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REVIEW / PRACA POGLĄDOWA

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THE PROCESS OF HUMAN AGING AND INVOLUTION CHANGES IN THE BRAIN

PROCES STARZENIA SIĘ CZŁOWIEKA A ZMIANY INWOLUCYJNE W JEGO MÓZGU

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S u m m a r y

The aging process and systemic changes occurring in it have an impact on the brain. Commonly observed symptoms of an old age such as cognitive impairment and slowness of movement are the illustration of the changes in the brain. These changes are for brain structure, quantities of neurotransmitters and hormonal activity. We can partially modify the time and the dynamics of the development of evolutional changes through an appropriate preventive action.

S t r e s z c z e n i e

Proces starzenia i ogólnoustrojowe zmiany w nim zachodzące nie pozostają bez wpływu na mózgowie. Powszechnie obserwowane objawy starości takie jak zaburzenia poznawcze, czy spowolnienie ruchowe są odzwierciedleniem zmian w mózgu. Zmiany te dotyczą struktury mózgu, ilości neurotransmitterów czy aktywności hormonalnej. Częściowo możemy modyfikować czas i dynamikę rozwoju zmian inwolucyjnych, poprzez właściwe działania profilaktyczne.

Key words: mózg, neuroprzekaźniki, ośrodkowy układ nerwowy, starzenie, inwolucja
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DEMOGRAPHIC SITUATION

In the last 50 years of the 20th century the average life expectancy extended by nearly 20 years. In the developed countries population of people under 65 is about 14% of the society. For the developing countries these statistics are determined at the level of 5 % [1].In Poland this coefficient is 13.6% which puts us just behind the developed countries (according to the report from the period of 2010-2011).An increasing proportion of older people in the population presents new challenges for modern medicine. The age under 65 is characterized by a significant increase in memory disorders as well as cognitive dysfunction. The risk of depression in this group of people is between 10-20% and very often occurs with senile dementia [2].

CEREBRAL TISSUE VOLUME

Human brain represents about 2% of the entire weight of the body. Its volume reaches a maximum at the age of about 20-40 years. The body of an adult is made up of 60-65% of water. In older people this ratio drops to about 50-55%.Lower hydration of the whole body is also reflected in brain tissues. Cytoplasm volume in every neuron decreases which leads to an individual neurons' reduction in volume. There is no change in the volume of the extracellular space. Decrease in brain volume is strictly connected with the

intracellular changes in nervous tissues. Mass of the brain decreases between the 3rd and the 8th decade of life by about 10%[3].Not all of the brain structures lose the same volume of water in connection with the loss of water. Cortical centers consisting of small neurons lose only about 5-8% of its surface. Losses in the fields of somatosensory and motor cortex are composed of large neurons and reach even 15%.Starting from the age of 25 a hippocampal mass decreases by about 2-3% in 10 years. The rate of decline increases after 75 and is up to1% per year. [4].Mass of the white matter of the brain decreases quite evenly. Loss of the grey matter is characterized by differentiation that depends on the region of the brain. The defects in the frontal and parental cortex are distinct. Smaller losses are recorded in temporal and occipital cortex[5].

PLASTICITY IN THE BRAIN AND CHANGES IN NEURONS

Reduction of intracellular water translates directly into increased protein content inside the neuron. This way the neurons can accumulate pathological proteins-amyloids interfering with their function. As the body grows older, the volume of glial cells in the brain increases. The rate of synthesis of myelin decreases although the astrocytes are not dimnished. The length of myelinated axons decreases by approximately 27-34%[3]. Impoverishment of a dendritic tree occurs in the aging neuron as well as disappearance of the spikes and reduction of the number of synaptic connections. The nerve cells' ability to multiply decreases which leads to a reduction in their total number[6].Cerebellum is very sensitive to change in reducing number of neurons(the largest number of dying Purkinje cells).Significant morphological changes occur in the brain motor cortex. Dysfunction of the brain structures and motor cortex is often the cause of imbalances and coordination in the elderly. An adult up to 80 years looses an average of 3-5% of the nerve cells in comparison to the value in adulthood. The greatest loss of neurons occurs in the cerebral cortex (10-17%) and striatum(8%).The processes of neurogenesis and synaptogenesis slow down with age. The number of synapses and dendritic branching decreases. The ability to create persistent interneuronal connections is reduced. Creating new connections between neurons may be impeded by the specific types of proteins and insoluble pigments that accumulate in the intercellular space. Lipofuscin, neuromelanin and senile plaques belong to them[6,8].Brain has a natural ability to adapt through the reorganization of its structures, synaptogenesis and neurogenesis. The younger person’s the brain plasticity is greater[7].Injuries or damages to the brain at early age give big changes to almost full or total restoration function of the damaged parts o f the brain in undamaged areas of the brain. Plasticity allows us to adapt to changing external and internal environment. With the ability to structural and functional reorganization, brain is capable of self-repair, adaptation, learning and remembering.

VASCULAR CHANGES

Cerebral vessels become less flexible, thinner and more susceptible to damage with age [9].Disorders of the proportion of collagen compared to elastin lead to the unfavorable changes in blood vessels. The level of elastin in vessels decreases and collagen grows. Vascular endothelium becomes less excitable on the action of acetylcholine and bradykinin. The vessel calcification and stiffness as well as smooth muscle hypertrophy occur [10].

With age synthesis of nitric oxide decreases (NO) NO gives relaxant effects as well as works extensively on vessels and takes part in the regulation of blood flow [11].Development of atherosclerosis is a frequent problem in the elderly. Cerebral atherosclerosis impairs perfusion and autoregulation of blood flow. This leads to deterioration of brain metabolism, its under-nutrition and oxygenation. These changes increase the risk of cerebral stroke [4,12].

NEUROTRANSMISSION IN THE ELDERLY

The greatest decline of neurotransmitters is noticeable in a dopaminergic, cholinergic and serotonergic system. The decrease also applies to other neurotransmitters e.g.dehydroepiandrosterone, GABA acids. Reducing the amount of neurotransmitter, worsening its receptor, binding and loss of adequate receptors for neurotransmitter are the cause of the impaired neurotransmission [6].

SEROTONERGIC AND GLUTANERGIC SYSTEM

Disorders of the serotoergic transmission may be the cause of depressive disorders and depression [13].Glutamic acid is one of the most important

neurotransmitters that stimulate our brain to act. Activating actions on neurons give positive effects on the entire brain. Over the years, there has been an increase of receptors AMPA compared to NMDA in the glutanergic system and thus, the brain plasticity reduces [13].

CHOLINERGIC SYSTEM

There is a clear correlation between the level of the brain cortex and the incidence and severity of dementia changes. The number of cholinergic cells in the Meynert nucleus drops by about 25-70%.This leads to a significant decrease in neurotransmitter because in Meynert nucleus there is about 90% of synthesized acetylcholine. The activity of choline acetyltransferase- the major enzyme involved in the synthesis of acetylcholine [14].

DOPAMINERGIC SYSTEM

Impairment of dopaminergic transmission largely depends on reducing the number of dopamine receptors D1 D2 in the caudate in putamen (?).The ability to bind dopamine decreases. Significant reduction of the number of dopamine receptors occurs in the nigra substantia. Dopamine reuptake also decreases [13].Dopamine level decreases by about 6% for each decade after 40 years of age. The loss of substantia nigra cells after 65 reaches even 10% per decade. Dopamine deficiency can lead to disorders of motor function such as problems with coordination of movements and slowness of walking and movement. [7].

DEHEDROEPIANDROSTERONE (DHEA)

Dehydroepiandrosterone boosts the process of new neuron formation as well as enhances memoryband calms. A total concentration of DHEA in the body is observed between 20-30 years. Cortisol working destructive to neurons is released in stressful situations. Dehydroepiandrosterone acts neuroprotectively and protects neurons from the toxic effects of cortisol [15].DHEA decrease is more severe in men. It is strictly connected with the disappearance of reticular layerbof the adrenal cortex which produces DHEA [12].DHEA has also an antioxidant, anti-depressant, anti-sclerotic and improving memory influence [10].

GAMMA-AMINO-BUTYRIC ACID AND MELATONIN

GABA plays an important role as a neurotransmitter in the inhibitory synapses. Stimulation of the receptors leads to opening the chloride channel and hyperpolarization of postsynaptic membrane. GABA is necessary for the psychomotor calm and for reducing muscle tension. Decreased GABA may cause epileptic seizures, restless leg syndrome and difficulty in falling asleep [8].Melatonin is working agonist hormone in relation to the GABA produced in the pineal gland. Its secretion declines with age which is associated with sleep disturbance and deterioration of its quality [13].The reuptake of the neurotransmitter in the body also decreases [14].

PATHOLOGICAL CONDITIONS ASSOCIATED WITH NEUROTRANSMISSION DISORDERS

We can see how important GABA is for our body watching people with the Huntington disease. Drastic decrease in the neurotransmitter is responsible for dyskinesias and for the characteristic movements occurring in this disease[8]. Alzheimer’s disease is associated with an excessive acetylcholine decrease to a lesser extent with norepinephrine, dopamine and serotonin. In Parkinson's disease such clinical signs as an increased muscle tone stooped posture of a body or motor dysfunction are caused by dopamine deficiency. We have to keep in mind that the physiological neurotransmitters' decline is natural in the elderly. The diseases listed above take place when the level of neurotransmitters decreases below the physiological norms[16].

PREVENTION

Aging is an inevitable process. We cannot stop all the changes that take place in our body but by appropriate preventive actions we can significantly slow them down. Focusing on maintaining a good brain condition we should especially take care of a good diet and regular mental activity. Through mental activity we can understand all the activities forcing our brain to work harder. This can be presented by crosswords, games requiring logical thinking e.g. chess or work, familly and social life [12]. If we want our diet to be correct, we cannot miss such ingredients as A B vitamin (especially B3 B6 B9 B12 C E K) as well as

minerals and microelements such as phosphorus, potassium, magnesium, zinc and boron. Such a diet supports activity of the brain, has a neuroprotective action, improves memory and concentration [17].

SUMMARY

Despite the changes that occur with age in our brain, the old age should not only be considered in terms of loss.

At the age of about 75 years of age our brain has significant possibilities for compensation arising from the deficiencies of aging processes. Such an action is even more complex dendritic tree in the elderly. These abilities are clearly smaller after finishing 75 years of age but still exist[18].An appropriate preventive can keep a very good brain condition until death.

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