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The Structure and Function of Blood-Brain Barrier in Ischaemic Brain Stroke Process

Struktura i funkcja bariery krew-mózg w przebiegu niedokrwiennego udaru mózgu

The central nervous system both anatomically and functionally has a certain autonomy in comparison with the rest of the system thanks to the so called barriers dividing brain from both blood and cerebro-spinal fluid.

Capillary vessels in brain are additionally surrounded by protoplasmic process of neuroglial cells. They are astrocytes which by means of protoplasmic process hermetically surround capillary vessels from the outside. Owing to that astrocytes create an additional layer, that has to be overcome by chemical compounds circulating in blood (2).

Brain barrier fulfils an immunological function. It protects brain tissue against fluctuations in concentration of respective components occurring in blood plasma and against destructive blood components (2, 7).

Lowering of brainal flow of blood below 10—15 ml/100 g/min causes deficit of glucose and oxygen, indispensable for proper oxydoreductive processes. The most important factor determining brain tissue damage is a constant shortage of highenergetic phosphate. Damage to mechanisms depending on energy causes ischaemic depolarisation phenomenon, after which potassium ions come out of cells and sodium and calcium ions come into them. Neurotransmitters, stimulating aminoacids including, are being freed in a quantity that is conductive to toxic activity. Fall of blood flow causing acidosis provokes disturbances in vessel selfregulation, and lactates created are additional factor that damages tissues. Pathophysiological changes mentioned above lead to heavy injury and death of cells (3, 12).

The intensifying acidosis and the process of maturing of morphological changes in ischaemic focus cause a rise in penetrability of blood-brain barrier (1, 2, 8).

Works considering behaviour of blood-brain barrier in the process of brain stroke, are for the most part based on experimental models.

Investigations conducted on animals showed that ischaemia alone does not induce disturbances in penetrability on blood-brain barrier in spite of noted morphological and histochemical changes in brain.

It was only compound working of ischaemia and hypoxy that caused an increased penetrability in this barrier with brain oedema and progressive injury of brain structures.

Kapuściński — while examining the function of blood-brain barrier on experimental model after an acute, short-term brain ischaemia did not find any disturbances in its function. It is possible that brain vessel endothelium is less susceptible to ischaemia than neurons (6).

Tyson's experiments carried out on animals show a positive correlation between the size of blood flow lowering and damaged brain tissue area (13).

Clinical experiences show that the brain stroke process with often accompanying brain swelling and increase of neurological symptoms in humans differs considerably from experimentally elicited ischaemia.

According to Hornig, injury in blood -brain barrier in humans is noticed after a few hours since acute ischaemia episode (5).

Niebrój-Dobosz qualifying albumin and immunoglobulin G relation in blood serum and cerebro-spinal fluid by means of isotachophoresis in patients with the brain stroke observed in 57% of patients a change in albumin relation, being the most sensitive index in penetrability of blood-cerebro-spinal fluid barrier (10).

Similar results were obtained by Al-Kassab and cooperatives and by Liu (1, 8).

Niebrój-Dobosz examinations did not show any correlation among the degree of the barrier penetrability and age of patients, acuteness of clinical process, illness duration and size of brain stroke (10).

Hornig evaluating albumin and alpha 2 macroglobulin relation in cerebro-spinal fluid and blood serum showed disturbances in blood-brain barrier in majority of brain stroke cases during the first two weeks of the stroke that remained in some patients for four weeks (5).

This author, examining the relation between blood-brain barrier penetration and size of the stroke focus in computer tomography showed a positive correlation between these parameters (5).

According to Olsson and cooperatives barrier mechanism disturbances occur during first three weeks since the brain stroke, while barrier function disturbance does not show any relation to the size of ischaemic focus (11).

Limited injury of blood-brain barrier causes penetration of water and electrolytes from vessels to surrounding tissues. Whereas the presence of plasma proteins in tissues means that penetration of vessels has been seriously damaged. As a result of ischaemia an increase of pinocytar bladder number is seen and endothelium cells and their unions are resistant to damaging factors (2, 7, 11).

Rafałowska's investigations showed the presence of blood-serum proteins in brain tissues for many days and even weeks from the beginning of the brain stroke, which can come out of early protein leaking from vessel placenta and remaining in brain tissue as a result of its free metabolisation. However, the experimental analysis speaks for the possibility of repeated disturbances in vessel penetration in brain stroke (1, 2, 8, 12).

In the tissues surrounding the stroke a fall of blood flow and increasing morphological changes are seen. The area of brain tissue damage also depends on duration of ischaemia (7).

Rafałowska and colaborators' investigations showed that in elderly patients disturbances in vessel penetration in ischaemic brain stroke are smaller than in middle-aged patients (12).

There was also found a considerable increase of vessel penetrability in the later phase of stroke in elderly rather than middle-aged patients, which indicates a slower increase of blood-brain barrier function disturbance. On the other hand it was shown that a few days after the brain stroke vessel penetrability disturbances in older and middle-aged patients are of similar character and intensity (12).

To the factors conditioning a slower increase of blood-brain barrier penetrability disturbances in older patients belongs probably lower metabolism of the old brain, which for many years has been preparing for disturbances in brain flow. Ischaemia of the old brain may cause a slower process of maturing of focal morphological changes and a slower increase of metabolic disturbances. The morphological condition of cell membranes may also be of importance (7, 12).

The qualitative and quantitative examination of the white substance brain myelin of the old brain may be a confirmation of the presence of the process mentioned above (9).

Wender and colaborators showed that cholesterol and sphingomyelin content in myelin in the stroke focus is significantly higher in patients above 70 years of age (14).

The fibrosis of capillary collagen basilar membrane may cause reduction of vessel penetrability in the old age. With age the course of enzymatic processes in capillary endothelium cells may change (2).

Among the factors that influence differences in blood-brain barrier penetrability are brain swelling, arterial hypertension, bacterial and virusal infections accompanying brain stroke (4, 12).

Dietriech and colaborators show the possibility that in the increase of blood-brain barrier penetrability may take part factors of the entire system depending among others on blood platelets and working of external of the system neurohumoral factors (3).

Different kinds of animals demonstrate different blood-brain barrier penetrability in different brain structures. This phenomenon probably occurs in humans, too. Coexistence in old patients of different chronical diseases accompanying ischaemic brain stroke may cause deeper than in experimental conditions damage of blood-brain barrier. It may also modify an increase of brain swelling and influence the phenomenon of maturing morphological changes in ischaemic area (2, 12).

Due to the causes mentioned above blood-brain barrier damage may ensue in various periods of brain stroke, the proofs of which are investigations lead by Hornig and associates (5).

According to Rafałowska disturbances in vessel penetrability in ischaemic strokes in humans are much longer than in experimental models of brain ischaemia (12).

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STRESZCZENIE

Ostre niedokrwienie mózgu powoduje szereg patofizjologicznych procesów, uszkadzających tkankę mózgową i powodujących zwiększenie przepuszczalności bariery krew-mózg.

Z piśmiennictwa wynika, że udar niedokrwienny mózgu powoduje zwiększenie przepuszczalności bariery krew-mózg już po kilku godzinach od wystąpienia ostrego niedokrwienia mózgu i zaburzenia w jej funkcjonowaniu utrzymują się przez okres dwóch tygodni.

Na stopień przepuszczalności bariery krew-mózg w zawale mózgu mogą wpływać: wiek chorych, przebyte schorzenia i współistniejące w tym powikłania udaru.