STUDY OF THE CHANGES IN THE POSITION AND THE PATTERN OF CHANGES OF THE BRAIN ARTERIES IN FETUSES AND FULL-TERM STILLBORNS

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Abstract

We studied cerebral blood vessels in 20 fetuses of the gestation age between 16-36 weeks, and in 5 full-term stillborn cadavers by the method of dissection. One portion of the brain samples were processed by filling the blood vessels with 10% solution of formalin, whereas in the other group we used Mixobar and injected it through carotid artery to demonstrate brain arteries. In early fetal life the arteries are thin and have a straightforward pattern, which is in a direct correlation with the development of the brain. In brain arteries of a 28-week old fetus we observed progressive changes at all three brain arteries that began to assume more curved pattern. Since a significant increase in the brain growth and formation of the gyruses and sulcuses of the brain occurs in the 32nd week, the arteries also assume a wavier pattern, and the number of its branches increases. In full-term stillborns, the arteries are much larger in caliber, they branch abundantly, and due to relatively wide brain sulcuses we may also conclude that their pattern is partially tortuous. From our results it is evident that there are changes in the position, pattern and relationship of brain arteries that are parallel with the brain development and formation gyruses and sulcuses of the brain.

Key words: brain, foetuses, cerebral blood vessels

Introduction

X-ray and anatomical studies of blood vessels by cerebral angiography are mainly done in adult persons. Padget (1), Suzuki (2), Vander Eecken (3), concluded that methods that were widely used to describe cerebro-vascular status of adults were scarcely used for studies of blood vessels in the fetal period. Fragile blood vessels and partially myelinated brain with high content of fluid represents a considerable problem in manipulation and preparation of the sample for the studies.

Large brain arteries develop parallel with the development of brain hemispheres. Streeter (4) reported that the growth of cranium does not follow the growth of hemispheres, thus inducing convolutions on hemispheres that are separated by temporary sulcuses. During the fourth month of the intrauterine life these temporary sulcuses disappear, probably as a result of slightly increased growth of the cranium. The initial fissures are fissura Sylvi, parieto-occipitalis fissure and calcarine fissure. Increase in the width of brain hemispheres and the brain itself, entirely changes the pattern of the first segment of middle cerebral artery from tilted to more horizontal pattern, as reported by Takashi (5) and Van Overbeeke (6).

Padget (7) reported that a branch of the middle cerebral artery which initially appears as straight artery, assumes a typical curved pattern of branches and an increase in the distance between its insular branches by the development of operculum. Until the 24th week the arteries mainly maintain a straight upward pattern, and after 32nd week the arteries begin to assume a curvy pattern as a result of the gyruses growth.

Materials and Methods

We investigated cerebral blood vessels in 20 fetuses at the gestation period between 16th and 36th week of intrauterine life, and in 5 full-term stillborn babies' cadavers by the method of dissection. One portion of the studied material was processed by filling the blood vessels with 10% formalin solution, and in the other group we injected Mixobar through carotid artery and thus presented cerebral arteries. The samples were then fixed in 5% formalin solution over a 30-day period. By careful dissection we removed bone structures and dura mater and approached the convex part of the brain. In the next stage we carefully removed the brain and analyzed the position, pattern and ramification of the brain arteries.

Results

In fetuses at the age of four months of intra uterine life, the anterior cerebral artery i. e. its post-communicant part has a vertical pattern. Only 1-2 short parts separate from this artery and their pattern is straight.

In 5-month old fetuses the pericallosal artery loses its vertical pattern in its initial part and slightly curves around genu corporis callosi. There is also greater number of collateral branches which are short and directed towards the upper edge of the hemisphere. The pericallosal artery running in the opposite direction spreads the upper edge of callous body and reaches splenium corporis callosi where it anastomoses with dorsal branch to corpus callosum of posterior cerebral artery. The cortical branches of the posterior cerebral artery are well differentiated as short and straight blood vessels. In the area of occipital lobe a wealth of venous vessels can be observed (Figure 1).

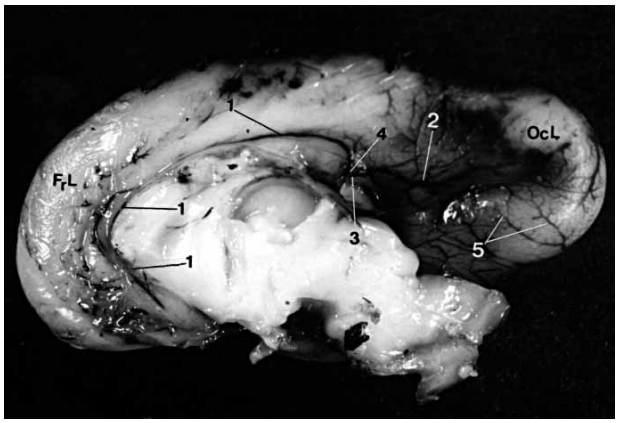

Figure 1. Medial side of the hemisphere. Anterior and posterior cerebral artery. Brain of 5-month old fetus

1 - anterior cerebral artery
2 - posterior cerebral artery
3 - dorsal branch to corpus callosum
4 - anastomoses ACA and ACP
5 - venous vessels of the occipital lobe
OcL - occipital lobe
FrL - frontal lobe

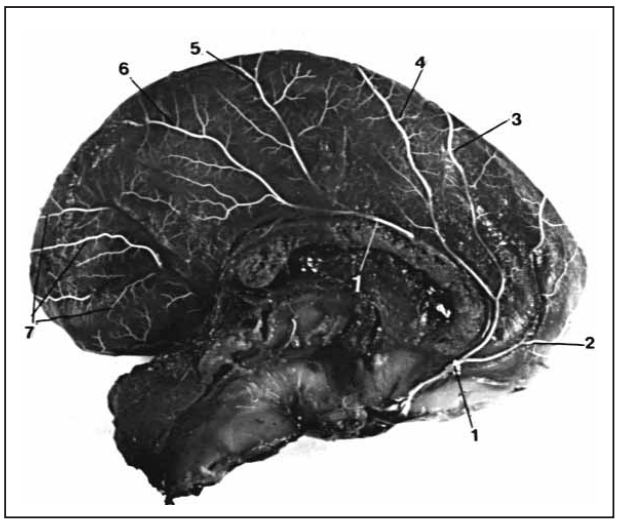

Figure 2. Arteries of the medial part of a hemisphere. Brain of 7-month old fetus.

1- callosomarginalis artery
2- anteromedial frontal branch
3- intermediomedial frontal branch
4- posteromedial frontal branch
5- paracentral branches
6- precuneal branches
7- posterior cerebral artery P4 (medial occipital artery)

The middle cerebral artery, in its initial part, runs horizontally to lateral cerebral fossa, and its insular part is detected as a vertical blood vessel, which is poorly ramified in the area of the insula. The insular operculum is not developed and it does not cover this part of the artery. The insular part connects with the cortical part of the artery that is poorly developed and consists of a few thin, vertically positioned blood vessels. In 6-month old i. u. fetus the pericallosal artery, in its initial infra-callous part, is tilted and its pre-callous part shows somewhat stronger curve around the knee of the callous body. Branches that spread from this part are numerous and longer, and ramify in their further spreading. The pattern of these branches is straight and without significant curves. Callosomarginal artery is also identified.

In 7-month old i. u. fetus (Figure 2) the pericallosal artery in its initial infra-callous part shows a slight concavity directed forward, while the pre-callous part shows even stronger curve around the knee of the callous body. The branches of this artery vascularize 2/3 of the medial part of hemisphere. The arteries are long and slightly wavy and the ending branches transfer to the convex edge of the hemisphere. These branches further diverge into miniature branches along their entire length and they approach each other but do not anastomose. The cortical branches of posterior cerebral artery that vascularize rear third of the hemisphere is also slightly wavy and branch into tiny branches that cover entire surface of the occipital lobe in the form of network.

In the superolateral part of the hemisphere in the same sample, the branches of the cortical part of middle cerebral artery spread from the lateral cerebral sulcus. It is possible to observe all cortical branches of this artery. In their initial part these branches are straight, while the secondary branches that stem from these branches have slightly wavy pattern. Branches that provide for vascularization of the frontal and parietal lobe converge with the branches of anterior cerebral artery which transfer from medial to super-lateral part of the hemisphere. The arteries that serve vascularization of the temporal lobe (Figure 3) also have the same morphological characteristics, and we have also observed that the number of arteries for its vascularization is slightly larger than in adult humans. In all cases we noticed that the ending branches of the pericallosal artery transfer to super-lateral surface of the brain. We also observed superficial veins, that is, superficial middle cerebral vein, prefrontal veins, frontal veins, parietal veins and occipital.

In full-term stillborns the anterior cerebral artery and its branches are of significantly greater caliber compared to the previously reported cases. The arteries have more wavy appearance, and the position and pattern of these blood vessels shows distribution almost identical to the one found in adult humans. (Figures 4 and 5)

Branches of the middle cerebral artery that can be observed on the convex side of the brain are of rather large caliber and assume more wavy pattern. They richly rami-

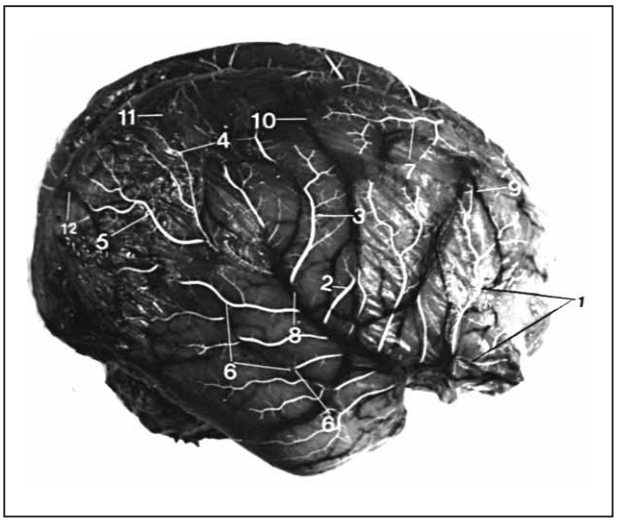

Figure 3. Convex part of the hemisphere.
Middle cerebral artery and superficial veins of the brain.
Brain of 7-month old fetus.

1 - lateral frontobasal artery
2 - artery of precentral sulcus
3 - artery of postcentral sulcus
4 - anterior parietal artery
5 - posterior parietal artery
6 - inferior cortical branches of the middle cerebral artery
7 - cortical branches of the anterior cerebral artery
8 - superficial middle cerebral vein
9 - prefrontal veins
10 - frontal veins
11 - parietal veins
12 - occipital veins

Figure 4. Medial part of hemisphere. Anterior cerebral artery. Sample of the brain of full-term stillborn

1 - anterior cerebral artery
2 - frontal polar artery
3 - callosomarginal artery
4 - branches of anterior cerebral artery which anastomose with posterior cerebral artery

fy into tiny/miniature branches that anastomose particularly in the part of the temporal lobe. Since the sulcuses are formed on the convex side of the brain, the arteries, in this stage of development, take their positions in the appropriate sulcuses, which mainly correspond to the position of arteries in adult humans (Figure 5). Operculum is not definitely formed and the branches of lateral frontobasal artery can still be observed in the area of insula.

Discussion

By following the developmental changes on arteries of fetuses between the 4th and the 9th month of intra uterine life, we dedicated particular attention to their position, shape, pattern and ramification of the main brain arteries. With the dissection method we came across certain difficulties in fixation and manipulation of the fetal brains. Those can be explained by the presence of considerable quantity of fluid in the fetal brain, since at the time of birth 85% of the brain weight consists of fluid. During the fixation, formalin reacted with precipitating collagen and muco-polysaccharides that can be found in very small quantities in

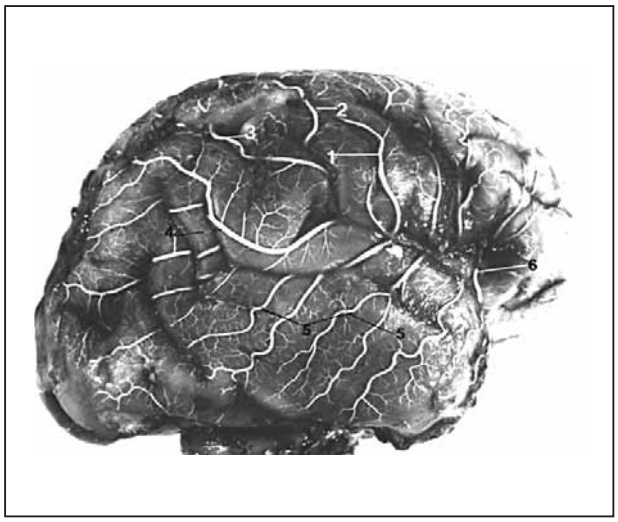

Figure 5. Convex side of a hemisphere. Middle cerebral artery. Sample of the brain of full-term stillborn

1- artery of precentral sulcus
2- artery of central sulcus
3- artery of postcentral sulcus
4- branch to angular gyrus
5- inferior cortical branches of middle cerebral artery
6-lateral frontobasal artery

the fetal brain. In addition, the fetal blood vessels are thin and fragile therefore injecting of Mixobar often caused ruptures in blood vessels and such material could not be taken for analyses. However, on the series of samples that included the gestation period between 16 and 40 weeks of intra uterine life, we managed to obtain relevant data about developmental changes on blood vessels of the cerebrum in the period of formation of brain convolutions and fissures.

We found much more literature data on embryonic development of blood vessels in the studies of Streeter (7), Padget (4), Kaplan (2), and Gillilan (1), while the data on fetal blood vessels were scarce.

Lie et al. (3) emphasized that if the data of the prenatal growth and topographic changes of different arteries are known, a normal perinatal angio-architecture is more understandable and pathogenesis of the safe congenital anomalies can thus be elucidated. These authors conducted a large study of the brain arterial system in fetuses, including vascular injections, filling, dissection and x-ray anatomy analyses. In the conclusion, the authors added that numerous fetal arteries' schemes already presumed adult configuration by the end of the first trimester.

In early fetal life the arteries are thin and have a straight pattern that is in direct correlation with the development of the adjacent brain structures. In the brain arteries of 28-week old fetus, it is possible to observe progressive changes in all the three brain arteries that change from straight into more curved pattern. Since the 32nd week of intra uterine life is marked by faster growth of brain and formation of brain convolutions and fissures, the arteries also assume wavier pattern, and the number of branches increases. In full-term stillborn babies, arteries are much larger in caliber, rich in branching, and due to relatively wide brain sulcuses it may be stated that their pattern is partially tortuous.

Conclusion

From our results it is evident that changes occur in the position, pattern and relation of brain arteries parallel with the development of the adjacent brain structures and the period of appearance of convolutions and fissures, which concurs with rather scarce literature data in this area.

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