CONTRIBUTION TO THE KNOWLEDGE OF POSITION, FLOW AND ARTERIAL DISTRIBUTION OF CEREBRAL BLOOD VESSELS IN FOETUSES 4 TO 9 MONTHS OF AGE

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Abstract

We studied cerebral blood vessels in 25 fetuses of gestational age 16-36 weeks and in 10 cadavers of still-born babies by injection-corrosive method. In the early fetal life, arteries are thin with the straight flow, which is directly connected with the brain development. Progressive changes are observed in all the three cerebral arteries in 28-week old fetus, which straight flow becomes more and more tortuous. As in the 32nd week the brain develops faster and gyri and sulci are being formed, the arteries assume wavy flow and number of their rami increases. In a still-born baby, arteries are of rather bigger caliber; they branch abundantly; and due to their relatively broad cerebral sulci, it can be said that their flow is partly tortuous. Our results show evidently that position, flow and relation of cerebral arteries change concurrently with the brain development and appearance of cerebral gyri and sulci.
Key words: fetus, brain, arteries, veins

Introduction

Fetal cerebral blood flow is fragile and partially myelinated brain with high content of water is very difficult to handle. According to Kier (1), lack of joint radiographic and anatomical studies in fetal period might be the result of technical problems. Newton & Potts (2), emphasize that normal perinatal angio-structure is more understandable and pathogenesis of certain congenital anomalies can be elucidated if data on prenatal growth and topographic change of different arteries are known. These authors conducted a large study of cerebral arterial system in fetus, including methods such as vascular injections, casting, dissection, and radiographic and anatomical analyses. The material subjected to our study consisted of aborted human fetuses, ranging in gestational age between 10 and 36 weeks; age was ascertained by measuring occipitotemporal diameter and cranio-coccygeal length. Numerous fetal blood vessels correspond to adult configuration already by the end of the first trimester. Hoyt (3) reports that increase in cranium is not followed by the growth of hemispheres, so that gyri separated by temporary sulci are formed on hemispheres. These temporary sulci disappear during the fourth month of intrauterine life, probably as the result of somewhat faster growth of cranium. Increase of width of cerebral hemispheres and cerebrum changes entirely the flow of the first segment of arteriae cerebri madiae from the slant upper to the more horizontal direction, as reported by Takashi (4). Padget (5) reports that branches of arteriae cerebri madiae appear at first as straight arteries and that development of operculum causes characteristic bending of its branches. Till 24 weeks arteries mainly maintain a straight direction, after 32 weeks they assume tortuous flow as the result of the growth of gyri. Streeter (6) reports that development of corpus callosum has great impact on the development of anterior cerebral arteries. As the corpus callosum develops, the anterior cerebral artery gradually loses its vertical flow and becomes more bent forward.

Material and methods

We studied cerebral blood vessels in 25 fetuses of gestational age between 16 and 36 weeks and in 10 cadavers of still-born babies by injection- corrosive method. All research described in the submitted publication involving human subjects and material derived from human subjects complied with ethical principles outlined in Helsinki Declaration. In making a successful preparation by this method a good condition of blood vessels is an important factor, thus the preparation started within 36 hours from the moment of death. Period longer than 36 hours considerably reduces value of the preparation. We accessed aorta arch blood vessels in the group of fetuses and still-born babies by opening the anterior thoracic wall. The initial parts of the right and left common carotid artery were prepared by careful dissection. During the preparation we took care to preserve the venous elements. In certain number of preparations, we injected plastic mass into the cerebral venous system of a still-born baby through internal jugular vein. The method consists of two phases, injection and corrosion phase. After carotids were approached, the ligature was made in blood vessels which were not necessary for stuffing. We inserted injection needles with a rounded point into the arterial lumen, which we fixed afterwards. 12% vinyl chlorid acetonic solution dyed with acid-resisting dyes was used as the injection mass. The stuffed preparations were placed into broad glass containers with cold water in order to harden the plastic mass. Preparations were immersed in technical HC1 after 24 hours. Soft tissues were degraded by acid, and blood vessels casts remained where plastic mass was applied. Aft-

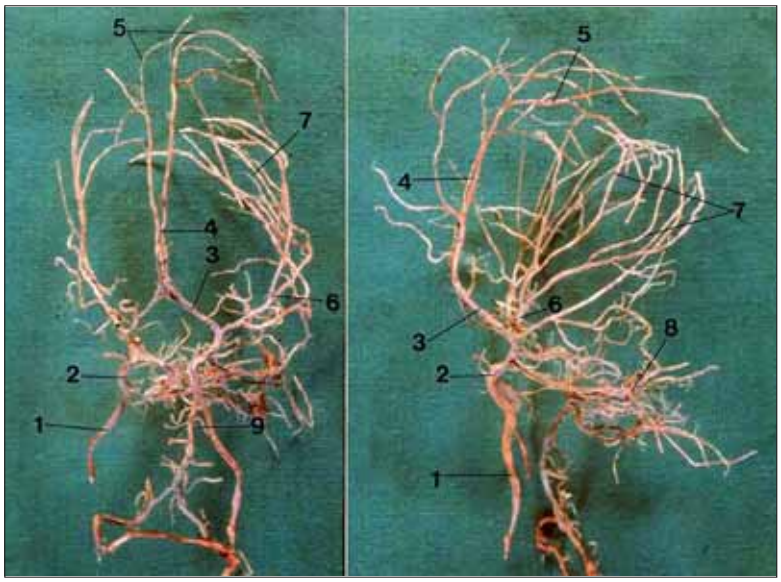

Fig. 1 Corrosive preparation of 20 weeks old fetus. Ventral and lateral aspects of the preparation

1. internal carotid artery
2. carotid siphon
3. anterior cerebral artery (precommunical part)
4. anterior cerebral artery (postcommunical part)
5. anterior cerebral artery (cortical part)

5. middle cerebral artery (sphenoidal part)
6. middle cerebral artery (cortical part)
7. posterior cerebral artery
8. basilar artery

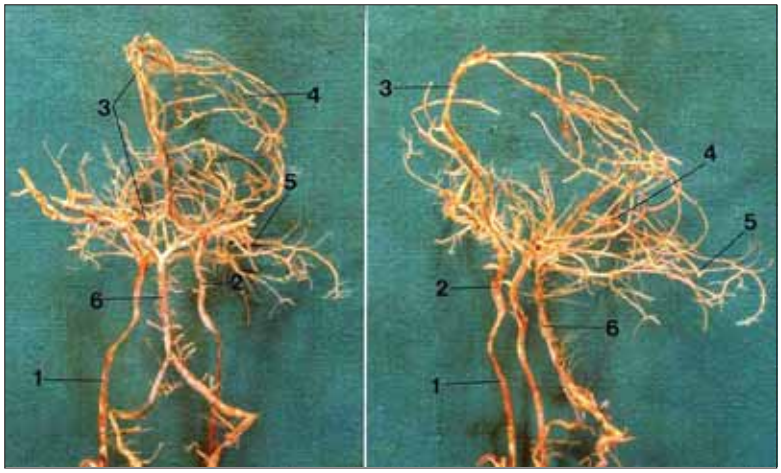

Fig. 2 Corrosive preparation of 24 weeks old fetus. Anterior and lateral aspects of the preparation

1. internal carotid artery
2. carotid siphon
3. anterior cerebral artery
4. middle cerebral artery
5. posterior cerebral artery
6. basilar artery

er 7 - 10 days, the preparations were washed with mild stream of water in order to remove soft tissue residues. Such received preparations were analyzed for developmental changes, flow and position of cerebral arteries.

Results

In injection-corrosion preparations of 20 weeks old fetuses carotid siphon is more open. Almost vertical flow of anterior cerebral artery is noticed. Branches of anterior cerebral artery flow in a straight line without significant bending. The middle cerebral artery is well visible. Its first segment, pars sphenoidalis, is directed on the bias upwards and laterally. On the left side we observed trifurcation of the first segment into periinsular branches which show a slight outwards convexity. On the right side, the first segment is directed more aslant upwards and laterally than on the left side. On insula level, the middle cerebral artery ramifies, so that width of the lumen reduces progressively as the rami occur. Cortical terminal rami of the middle cerebral artery display a straight flow. Anterior cortical branches of the middle cerebral artery are shorter while the parietal branches are considerably longer (Fig. 1). In 24 weeks old fetus carotid siphon is plane. Middle cerebral artery is no more vertical but displays a slight bending in genu corporis callosi area. The initial part of middle cerebral artery assumes more horizontal flow. Peripheral branches of anterior and posterior arteries have slightly wavy flow, while branches of middle cerebral artery are scanty (Fig. 2). In fetus of 28 weeks of intrauterine life, progressive changes are observed in all of the three cerebral arteries, whose straight flow becomes more and more tortuous. Initial part of middle cerebral artery is placed almost horizontally, and increased distance of periinsular arteries from anterior cerebral artery is observed. In preparations of 32 weeks old fetus, pericallosal artery has a more expressed angle, so that all three parts of this artery are well visible. Arteries have tortuous flow, and abundance of blood vessels is observed. Cortical branches of the anterior cerebral artery pass over the upper edge of hemisphere toward the middle cerebral artery; convergence of cortical branches of all the three cerebral arteries can also be observed (Fig. 3).

Corrosive preparations of still-born babies display rather long tortuous arteries, and their branching pattern is similar to that of adult persons. Cortical rami are distributed

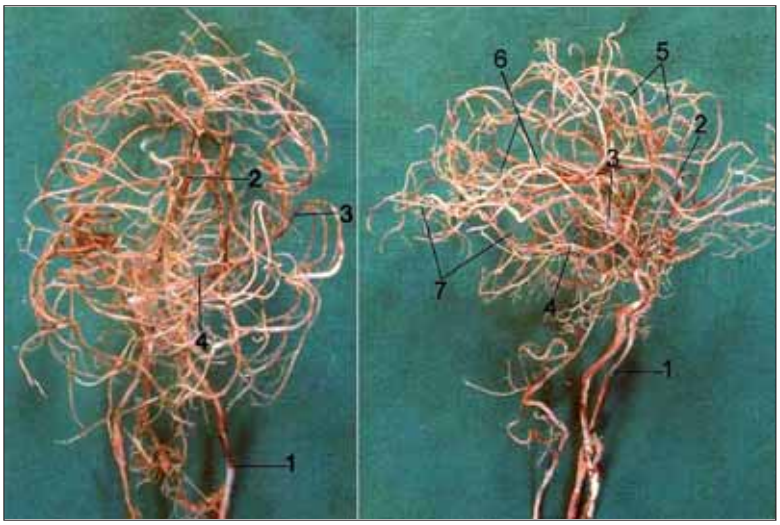

Fig. 3 Corrosive preparation of 32 weeks old fetus. Anterior and lateral aspects of the preparation.

1. internal carotid artery
2. anterior cerebral artery
3. middle cerebral artery
4. posterior cerebral artery
5. anterior cerebral artery (cortical part)
6. middle cerebral artery (cortical part)
7. posterior cerebral artery (cortical part)

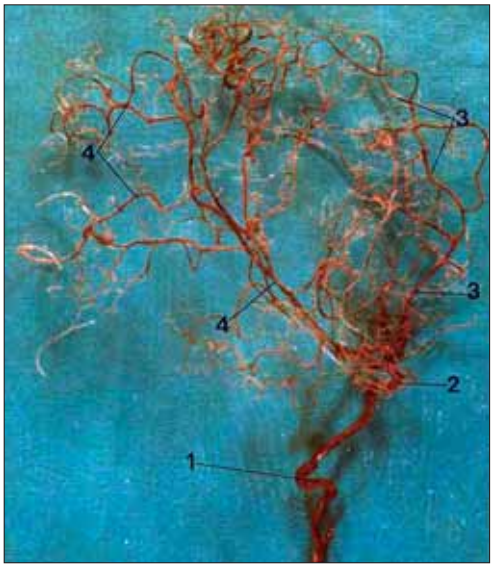

Fig. 4 Corrosive preparation of a still-born baby. Lateral aspect

1. internal carotid artery
2. carotid siphon
3. anterior cerebral artery
4. middle cerebral artery

in such a way that one part of rami leaves the place of vascularisation of the particular area, while the other part of rami approaches that place of vascularisation, so that the territories of vascularisation overlap. Carotid siphon displays a sharp bend (Fig. 4). By injecting the plastic mass into the jugular vein we obtained corrosive preparations that display the venous system of still-born babies. Dural sinuses are well observed, also superficial and deep veins of the brain. The lower anastomic vein (Labbe), which connects transverse sinus with superficialis meddle cerebral vein is observed. Well displayed are prefrontal parietal and occipital veins, as well as abundance of vein vessels around the foramen magnum (Fig. 5)

Discussion

In monitoring developmental changes in arteries of fetuses 4-9 months of age we paid a great attention to the position, shape, flow and ramification of main cerebral arteries. By the injection-corrosive method in fetuses 4-9 months of age we received relevant data about the position, flow, relations, variations and anastomoses between separate cerebral arteries. It should be taken into account that fetal vessels are thin and fragile, which was manifested by frequent intracerebral and intracranial extravagations of our injection material, regardless of the fact that we injected the material under low pressure and slowly in phases. In early fetal life arteries are thin and have a straight flow, which is directly connected with development of the respective cerebral structures. Cerebral arteries of fetuses 28 weeks of age display progressive change on all three cerebral arteries which straight flow becomes more and more tortuous. As in the 32nd week of intrauterine life, the brain develops faster and gyri and sulci are being formed, the arteries assume wavy flow and number of their branches increases. In a still-born baby, arteries are of rather bigger calibre; they branch abundantly; and due to their relatively broad cerebral sulci, it can be said that their flow is partly tortuous.

More literature about embryonic development of blood vessels was found in works of Streeter (6), Padget (5), Kaplan (7), while literature about fetal blood vessels is scant. Newton and Potts (2) emphasize that should the data on prenatal growth and topographic changes of different arteries be known, normal perinatal angio-architecture would be more understandable and pathogenesis of certain congenital anomalies may be illuminated. These authors prepared a great study of cerebral arterial system in fetuses, including vascular injections, casting, dissection, and radiographic and anatomic analyses amongst their methods. In the conclusion to their studies, the authors report that numerous fetal arterial schemes already suppose adult configuration at the end of the first trimester. Comparing our findings on fetal blood vessels with those of

the other authors who were partially occupied with these issues, we can say that they do not deviate from those of Streeter (6) and Hoyt (3). Van Overbeeke (8), and Icardo (9) report that as cerebral hemispheres grow over thalamus and midbrain, so the tree of posterior cerebral artery moves more backwards and thus vacularises ever increasing number of visible structures, what is also in accordance with our findings.

Conclusion

Our findings clearly show that changes appear in position, flow and relation of cerebral arteries concurrently with the development of adjacent cerebral structures and occurrence of gyri and sulci, what concurs with rather scant literature published in this field.

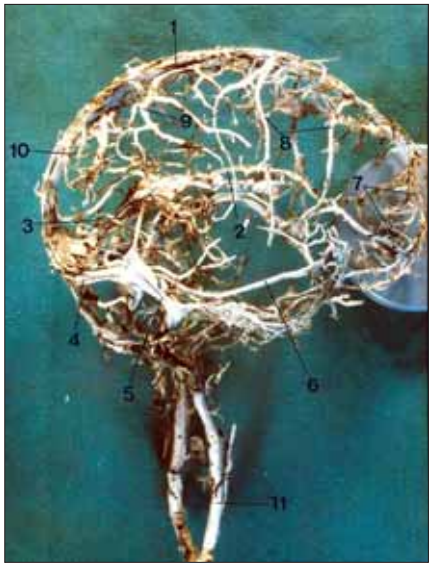

Fig. 5 Corrosive preparation of a still-born baby. Cerebral veins and sinusi durae matris. Lateral aspect of the preparation.

1. superior sagittal sinus
2. inferior sagittal sinus
3. straight sinus
4. transverse sinus
5. sigmoid sinus
6. inferior anastomotic vein (Labbé)
7. prefrontal veins
8. frontal veins
9. parietal veins
10. occipital veins
11. internal jugular vein

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