CHANGES IN BLOOD VESSELS IN FETUSES 4 TO 9 MONTHS INTRAUTERINE LIFE OLD BY POSTMORTEM ANGIOGRAPHY METHOD

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Abstract

We monitored changes in caliber, position and branching of blood vessels in fetuses of 4 - 9 months of intrauterine life. By precise dissection we prepared starting parts of common carotid artery and internal jugular vein in 40 cadaver fetuses. The vessels were injected with Telebrix and subjected to postmortem angiography at the Institute of Radiology Clinics Center in Sarajevo. Thereafter, arteries obtained were compared and analyzed. In preparations of few months old fetal material we observed arteries of fairly straight course, low caliber and with no observable ramification. When preparations of more mature stillborn infants were examined, we detected arteries of undulating course, more expressed ramification and higher caliber. In stillborn babies, all three arteries are of high caliber with rich branching. Considering that in this phase of brain development sulcuses are relatively wide, we can say that course of arteries is partially tortuous. Analysis of venous vessels shows good distinction of venous sinuses and subarachnoidal cisterns. We can conclude with great certainty that the changes occur in position, caliber and relationship among vessels in fetus during the period of brain sulci and gyri formation.

Key words: brain, fetuses, cerebral blood vessels.

Introduction

Large cerebral arteries develop concurrently with cerebral hemispheres reaching their utmost development in the second and third month of human fetal life (1). Moniz's presentation of cerebral angiography as a new diagnostic method for localizing pathological changes enabled clinical researchers to estimate the adequacy of collateral circulation. Upgrade in this technique, i.e. introduction of serial angiography, enables visualization of cerebral arteries and veins and thus provides more anatomic details regarding course, caliber, direction and possible anastomoses between cerebral arteries. Kier (2) considers that inadequacies of joint roentgengraphy-anatomical studies in fetal period can be attributed to technical obstacles. Cerebral fetal blood course is fragile and partially myelinated with high water content which considerably hampers handling.
Newton and Potts (3) emphasize that normal prenatal angio-architecture is more understandable and pathogenesis of safe congenital anomalies may be illuminated if data on prenatal growth and topographic change of different arteries are known. These authors have prepared a detailed study of the cerebral arterial system in fetus, which included methods such as vascular injections, molding, dissection and roentgenography-anatomical analyses. Material they used for their research consisted of aborted human fetuses, ranging from 10 to 36 weeks in gestation age. The age was determined by measuring occipitotemporal diameter and cranio-coccygeal length. Numerous fetal blood vessels correspond to the adult configuration already by the end of the first trimester. Hoyt (4) reports that enlargement of cranium is not followed by the growth of hemispheres, so that gyri are formed on hemispheres that are separated by temporary sulci. These temporary sulci disappear during the fourth month of intrauterine life, probably as the result of somewhat faster growth of the cranium. Takashi (5) reported that the increase in the width of cerebral hemispheres and the brain as a whole changes the course of the first segment of middle cerebral artery from the slanting into the more horizontal direction. Padget (6) reports that the branches of middle cerebral artery appear as straight arteries at first and that development of the operculum causes characteristic winding of its branches. Until the 24th week, the arteries flow mostly in a straight line upwards; after the 32nd week the artery starts to take tortuous course as the result of gyri growth. Streeter (7) reports that development of corpus callosum has a great impact on development of anterior cerebral artery. Through the development of corpus callosum, anterior cerebral artery gradually loses its vertical course and becomes bent more forward.

Material And Methods

Blood vessels of cerebrum were studied by serial postmortem angiography in 30 foetuses of gestation age from 16 - 36 weeks intrauterine life and 10 cadavers of stillborn babies. Opening the frontal thoracic wall and preparing neck regions provided access to the common carotid artery, through which we carefully inserted a thin needle into the internal carotid artery and fixed it. We injected the arteries with the contrast medium (75% Telebrix solution). Radiography was made simultaneously with the injection of contrast medium. Thus we received angiograms displaying blood vessels which vascularise the cerebrum. We analyzed the angiograms by following developmental changes in course, position and anastomoses of cerebral arteries.

Results

Anterior cerebral artery, middle cerebral artery and posterior cerebral artery are displayed on angiograms of fetuses of 16 weeks intrauterine life. These arteries are observed as thin and of straight course. The horizontal segment of middle cerebral artery is placed aslant and upwards. The right and left hemispheres are filled symmetrically. Although the contrast medium was injected through internal carotid artery, retrograde filling occurred though cerebral arterial circle of Willis and basilar artery and vertebral arteries. (Fig. 1)

Angiograms of fetuses of 20 weeks intrauterine life show arteries of somewhat higher caliber. Arteries do not lose their straight course although their length increases considerably, so that blood vessels reach almost to the interior outlines of cranium. The initial part of middle cerebral artery is oriented aslant and upwards. Also, ramification of main cerebral arteries occurs in this stadium. It is observed that branches of pericallosal artery incline toward convexity of the brain, where they meet middle cerebral artery branches, which implies the possibility that cortical anastomoses already exist in this stadium (Fig. 2). Angiograms of 28 weeks intrauterine life fetuses show progressive changes in all of the three cerebral arteries, which from the straight assume ever more winding course. The initial part of middle cerebral artery is placed almost horizontally. Distance of insular branches increases toward lateral position as shown in the AP projection. Both cerebral arteries are clearly shown. Posterior communicating artery is also shown, through which is vertebral artery retrogradely filled and observed (Fig. 3).

From the 32nd week of fetal life onwards, the arteries assume more winding course, as well as a greater number of branches shown as a dense arterial net. Series of angiograms show that insular part of middle cerebral artery is considerably distant from anterior cerebral artery at this gestation age. Anastomoses of cortical branches of anterior cerebral artery and middle cerebral artery can also be observed. In several cases anastomoses of anterior cerebral artery and posterior cerebral artery are established in splenium corpus callosum region (Fig. 4).

No essential changes are observed from 32 to 40 weeks intrauterine life. Analysis of stillborn babies' angiograms show clearly expressed winding course of cerebral arteries. All of the three cerebral arteries are considerably strong, with winding course and rich branches. Vertebral artery is filled retrogradely through Willis' circle (Fig. 5). Arteries that vascularise the basal ganglia, hypothalamus and choroid plexus appear in the form of wide blood vessels. Lateral angiogram (Fig. 5) shows an abundance of blood vessels. Middle cerebral artery has an expressed slant position and its insular part is well shown. It is established that distribution of blood vessels and their ramification is similar to that seen on angiograms of the adults. Lateral projection shows well all cerebral arteries (Fig. 5). Certain deviations are noticed in some cases. In our research material we have encountered a rather interesting case of 36 weeks intrauterine life fetus. In the early filling phase (Fig. 6), the AP projection clearly shows anterior cerebral artery and middle cerebral artery. Asymmetry of the right and left cerebral arteries is visible. Distance of anterior cerebral artery from insular branches of middle cerebral artery is smaller and matches the distance found in the adults.

In the late filling phase, long, high caliber cerebral arteries are visible. Blood vessels are longer and do not match with gyri. Arteries are very tortuous, so that it can be said that blood vessels "spare gyri" exist. A strong anastomoses exist that enable retrograde filling of arteries. The slowed down filling of the right side is also characteristic, as well as the widened subarachnoid space (Fig. 6).

We have succeeded to partially show dural sinuses also by injecting contract medium through interior jugular vein (Fig. 7). Internal jugular vein, superior sagittal sinus and transverse sinus are shown.

Confluence of sinuses is well shown as well as the abundance of vein vessels that can be observed in the region of foramen magnum; sigmoid sinus is also shown.

Discussion

Following the developmental changes in arteries of fetus of 4-9 months of intrauterine life, we have paid great attention to the position, shape, course and ramification of the main cerebral arteries. By following the serial postmortem angiography in fetus of 4-9 months of intrauterine life we obtained relevant data about the position, course, relation, variations and anastomoses between individual cerebral arteries. It should also be considered here that fetal vessels are thin and fragile what was manifested through frequent intracerebral and intracranial extravasation of our injected material, regardless of the fact that we injected it into the brain arteries under the low pressure and gradually. Newton and Potts (3) emphasize that normal prenatal angioarchitecture is more understandable and pathogenesis of safe congenital anomalies can be illuminated if data on prenatal growth and topographic change of different arteries are known. These authors have prepared a detailed study on the cerebral arterial system in fetus, including methods such as vascular injections, molding, dissection and roentgenography-anatomical analyses. The authors conclude their study by reporting that numerous fetal schemes are already supposed in adult configuration by the end of the first trimester. In early fetal life arteries are thin and have straight course, which is connected directly to development of their related brain structures. Brain arteries of fetus of 28 weeks its intrauterine life show progressive changes in all of the three cerebral arteries which from the straight assume ever more winding course. As in 32nd week intrauterine life, brain growth and development of gyri and sulci is more rapid, arteries also assume more winding course and number of their branches increases. A stillborn infant has ar-

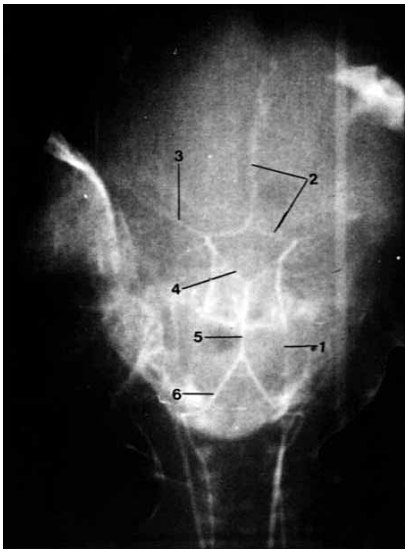


Fig. 1. Carotid angiogram in foetus of 16 weeks I.U. life. AP projection.

1. internal carotid artery
2. anterior cerebal artery
3. middle cerebal artery
4. posterior cerebal artery
5. basilar artery
6. vertebral artery

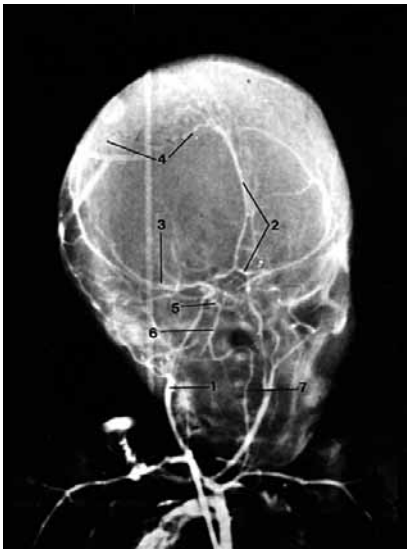


Fig. 2. Carotid angiogram in foetus of 20 weeks I.U. life. AP projection.

1. internal carotid artery
2. anterior cerebal artery
3. middle cerebal artery
4. cortical anastomosis between anterior cerebal and middle cerebal artery
5. posterior cerebal artery
6. basilar artery
7. vertebral artery

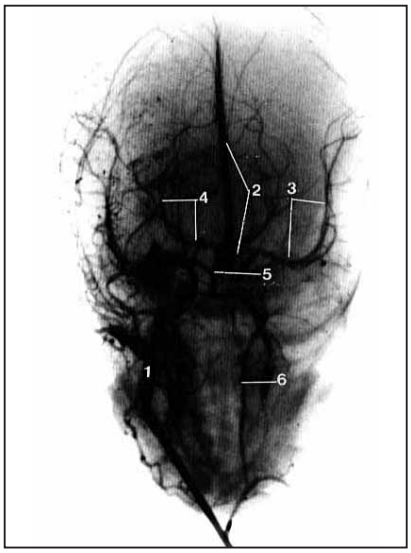


Fig. 3. Carotid angiogram in foetus of 28 weeks I.U. life. AP projection.

1. internal carotid artery
2. anterior cerebal artery
3. middle cerebal artery
4. posterior cerebal artery
5. basilar artery
6. vertebral artery

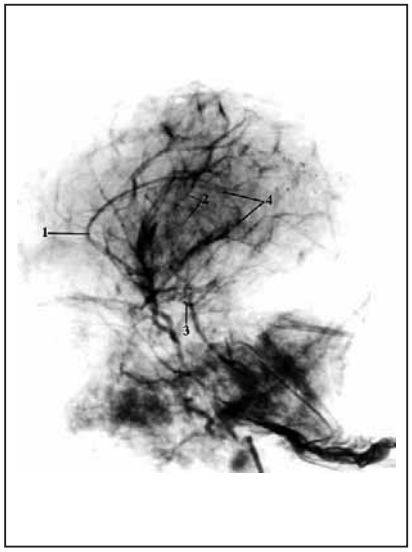
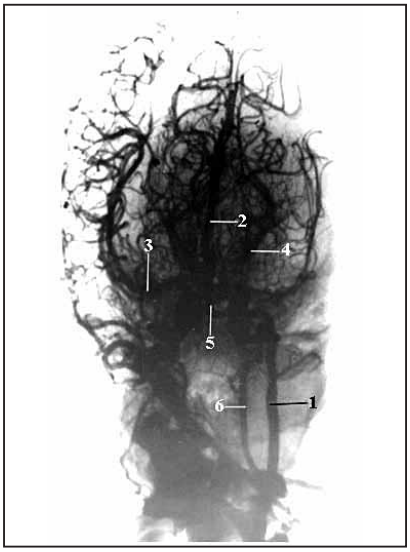


Fig. 4. Carotid angiogram in foetus of 32 weeks I.U. life. Lateral projection.

1. anterior cerebal artery
2. middle cerebal artery
3. posterior communicating artery
4. Anastomosis ACA and ACP in splenium corporis callosi region



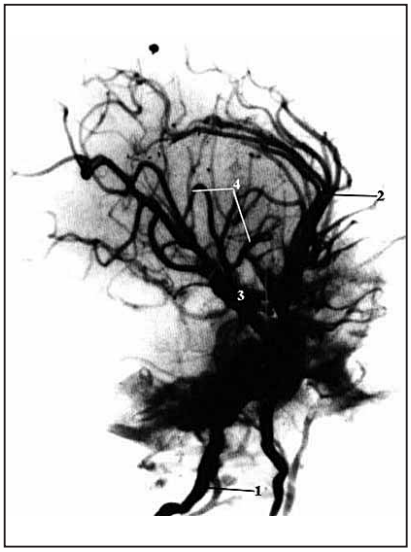
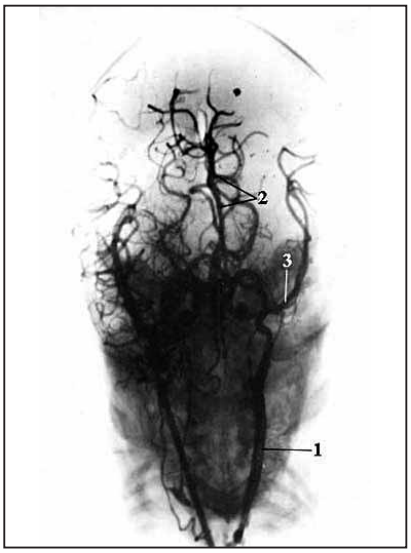


Fig. 5. Carotid angiogram of a stillborn baby. AP and lateral projections

1.internal carotid artery
2. anterior cerebal artery
3. middle cerebal artery
4. posterior cerebal artery
5. basilar artery
6. vertebral artery

1. internal carotid artery
2. anterior cerebal artery
3. middle cerebal artery
4. middle cerebal artery (insular part)



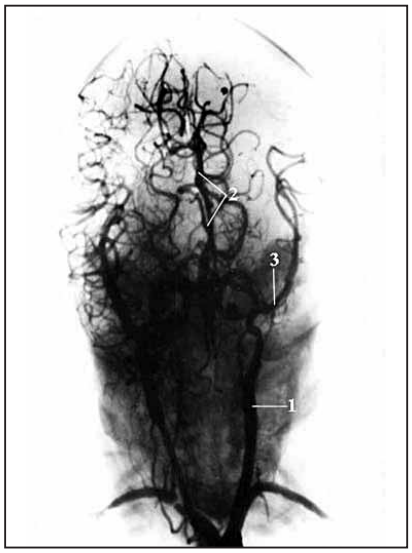


Fig. 6. Carotid angiogram in foetus of 36 weeks I.U. life. AP and lateral projections.

1. internal carotid artery
2. anterior cerebral artery
3. meddle cerebral artery

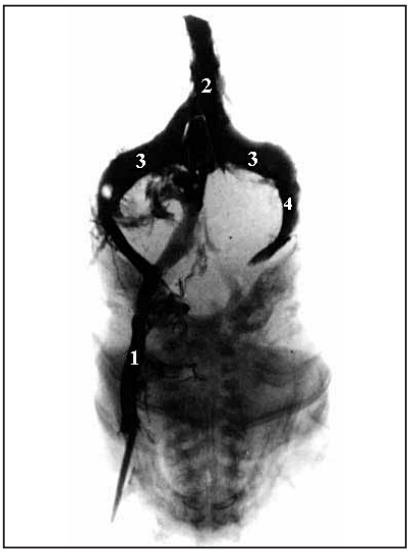


Fig. 7. Dural sinuses AP projection.

1. internal jugular vein
2. superior sagittal sinus
3. transverse sinus
4. sigmoid sinus

teries of significantly higher caliber; they branch abundantly, while due to their relatively wide sulci, it can be said that their course is tortuous. It should be noted that also in the early fetal life we have ascertained anastomoses between anterior cerebral artery and posterior cerebral artery in fetuses of 32 weeks intrauterine life. Also, certain deviations have been observed. In fetuses old 36 weeks intrauterine life, we have ascertained that brain arteries are of high caliber and great length. Length of blood vessels does not match with gyri, while arteries are very tortuous, so that it can be said that blood vessels "spare gyri" exist. Comparing our findings on fetal blood vessels with the results of other authors occupied to some measure with the subject issues, we can say that our findings do not deviate from those of Hoyt (4), and Streeter (7). Icardo (8), Kaplan (9) and Van Overbeeke (10), reports that posterior cerebral artery tree moves more backwards as the brain hemispheres grow over the thalamus and midbrain thus vascularising ever greater number of observable structures, what is also in accordance with our findings.

Conclusion

Our findings show clearly that position, course and relationship of brain arteries change concurrently with the development of adjacent brain structures and gyri appearance, what is in accordance with scarce literature data in this field.

References

(1) Hodes P.J. et all. Cerebral angiography. Fundamentals in anatomy and physiology. Am. J. Roentgenol. Radium Their Nucl. Med. 1953; 70: 61-82.

(2) Kier L. Development of cerebral vessels. Section I. Fetal cerebral arteries: a phylogenetic and ontogenetic study. In: Newton T.H. and Potts G.D. (eds): Radiology of the skull and brain. Angiography. Mosby Co., Saint Louis, 1974.

(3) Newton T.H. and Potts D.G.Radiology of the scull and brain. Angiography. Mosby Co., Saint Louis, 1974.

(4) Hoyt W.F. et all. The posterior cerebral artery. Section I. Embryology and developmental anomalies. In: Newton T.H. and Potts D.G. (eds): Radiology of the Skull and Brain. Angiography. Mosby Co. Saint Louis, 1974.

(5) Takashi M. et all. Roentgenographic anatomy of the cerebral artery. Radiology 1986; 8/90: 271-297.

(6) Padget, D.H. The development of the cranial arteries in the human embryo, Contrib. Embryol. 1948; 32:205-262.

(7) Streeter, G.L. The development alterations in the vascular system of the brain of the human embryo. Contrib. Embryol. 1918; 8:5-38.

(8) Icardo J.M. The cerebral arteries: Cortical patterns and vascularisation of the cerebral nuclei. Acta anat. 1982. 113; 108-116.

(9) Kaplan H.A. Anatomy and embriology of the arterial system of the forebrain In: Vinken P.J. and Bruyan G.W. (eds): Handbook of Clinical Neurology. North - Holland Publishing Co., Amsterdam, 1975.

(10) Van Overbeeke J.J. The Development of the Variations of the Human Basal Cerebral Arteries. An Ontogenetic Study. Thesis Utrecht University, 1991