Neurogenesis In Adult Brain Induced by Peripheral Nerve Injury

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Abstract

Neurogenesis is the brain forms new neurons. On the other hand, the peripheral nervous system is the nervous system's allocation, which contains all nerves lying outside the CNS. The PNS's role is to create a link between the limbs, skin, and organs to the CNS. The formation of neurons in adults is believed to be blocked by the subgranular zone connected to the subventricular area and the dentate gyrus in the CNS. The formation of neurons is active in the development during the prenatal period in the PNS. The growth occurs with the aid of neuroepithelium being absent (Sommer et al., 1996). The injury of the peripheral nervous system in adulthood means that it is restricted from producing neurons. In the adult PNS, there are sensory ganglia that contain precursor cells that can differentiate into neurons after proliferating into Vitro hence getting induced. When the PNS is injured, the generation of new neurons is impacted. Induced neurogenesis in the PNS has not been explored (Olsson, 1990). The paper focuses on adult neurogenesis and the potentiality of reduced production of neurons in injured adult PNS.

Key Words: Adult neurogenesis, peripheral nervous system, dorsal root ganglia, autonomic ganglia, mesenchymal stem cells

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Abbreviations

PNS (Peripheral Nervous System), DRG (Dorsal Root Ganglia), NG (Neural Ganglia), NSC (Neural System Cell), MSCs (Mesenchymal stem cells), and CNS (Central Nervous System).

Introduction

Various components are affected when the peripheral nerves are injured. These components are concerned because the quality of sensation of the PNS, which is intact, is affected. The sensation depends on cortical interpretation, degree, and overlap of neurons' receptive fields, innervating neuron count, and sensory receptor organs' density (Pardo et al., 2018). When the PNS is injured, all the above components are affected. The PNS can function well by restoring specific reinnervation through adequate neurons (Bosio et al., 1996).

Therefore, it is evident that poor sensory outcome after the PNS has been injured occurs due to the death of sensory neurons. The end of the sensory neurons fails the reinnervation of organs to be targeted.

Discussion

Neural system cells can differentiate into cells and neurons that resemble Schwann cells. Neural system cells can differentiate and express their neurotrophic factors, which are essential for the production of neurons. After NSCs differentiate, they are key players to repair injury of the peripheral nerve. Astrocytes, oligodendrocytes, and neurons play a role after the Schwann cells differentiate to repair damaged peripheral nerves (Giometto et al., 2010).

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Additionally, neurons, astrocytes, and oligodendrocytes develop following NSC differentiation and should represent a primary focus of research in studies of the regeneration of injured peripheral nerves (David & Aguayo). These questions must be addressed in future research. With current techniques, it is challenging to transplant NSCs into humans.

When the peripheral nerves are injured, all the neurons connected to the nerve will die. The likelihood of an injured nerve recovery depends on the regeneration of axons, the number of neurons, and neuronal phenotypes development (Ekdahl et al., 2003). When peripheral nerves are injured, arranged events on plastic changes aimed at restoring damaged connections are induced. When the peripheral nerves are damaged, their axons start to sprout—the fibers of the nerves sprout neuritis that repair the damaged sites.

Damage to an adult's peripheral nerves induces mechanisms and factors that control the proliferation of neurons', differentiation, and migration during the entire development. The adult mammalian brain has not reported the replacement and addition of the large existing neurons resulting from increased neurogenesis. When neurons are damaged in adults, other neurons generation is dependent on the hippocampus and epithelium (Parent, 2003). The dorsal root ganglia of an adult rat have shown that there is reduced postnatal neurogenesis. The subpopulation of cells in an adult DRG has samples of p75 neurotrophin and nestin receptors. The cells form spheres and clusters, which further differentiate into glia hence forming tertiary and secondary neurospheres.

DRG also shows the presence of cells that have neural progenitor phenotypes. The trophic environment plays a crucial role in determining the production of neurons in adult sensory ganglia (Bixby et al., 1988). The trophic environment further affects the nature of differentiation in ganglia. There is a need to determine the conditions necessary for the induction of neurons in regions that are physiologically non-neurogenic in an adult's nervous system. The understanding helps develop strategies in therapy to repair the damage of peripheral nerves—effective treatment of a peripheral nerve that has been damaged does not exist. Results of the production of neurons and injury-induced repair in an adult's nervous system have been convincing (Wei et al., 2010). There is a problem in finding methods to stimulate the production of neurons and repair induced injury.

The neurogenesis process in the PNS of an adult has been shown through studies showing the relationship between age increase and rat DRG neurons. Adult production of neurons can take place in an adult rat.

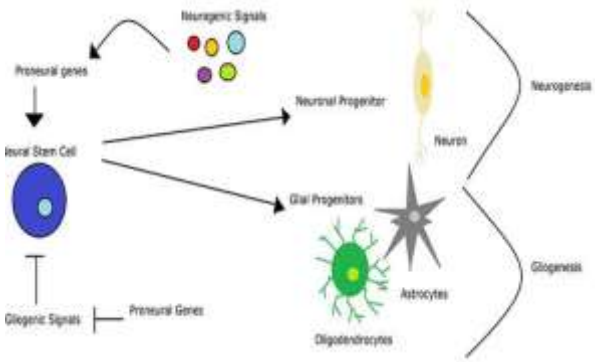

Figure 1. A figure showing the mechanism of neurogenesis

The production of neurons can occur when the intestinal wall produces many cells because of neuronal precursors differentiation and not because of cell proliferation. The process is induced by functional stimulation, which is increased beyond normal. An adult rat's small intestine can produce cells beyond normality in its small intestine loops far up from its stenosis (Rutkowski et al., 1995). The neuron production also increases, showing that there is a strong possibility of neuron output in the PNS of the mammal.

The 20th-century studies on neuron differentiation, regeneration, and plasticity led researchers to appreciate that damage on neurons can be compensated. The generation of new neurons can be carried out in an adult peripheral nervous system. Neural regeneration research report revealed a few physiological levels of neural proliferation (Mosahebi et al., 2001). However, reports report focused on less-rigorous approaches like neural counts. The research in the 21st century came up with more powerful tools to be used in the study of neurogenesis in adults (Richardson et al., 1990).

The past few decades have experienced the revival of neurogenesis in the peripheral nervous system debate. Postnatal neuro-genesis injury may be a result of neural precursor proliferation and also due to the late post-mitotic cells differentiation. A postnatal adult dorsal root ganglia contain a niche in the neural precursor. The niche proliferates to respond to the administration of factors that differ and, when induced, differentiates into mature enough sensory neurons (Jiang et al., 2008). DRGs explants are present, which are sub-population of cells that express neural progenitors creators. These DRG explants have the ability to differentiate into glia and neurons at optimum culturing requirements.

Below is a table showing what leads to neurogenesis, therapy to enhance the microenvironment of nerves and how nerves multiply.

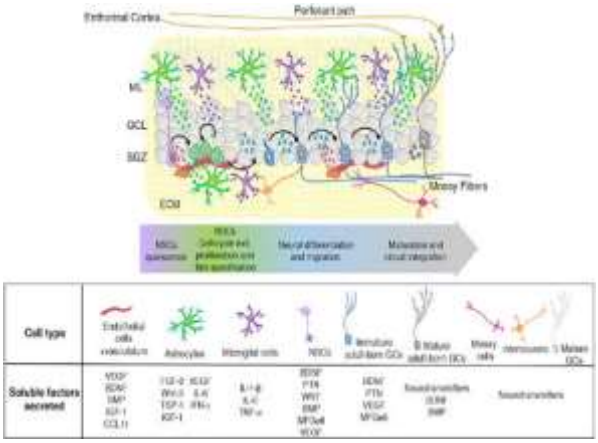

Table 1: Cell type and the soluble factors it secretes in the process of neurogenesis

Progenitors are produced in the satellite glial cells. The satellite glia cells play the role of the stem cell niche of the DRG. Neural progenitor's niche can persist. The progenitor niche is observable in the sensory ganglia besides the adult life.

Progenitors get produced from the differentiation of cells after injury. These many differentiated cells become neurons. The cells are immuno-reactive enough for a specific neuron antigen. In the case of adult rats exposed to different treatment processes, many newborn neurons get to mature and survive for as long as ten months before treatment. Capsaicin-treated rats show more NG and abdominal, thoracic, and cervical vagal trunks than those of the vehicle-treated rat samples (Mosahebi et al., 2001).

Furthermore, the rats' experimentation revealed that small axon profiles exist in the tissues of the capsaicin-treated rats when a cervical vagus undergoes electron microscope viewing, an indication that new neurons, when faced with destruction, caused capsaicin treatment, extend their developments to vagal trunks. The NG cultures on the capsaicin injected rats had bipolar neurons, which normally exist during development.

After the death of cells after destruction induced by capsaicin treatment, ganglion progenitors enter the cell division cycle, divide, differentiate, and end up as the sensory neurons. Their population is large enough to indicate and provide injury responses when they happen to the body organs (Eldridge et al., 1989). The DRG stem cell preserves its multi-potency all through adult life. Neural stem cells are also multipotent in adult DRG. These DRG NSC have the ability to increase on their own, an indication that they undergo mitosis at their expense.

NSC in adult DRGs posses glial and neural makers, transient receptors, and serotonin transporter. These components play a major role in response transmission in case of an injury in the body. The awareness of an injury is quickly made for an instant response on how to halt it. After a traumatic nerve peripheral crush, neural progenitors are present. Axonal damage causes morphological changes (Ide et al., 1983). The time in lapse and immune-fluorescence character of cells phenotype in electron microscope scan analysis shows the neural precursors' representation by satellite glial cells that proliferate actively after injury and can differentiate to reach neuronal lineage.

Within the DRG, a multipotent progenitor cell niche is present throughout one's adulthood. The adult sensory neurogenesis niche can be in the ganglia or the nerve trunks. However, neural boundary cells derived in the crest that mark the boundary of the nerve in the spinal cord may present a late migration of stem cells population that produce new glia and neurons in DRGs (Frostick et al., 1998). New neurons in adult sensory cells can originate from migrating external stem cells

and the internal precursors, which shows the alternating ways of sourcing new neurons.

Neuro-glia stem cell is present in the nervous system. Adult neurogenesis exists in the adult intestines as there is the presence of new neurons differentiating in the myenteric plexus. The myenteric plexus happens to be a nerve supply in the intestinal tract and controls its motility.

An injury can stimulate neurogenesis in the gut. Neurogenesis in the gut increases the number of peripheral neurons under the stimuli of an injury. It is recognized as the proliferation of neural stem cells that occurs with neural differentiation following after that (Rodríguez et al., 2000). Also, there may occur late post-mitotic neural differentiation in response to the change as indicated by the sensory nerve cells after an injury. From the clinical perspective, due to limited neural precursors amounts, the effect in the repair mechanism by the neurons can only be temporary and limited when an injury occurs—this opposite of what happens when there is a proper and right stem-cell niche.

A peripheral nerve injury induces neurogenesis in an adult mind. The generation of newborn nerve cells marks the start of a mechanism that seeks to control the effects of an injury in the body (Liu & GU, 2020). The mechanism is characterized by several cell division and differentiation processes that all work in the same direction to respond to the damage.

The power of generating new neuron cells lies with the glia. There is a possibility that satellite glia and the Schwann cells can both make to be the neuronal precursors. Neuronal progenitors and the glia are capable of being stimulated to resume a lesser differentiated status that is in line with their lineage (Muratori et al., 2015). De-differentiation can even proceed further backward and retreat to the point of trans-differentiation of the neural cells, where they switch lineage. These mechanisms are the cause of the induced neurogenesis in the peripheral nervous system of adults. The presence of progenitor cells in the peripheral nervous system can enable an autologous new neuron fixing in the damaged area of the CNS, which refills the lost neuron caused by an injury (Wang, 2017). The above may prove to be a significant measure in the field of regeneration and plasticity in adults' nervous systems.

Conclusion

Injury of the peripheral nerve occurs in a percentage of 30% in patients suffering from trauma. Concern about learning about the damage of peripheral nerve should be necessary as the condition can cause a disability. The target of making an injured nerve healed is by making sure that a nerve's function is achieved normally (Rusanescu & Mao). To reset an injured nerve's role to normal, a long stay in the hospital, outpatient care, and huge costs is incurred. It is rare to repair a damaged nerve to become normal and perform its motor and sensory functions (Margiana et al., 2020). Microenvironment factor greatly affects injury of the peripheral nerve management. The nerves' microenvironment can be effectively enhanced through the insertion of therapy that is supportive like one of the Mesenchymal stem cells. NSC transplantation can be applied in clinical trials to repair damages on the CNS (Kumar et al., 2019). NSC transplantation deals with transplanting neural progenitor cells. Using NSCs in improving peripheral nerve injuries may possess high potentiality hence bringing positive results to humans.

Conflicts of interest

The authors declare that there was no conflict of interest.

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