SIGNIFICANCE OF ESTABLISHING COLLATERAL CIRCULATION BY LEPTOMENINGEAL ANASTOMOSES IN THE OCCLUSION OF ARTERIAE CEREBRI MEDIAE

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ABSTRACT

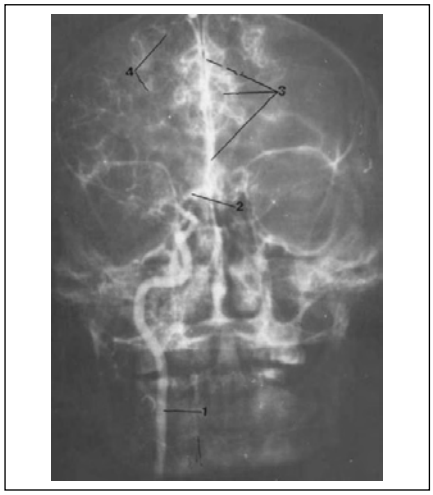
We have investigated establishment of collateral circulation in patients with cerebral circulation disorder. Thirty angiograms of patients treated at Neurological Department of Hospital Centre in Sarajevo suffering from arteriae cerebri mediae occlusion were used for this study. Cerebral anastomoses that included connections between arteriae cerebri anterior and arteriae cerebri mediae over leptomeningeal anastomoses occurred in some patients suffering from occlusion of this arteriae. It was concluded that the majority of anastomoses existed between big leptomeningeal branches of postcommunicant segment of a. cerebri anterior and branches of cerebri mediae. These collaterals are of great significance as their functional ability is sometimes of a high degree in cases of occlusion of one or the other artery. It can be concluded that anastomosing of the blood vessels increases their volume in the whole and therefore more blood can be provided, although physiological factors should not be neglected, as functional effectiveness of collateral circulation in postocclusive states depends also on the state of the whole cerebrovascular system, then on the speed of creation of occlusion (thrombosis or embolism), systemic arterial pressure, volume and viscosity of the blood.
Key words: arteriae cerebri mediae, anastomosis, collateral circulation.

INTRODUCTION

Functional effectiveness of collateral circulation in postocclusive states depends on many factors: on the number of anastomoses and their calibres, on the state of the whole cerebrovascular system, vascular variations and anomalies, on the speed of creation of occlusion (thrombosis or embolism), on the systemic arterial pressure, on volume and viscosity of the blood. According to the type and position of anastomosed arteries, all anastomoses can be classified as cervical, extracranial, extracrania-intracranial, extracerebral, extracerebral-cerebral, and at last cerebral anastomoses. Cerebral anastomoses include connections between cerebral arteries themselves in the region of subarachnoid cisterns and on the brain surface. These anastomoses include bilateral and leptomeningeal anastomoses between individual brain arteries. Duvernoy (3), reports that leptomeningeal (pial) anastomoses are located on the surface of practically the whole brain and the spinal cord. Most of them are lodged in subarachnoid space near pia mater, and a smaller number of anastomoses, usually of bigger calibre, in the cisterns of that space. In his comprehensive study, the author reports that pial anastomoses are placed mostly within pial arterial and arteriolar nets. Besides small anastomoses of 10-μm diameter, there are also big ones whose calibre ranges between 25 and 90 μm. These anastomoses are present in the field of arborisation of one leptomeningeal branch or its rami of the same cerebral arteries, or they connect leptomeningeal branches of adjacent arteries of the brain. However, Lin et Kricheff (6) report that the greatest number of anastomoses exists between big leptomeningeal branches of postcommunicant segment a. cerebri anterior and branches of arteriae cerebri mediae. These collaterals are of great clinical significance, as their functional ability is sometimes of a high degree in cases of the occlusion of one or another artery. According to Brain (1), who studied the nature of the blood flow in the brain, there are three levels of collateral circulation. The first level represents carotid and vertebral-basilar system placed proximally to the arterial ring. The other level is the circulus arteriosus Willis-i itself, while the third level of collateral circulation spaced distally represents cerebral arteries. Krayenbuhl et Yasargil (5) and Fields (4) report that arteriography became one of the most efficacious methods in diagnosing occlusive cerebrovascular disease. This technique has been used for gathering all other information that could not have been collected in any other way. This is particularly reliable in respect to the implication of two separate, but connected aspects of cerebral ischemia - various clinical manifestations of vascular occlusion and variable recovery after functionally neurological deficiency.

MATERIAL AND METHODS

For preparing this paper we used 30 angiograms of patients at Neurological Department of Hospital Centre in Sarajevo with suspected occlusion a. carotis internae, by the method of direct carotid arteriography. Screening was made serially and in two projections, so that all circulation phases could have been monitored. Angiograms were analysed in details.

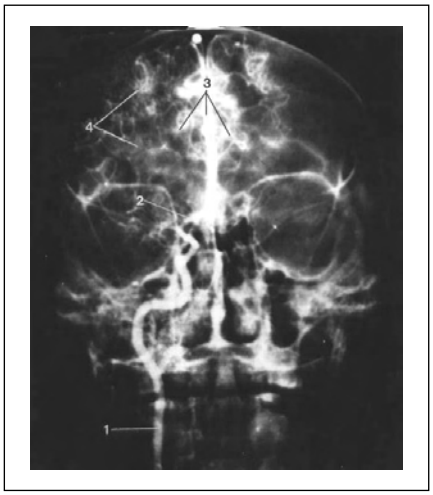


1- internal carotid artery
2- anterior cerebral artery (precommunical part)
3- pericallosall artery et calosomarginal artery
4- anterior cerebral artery (cortical part)

Figure 1 Carotid angiogram. AP projection. Occlusion middle cerebral artera early filling phase.

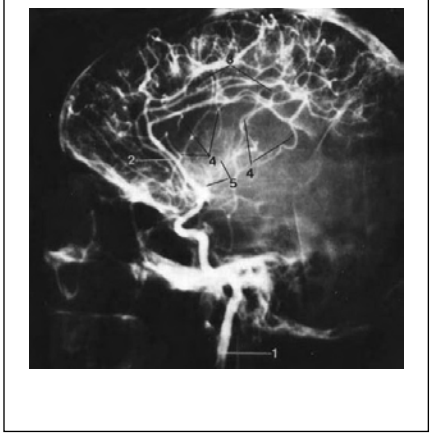
1- internal carotid artery
2- pericallosall artery
3- anterior cerebral artery (cortical part)
4- Leptomeningeal anastomoses departing from pericallosall artery

Figure 2 Carotid angiogram. Lateral projection. Occlusion of, midlle cerebral artery early filling phase



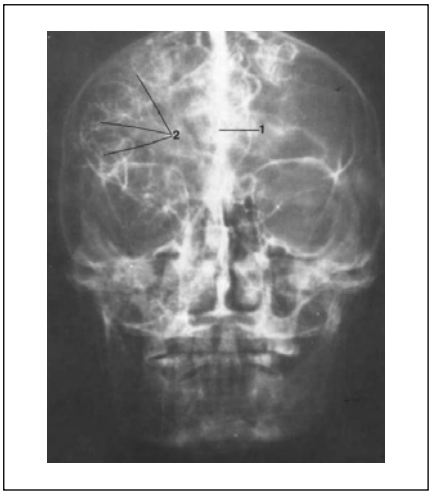
1 internal carotid artery
2- anterior cerebral artery (precommunical part)
3- pericallosall artery
4- anterior cerebral artery (cortical part)

Figure 3 Carotid angiogram. AP projection. Occlusion of middle cerebra artery.



1- internal carotid artery
2- pericallosal artery
3- anterior cerebral artery (cortical part)
4- Leptomeningeal anastomoses departing from pericallosal artery
5- middle cerebral artery retrograde filling).

Figure 2 Carotid angiogram. Lateral projection. Occlusion of, midlle cerebral artery early filling phase



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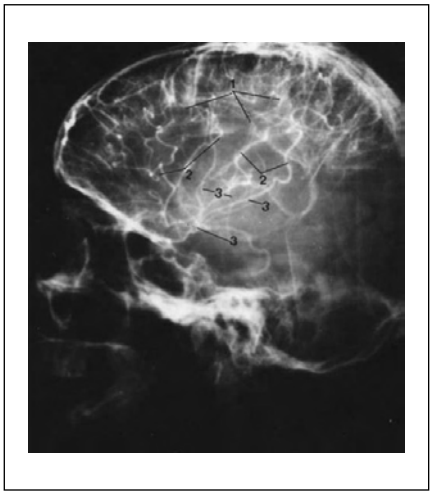
2- anterior cerebral artery (precommunical part)
3- pericallosall artery
4- anterior cerebral artery (cortical part)

Figure 3 Carotid angiogram. AP projection. Occlusion of middle cerebra artery.



1 internal carotid artery
2- anterior cerebral artery (precommunical part)
3- pericallosall artery
4- anterior cerebral artery (cortical part)

Figure 3 Carotid angiogram. AP projection. Occlusion of middle cerebra artery.

RESULTS

We used our materials to analyse cases with the occlusion of arteriae cerebri mediae. The analysed cases were the angiograms of patients who survived the occlusion of arteriae cerebri mediae owing to the well developed leptomeningeal anastomoses between the blood vessels inserted into pia mater and flowing over the brain cortex. Having analysed such cases with arteriae cerebri mediae occlusion through its early, mid and late phases of filling, we discovered the creation of collateral circulation between the front and mid arteries of the brain. Well filled arteria carotis interna, as well as arteria cerebri anterior have been displayed on angiograms in the early phase of filling, while the arteria cerebri media could not be filled with contrast medium, what implied occlusion of this artery. Precommunicant segment of the arteriae cerebri anterior is of somewhat greater calibre than usually, while arteria pericallosa and its callosomarginal branches are well displayed, and it is also displaeyd that terminal branches of arteria cerebri mediae are filled over the cortical branches of arteriae cerebri anterior (Fig. 1 and 2).

Arteria pericallosa is of a wider lumen; it is well filled and is richly ramified. Small blood vessels can be seen departing from precallosus and supracallosus parts of a. pericallosae directed toward vascularising space of arteriae cerebri mediae, which is not displayed on the lateral projection. These blood vessels represent leptomeningeal collaterals departing from arteriae pericallosae.

Mid phase of arterial filling does not display significant differences compared to the eraly phase of filling (Fig. 3 and 4).

It has been only discovered that branches of a. pericallosae are more strongly expressed, also that cortical branches of arteriae cerebri anterior with their terminal branches fill terminal cortical branches of arteriae cerebri mediae and that over these cortical anastamoses vascularisation is beeing established in the field of terminal branches of arteriae cerebri mediae. The blood vessels are observed which are more clearly expressed than in the early phase of filling, i.e. they are longer, of bigger calibre and more numerous, and they fill the arteriae cerebri mediae retrogradely (Fig. 4). In the late phase of filling on its passage from arterial into the vein pahse, the arteria carotis interna is not displayed, neither precommunicant segment of arteriae cerebri anterior, but sinus sigittalis superior is. Establishment of the complete space of revascularisation in the field of ocluded artery is displayed on the side where occlusion of the arteriae cerebri mediae over arteriae cerebri anterior occured (Fig. 5).

In the same phase of filling (Fig. 6), it is already evident that collateral circulation has been established over leptomeningeal anastomoses, so arteriae cerebri mediae are filled retrogradely.

DISCUSSION

Establishment of collateral blood pressure has undoubtedly great clinical significance for prognosis and outcome of cerebrovascular disease. Already in 1785, John Hunter was among the first persons who studied collateral circulation as he noticed that after the main artery of "abrupt growth" of an antler was tied, its growth was not interrupted, and he also noticed abrupt appearance of

increased blood vessels that conveyed the blood around the place of obstruction. Wepfer (7) reports that the most common way of anastomosing is when two vessels go one into the other, or one continue into the other, or one vessel opens into the other from which other blood vessels depart, but there exists also communication between two carotids, as well as between them and vertebral arteries where communication channel goes directly between them. The same author reports that such anastomosis occurs more often in smaller than in bigger arteries. It is rarely found that the main stems anastomose one with another. The same case is notices in the brain. Carpenter and Sutin (2) report that arteries anastomise with big branches before they distribute into the brain. The benefit of this appearance is that all parts of the brain can have the same quantity of the blood at any time, even when some disorder has blocked the circulation in the brain, because they do not anastomose in the brain substance itself. The authors also argue that anastomosis of the blood vessels increases their volume in the whole, and therefore provides greater quantity of the blood. That kind of the net which they create increases the size of the vascular system, and in order to meet this demand they take lateral and circular direction giving so to the vascular system bigger length than if they would simply go from their start to the aim in straight lines. Cerebral anastomoses include connections between the brain arteries themselves in the area of subarachnoid cisterns and on the brain surface. These anastomoses include bilateral and leptomeningeal anastomoses between the brain arteries themselves. Duvernoy (3) reports that leptomeningeal (pial) anastomoses exist on the surface of practically the entire brain and spinal cord. Most of them are lodged in subarachnoid space near piae mater, and a smaller number of anastomoses, usually of bigger calibre, are lodged in the cisterns of that space. These anastomoses are present in the field of arborisation of one leptomeningeal branch or its further branches of the same brain artery or they connect leptomeningeal branches of adjacent brain arteries. However, Lister et al. (4) report that the greatest number of anastomoses exist between big leptomeningeal branches of the postcommunicant segment a cerebri anterior and branches of arteriae cerebri mediae. These collaterals are of the great clinical significance, as their functional ability is sometimes of a high degree in cases of occlusion of one or the other artery, what is in accordance with our findings which verified the establishment of leptomeningeal anastomoses that enabled retrograde filling of arteriae cerebri mediae and survival of patients.

CONCLUSION

It can be concluded that anastomosing of the blood vessels increases their volume in the whole, and therefore more blood can be provided, although physiological factors should not be neglected, as functional effectiveness of collateral circulation in postocclusive states depends also on the state of the whole cerebrovascular system, then on the speed of the creation of occlusion (thrombosis or embolism), systemic arterial pressure, volume and viscosity of the blood.

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