AGE-RELATED HISTOLOGICAL CHANGES

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ABSTRACT

With age, the regenerative capacity of epithelial cells decreases, which slows down the process of skin regeneration. The basement membrane thickens, which affects the metabolism between tissues and the nutrition of cells. The thickness of the epidermis decreases, which reduces the protective function of the skin.

Age-related histological changes are associated with morphological and functional changes in tissues and cells in the body. These processes occur as a result of natural aging and are manifested in various organs and systems. Scientists from the Stanford Institute of Medicine in the USA have determined the age at which rapid changes begin in the human body. Two periods of rapid changes in human life that affect health have been identified: 44 years and 60 years. According to scientists, in people over 40 years of age, significant changes were observed in the number of molecules associated with cardiovascular diseases, skin and muscle condition. In people over 60 years of age, changes were added related to carbohydrate and caffeine metabolism, immune regulation, and kidney function.

1. Changes at the tissue and cellular level

Epithelial tissue

With age, the regenerative ability of epithelial cells decreases, which slows down the skin renewal process. The basement membrane thickens, which affects the metabolism between tissues and the nutrition of cells. Most epithelial tissues (for example, skin and mucous membranes) atrophy, as a result of which their protective function weakens. Keratinization processes in the skin increase, which leads to dryness and fragility of the skin. Thinning of cubic and columnar epithelia is observed in the mucous membranes of the intestines and respiratory tract.

Connective tissue

With age, the synthesis of collagen and elastin in connective tissue decreases, which leads to a loss of skin elasticity. Fibrosis processes increase, that is, in some organs, connective tissue is formed excessively, and their elasticity decreases. Glycosaminoglycans in the extracellular matrix decrease, and the ability of tissues to retain moisture decreases.

Hyaline cartilage in the joints thins and degenerates, which leads to the development of arthritis and osteoarthritis.

Muscle tissue

With age, skeletal muscle mass decreases, a condition known as sarcopenia. The number and diameter of myofibrils decrease, resulting in decreased muscle strength and endurance. The number and activity of mitochondria decrease, which slows down the process of energy production. Fat and connective tissue elements increase in muscle tissue, which causes muscles to stiffen and lose flexibility.

Nervous tissue

The number and growth capacity of neurons decrease, especially in the brain and spinal cord. The axonal transport processes of neurons slow down, which slows down the transmission of signals. The myelin sheath thins, reducing the speed of nerve impulse transmission, resulting in slowed reflexes. Amyloid proteins and neurofibrillary tangles accumulate, which can lead to the development of neurodegenerative diseases (for example, Alzheimer's disease).

1. Changes in organs and systems

Skin

The thickness of the epidermis decreases, which reduces the protective function of the skin. In the dermis, collagen and elastic fibers degenerate, resulting in wrinkles and loss of skin tone. Adipose tissue decreases in the hypodermis, which leads to thinning and dryness of the skin. The blood supply to the skin decreases, wounds heal slowly, and the susceptibility to infections increases.

Cardiovascular system

The elasticity of the artery walls decreases, which can lead to an increase in blood pressure. Atherosclerosis develops, that is, blood circulation is impaired as a result of the accumulation of fat and calcium in the vessel walls. Myocardial cells (cardiomyocytes) decrease, which reduces the force of heart contraction. Fibrous changes in the heart muscle increase, increasing the risk of heart failure.

Respiratory system

The elasticity of the pulmonary alveoli decreases, which reduces the efficiency of breathing. The number of pulmonary capillaries decreases, which slows down the process of gas exchange. Mucus production increases in the bronchi, which can lead to phlegm accumulation and the development of chronic inflammatory processes.

Digestive system

The intestinal epithelium becomes thinner, resulting in a decrease in the absorption of nutrients. The number of liver cells (hepatocytes) decreases, which affects the detoxification processes in the body. Atrophic processes occur in the gastrointestinal mucosa, which leads to a decrease in the secretion of gastric juice.

Bone and joint system

Osteoporosis develops, that is, as a result of a decrease in bone mineralization, bones become brittle. Osteoblast activity decreases and osteoclast activity increases, as a result, bone tissue is slowly restored. The cartilage layer of the joints atrophies, which leads to arthritis and difficulty in movement.

Kidney and urinary system

The number of kidney glomeruli decreases, which reduces the body's ability to maintain fluid and electrolyte balance. The filtration capacity of nephrons decreases, as a result of which toxic substances can accumulate in the body. The elasticity of the bladder muscles decreases, and the ability to hold urine weakens. There are theories put forward by various scientists regarding age-related histological changes. These theories try to explain the causes of the aging process and the mechanisms of its action at the histological level.

Genetic theory (Hayflick limit)

According to the research of scientist Leonard Hayflick, somatic cells have the ability to divide a certain number of times, after which the aging process begins. The limit of cell division is called the Hayflick limit (human fibroblast cells can divide approximately 50 times). This process is associated with the shortening of telomeres. Telomeres shorten each time a cell divides, which leads to cell aging.

With age, the ability of epithelial and muscle cells to divide decreases. Connective tissue reduces collagen synthesis, which leads to a loss of skin elasticity.

Free radical theory

Denham Harman free radicals are reactive molecules formed in the body in the presence of oxygen, which damage cell membranes, proteins, and DNA. With age, the accumulation of free radicals increases oxidative stress and causes cell degeneration.

The breakdown of the myelin sheath slows down the transmission of nerve impulses. Damage to mitochondria slows down the energy production process, which affects the functioning of muscle and nerve tissue. Degradation of skin collagen causes wrinkles.

Autoimmune theory

Roy Walford and other immunologists believe that the aging process is associated with the body's autoimmune reactions against its own cells. With age, the immune system perceives healthy cells as foreign and begins to attack them. As a result, chronic inflammation and degenerative diseases develop.

The activity of the thymus and bone marrow decreases, as a result of which the renewal of immune cells slows down. Inflammatory processes in the connective tissues increase, which causes degeneration of joint and cartilage tissues. Neurons in the brain atrophy, which can lead to neurodegenerative diseases.

Epigenetic Theory

David Sinclair, Steve Horvath With age, gene expression in cells undergoes epigenetic modifications, that is, the activity of genes changes without changing the structure of DNA. The accumulation of methyl groups blocks genes and disrupts the activity of cells.

Hepatocyte and nephron activity decreases, which leads to impaired liver and kidney function. Muscle cell regeneration slows down, resulting in a decrease in muscle mass (sarcopenia). Skin cell renewal slows down, which causes the skin to thin.

Mitochondrial Theory

Douglas Wallace Mitochondrial DNA becomes damaged over time, which affects the cells' ability to produce energy. With age, mitochondrial damage from oxidative stress increases, which accelerates the aging process. Energy production in muscle tissue decreases, which leads to muscle weakness. Nerve cell metabolism slows down, resulting in cognitive

decline. The efficiency of gas exchange in the alveoli of the lungs decreases, which makes breathing more difficult.

Somatic mutation theory

Scientist Alexey Olovnikov Aging of cells occurs as a result of the accumulation of DNA mutations. Due to mutations, genetic material is damaged and cells cannot perform their normal functions. The risk of developing cancer increases, because DNA mutations damage the genes that control cell division. Liver and kidney cells degenerate, which affects the body's detoxification processes. Vision and hearing decline as the photoreceptors of the retina and the auditory cells of the inner ear degenerate. The aging process is a complex and multifactorial process, and its manifestation at the histological level is associated with the above-mentioned theories. Genetic factors, oxidative stress, autoimmune reactions, epigenetic changes, and mitochondrial damage are among the main causes of age-related histological changes. Age-related histological changes cause complex morphological and functional changes in various tissues and systems of the body. These processes are characterized by reduced tissue regeneration, loss of elasticity, and slowing down of cell metabolism. A deeper study of these changes will help to understand the aging process and develop anti-aging measures.

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