system of the brain in normal kittens 20-45 days old, we observed an increased amount of blood in the vessels of the cerebral hemispheres, a more dense distribution of eythrocytes in the capillaries, and some increase in the lumina as compared with the capillaries of normal 10 day old kittens. At the same time, some differences in the condition of the vascular-capillary system of the cerebral hemispheres could also be observed in this age group. In 20 day old kittens, for example, there were fewer capillaries manifested by the Eros method and fewer with irregular lumina than were found in 30 day old kittens, etc. As the age of the kitten increased, the hyaloplasm stained less and less with acid fuchsin. Therefore, vessels stained with acid fuchsin were visible on a light background in normal kittens more than 30 days old and in mature animals. The decreased intensity of the acid fuchsin stain in the hyaloplasm indicates the reduced acidity of the basic brain substance, which, in turn, is connected with the gradual disappearance of edema in the brain as the kitten grows older. The condition of the vascular-capillary system of the cerebral hemispheres in normal kittens 1.5-2 months old was almost identical with that of the mature body. At this age, however, growing capillaries were still rather frequently found in individual portions of the brain [1].

The picture of the condition of the cerebral hemisphere vascular-capillary system was different in the animals of various ages which had died from asphyxia.

In 1-2 day old, asphyxiated kittens, marked dilatation was observed in the veins and arteries of the cortex (Fig. 2), white matter, subcortex, and in the vessels of the pia mater of the brain; erythrocyte-containing capillaries were considerably more numerous than in the brains of normal kittens of the same age. There were also much fewer of the capillaries filled with plasma alone. Moreover, in this age group of asphyxiated kittens, capillaries with uniform lumina predominated, and a slight dilatation of the capillaries was also observed.

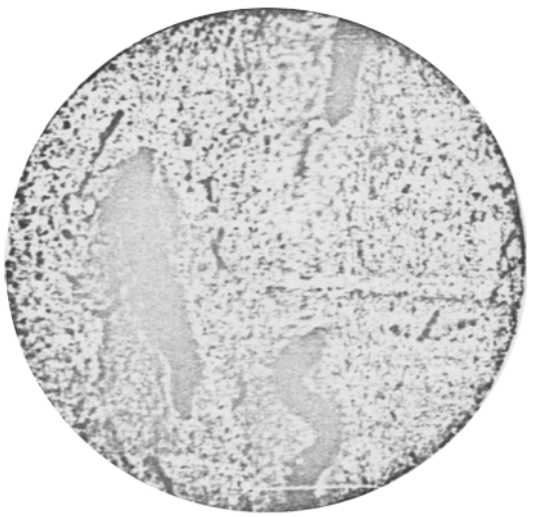

Fig. 2. Vascular-capillary system of the cerebral cortex of a one-day old, asphyxiated kitten. Eros method of staining. Magnification 15 x 10.

Histological study of the cerebral hemispheres from 1-2 day old, asphyxiated kittens confirmed the information obtained from quantitative blood determination, i. e., that the blood supply increased. Analyzing the preparations made from the cerebral hemispheres of these kittens, we observed also that the larger vessels, particularly, were dilated and that the capillaries were more filled with blood because of the increased blood supply to the cerebral hemispheres (Fig. 2).

As we have already mentioned, compared with the normal animals we found no changes in the blood supply to the cerebral hemispheres of 3-10-day old, asphyxiated kittens. However, histological examination disclosed some peculiarities in the condition of the vascular-capillary system of the cerebral hemispheres from the kittens which had been asphyxiated. On the preparations processed by the Eros method, an intense acid fuchsin coloring was often noticed in the hyaloplasm of the cortex and sometimes in the nerve cells. The vascular walls and the plasma often were stained as well as the erythrocytes. In the cortex and white matter, a relatively small number of erythrocyte-containing capillaries was observed. Finally, in those cases where we discovered capillaries especially poorly filled with blood in the cortex, the dilatation of individual venous vessels was observed in the white matter of the brain.

The preparations processed by the Masson method showed a large number of plasma-filled cortical

capillaries and individual vessels which contained mostly plasma. The stronger acid fuchsin coloring of the hyaloplasm, nerve cells, vascular walls and plasma indicated that the brain tissue of the asphyxiated animals had a more acid reaction to the medium than the brain tissue of normal animals. All the brain tissure properties enumerated above indicate an expressed condition of brain edema [4].

It should also be mentioned that a large number of constricted capillaries with uniform lumina was found on the cerebral hemisphere preparations impregnated with silver. There were less capillaries with irregular lumina than normally.

Therefore, although quantitative blood determination in the greater cerebral hemispheres of asphyxiated kittens 3-10 days old could not show results in any way differing from those received upon analogous examination of healthy kittens of the same age, histological examination showed that there was a difference which consisted in the presence of more sharply expressed symptoms of edema in the brains of the asphyxiated kittens.

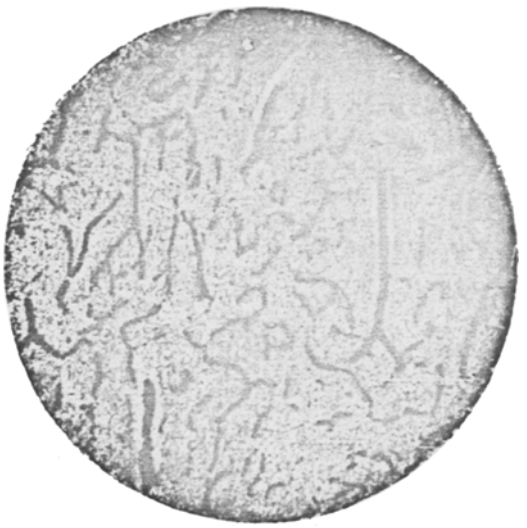

Fig. 3. Vascular-capillary system of the cerebral hemisphere cortex of a mature cat after asphyxiation. Eros method of staining. Magnification 15 × 10.

The data presented concerns 3-10 day old kittens, used in the experiment 15-30 minutes after eating, i. e., in the condition we assumed to be normal. If the kittens had been experimented on 2-6 hours after eating, there would have been an increase of the blood supply to the cerebral hemispheres under conditions of asphyxia. Histological examination of the cerebral hemispheres of such kittens showed practically the same features of the vascular-capillary system as were present in kittens 1-2 days old after lethal asphyxia.

In kittens 20 days old or older which had died from asphyxia, most of the capillaries were dilated and well-filled with blood in all sections of the cerebral hemispheres. In contrast to the kittens only a few days old, constricted capillaries and capillaries with irregular lumina were rarely found in this age group.

The large arterial and venous vessels were also dilated in all sections of the cerebral hemispheres.

In 30-45 day old kittens, capillary dilatation was more marked than in the 20 day old kittens.

Practically speaking, the condition of the vascular-capillary system of the cerebral hemispheres in such kittens was almost the same as that in mature cats which died from asphyxiation (Fig. 3).

On silver-impregnated brain sections from mature cats, one could see short, sharply constricted capillaries which looked like threads 1-1.5 microns in diameter, although there was a predominance of dilated capillaries.

Therefore, in kittens of the older age groups and in mature cats, the increased blood supply to the cerebral hemispheres after lethal asphyxia results in the dilatation of all the components of the vascular system.

The following is important in comparing the condition of the vascular-capillary system of the cerebral hemispheres in animals of different ages which have died from asphyxia. In kittens up to 10 days old (especially in 1-2 day old kittens and in hungry kittens 3-10 days old), a sharp dilatation of the larger vessels and, to a lesser degree, of the capillaries was noticed. Dilatation of the large vessels was more pronounced in kittens of this age group than in older kittens and mature cats. Here, it must be taken into account that the brain is somewhat smaller in kittens a few days old than in mature animals. At the same time, the diameters of the large vessels of the cerebral hemispheres in kittens 1-2 days old and in hungry kittens 3-10 days old, which have died from asphyxia, is either the same or greater than that in mature animals. Moreover, the older the animal, the more blood-filled the capillaries and the wider their lumina.

Consequently, histological examination of the cerebral hemispheres from cats of different ages which died from asphyxia confirms the data obtained from quantitative blood determination which was presented in the first article.

SUMMARY

Some peculiarities in the reactions of the vascular system of the brain in one-month old kittens were noted with the aid of the histologic method. Dilatations of large vessels and dilatations to a lesser degree of capillaries has been noted during asphyxia in newborn kittens, likewise in 3-10 day old hungary kittens. 3-10 day old kittens (which had been previously fed) died of asphyxia with a pronounced edema of the brain. The reaction of the cerebral vessels at the end of the first month of life in cases of asphyxia is practically the same as in a mature animal.

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