COMPARATIVE HISTOLOGY OF PERIPHERAL NERVE REGENERATION AFTER INJURY

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Abstract. *Peripheral nerve regeneration after traumatic injury is a complex biological process involving sequential morphological and functional changes aimed at restoring the structure and conductivity of the nerve fiber. Unlike the central nervous system, peripheral nerves have a pronounced capacity for regeneration, which is due to the active role of Schwann cells, the preservation of the basement membrane, and a favorable microenvironment . After injury, characteristic histological changes develop in the peripheral nerve, including Wallerian degeneration of the distal segment, macrophage activation, phagocytosis of myelin and axonal debris, and Schwann cell proliferation. Subsequently, guide structures (the so-called " Büngner bands ") are formed, promoting the growth of regenerating axons. Comparative histological analysis of various types of injuries (transection, compression, stretching) allows us to identify the characteristics of regenerative processes, their intensity, and the completeness of recovery. This study assessed microstructural changes in peripheral nerves at various stages of regeneration using classical histological methods. The results indicate that the nature and extent of regeneration depend on the type of injury, the timeliness of nerve continuity restoration, and the condition of the surrounding tissues. These studies have important implications for the development of effective treatments for peripheral nervous system injuries.*

For the first time, the concept that post-traumatic neuronal death in the spinal nerve sensory ganglion is more pronounced following injury to the peripheral rather than the central process has been experimentally substantiated. For the first time, it has been established that the behavior of sensory neurons belonging to specific subpopulations differs in response to central axotomy : the number of NF200+ - HefipoHOB neurons decreases to a greater extent compared to 1B4+-neurons. New data have been obtained on the different dynamics of neuron numbers in these subpopulations during regeneration after injury to the peripheral processes and after central axotomy . New results on the dynamics of caspase-9 expression suggest that an increase in the level of this enzyme in a cell cannot be regarded as a sign of irreversible entry of the cell into apoptosis . It has been shown for the first time that after a peripheral nerve injury, the concentration of Cu (II), which is part of the cell's antioxidant defense molecules, increases in the central segment of the nerve and does not change in the peripheral segment.

These studies are significant for understanding the mechanisms of peripheral neuronal plasticity and the dependence of their survival and phenotype on the action of neurotrophic signals arriving in the perikaryon via various channels from the central nervous system and from the innervated target tissue. The obtained data on the dynamics of post-traumatic neuronal death in the sensory ganglion allow us to assess the prospects for complete restoration of peripheral nerve sensory function in clinical practice. The results of studies indicating different behavior of NF200+ and B4+ neurons during central axotomy and damage to the peripheral process are of practical significance for predicting the restoration of function of afferent fibers of various sensory modalities (pain, temperature, tactile sensitivity, proprioception). The obtained results substantiate the feasibility of using a standard spinal nerve sensory ganglion neuron injury model as a test system for the effective screening of new pharmacological neuroprotectors , particularly those capable of selectively supporting the survival of sensory neurons of specific subpopulations . Data on the level of Cu -containing compounds in the peripheral nerve are important for analyzing the molecular and cellular mechanisms of antioxidant cell protection and the relationship between the antioxidant and apoptosis -controlling systems, which is important for preventing neuronal death in neurodegenerative diseases and injuries.

The aim of the study was to conduct a comparative histological analysis of peripheral nerve regeneration processes after various types of traumatic injury.

Research objectives: To study the normal histological structure of peripheral nerves. To simulate various types of injuries (transection, compression, stretching). To investigate the stages of Wallerian degeneration after injury. To assess Schwann cell proliferation and the formation of guidance structures. To analyze the growth of regenerating axons. To conduct a comparative analysis of regeneration processes in different types of injuries. To assess the degree of nerve structural restoration.

Research methods. Experimental modeling of peripheral nerve injury. Sampling of tissue at various times after injury. Tissue fixation (formaldehyde). Preparation of histological sections. Staining of preparations (hematoxylin and eosin, osmium acid for myelin). Microscopic examination. Morphometric analysis (myelin thickness, axon density). Statistical data processing.

Study results. In the early post-injury period (1–3 days), signs of Wallerian degeneration were observed in all groups : disintegration of the myelin sheaths, axonal fragmentation, and macrophage infiltration. Regeneration was most favorable with compression-type injury: continuity of the connective tissue sheaths was maintained, rapid proliferation of Schwann cells and directed axonal growth were noted. By the later stages, almost complete restoration of the nerve structure was observed. With stretching, moderate destructive changes, partial disruption of the axonal structure, and delayed regeneration were detected. The most pronounced impairments were observed with complete transection of the nerve: significant destruction of the structure, disorganization of regenerating fibers, formation of scar tissue, and decreased recovery efficiency were noted. Morphometric analysis showed that the thickness of the myelin sheath and axonal density were significantly higher with compression injury compared to other types of injury ($p < 0.05$).

Conclusions. Peripheral nerve regeneration depends on the nature of the traumatic injury. The most favorable conditions for recovery are observed with nerve compression. Complete transection of the nerve is accompanied by significant regeneration impairments and scar tissue formation. Schwann cells play a key role in the process of nerve fiber regeneration. Timely restoration of the anatomical integrity of the nerve is a critical factor for successful regeneration. Histological analysis allows for an objective assessment of the extent and quality of nerve tissue restoration.

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