Neurocosm International Journal (NIJ)
Vol-2, Issue-2, June 2021

e-ISSN: 2582-7480

The Importance of Avoiding "Dark" Neurons" in Experimental Neuropathology

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Abstract

Dark neurons assist to utilize neuropathology for understanding the effect of different neurological disorders such as hyperglycemia, dementia, and Alzheimer's disease. This factor assists in identifying the vital signs of disease and the progression process of disease and monitoring transformation in the brain associated with the protein accumulation in the neurotransmitter. The DN has also appeared in the abscess of trauma or the mechanical forces applied in a brain that define diseases related to the central nervous system. This factor reflects the cause of the excellent fixation of the production process of dark neurons in experimental neuropathology in the reversibility of dark neurons.

Keywords

Central Nervous System, Dark Neurons, Experimental Neuropathology, Neurotransmitter, Protein Accumulation.

INTRODUCTION

The article focuses on two variables that are dark neurons within experimental neuropathology. There is a histological artifact within the brain where there is a presence of stained neurons in the brain and these cells have been termed as "***dark neurons***" (DN). However, neuropathology has been revolving around studying different diseases in relation to the eyes as well as the nervous system. The dark neurons have been considered to be real pain whereas most of the work within the brain has been based on the different patterns of the neuron activities [1]. The dominance related with the DN has been more as it makes the brain as the tiny minority within the brain. There are some studies that have illustrated that 90-99% of the dark stained neurons have been seen to be recovering after a certain period while some proportions of the neurons have evolved as DNs.

"***Hyperstained dark shrunken neurons***" have been found to be a common finding within both clinical as well as experimental neuropathology. DNs represents neurons that have been undergoing morphological features which includes "***silver staining and hyperchromophilia***", "***corkscrew appearance***" along with dark staining. Neurons have been considered to be expensive for building along with maintaining which is an issue. Dark neuron make up the cortex which is the outer layer within the cerebrum where there are no activities performed by the dark neurons. There are four various types of DNs that are "***artefactual***", "neostriatal", "***irreversible and reversible types***". As DNs undergo different morphological characteristics which includes volume reduction as well as reduction where the nature of the phenomenon has been dependent on the reactions within the cytoskeletal elements [2]. It has been further stated that neurons have been apoptotic neurons where around 10% of the dark neurons have been entering into the dead phase.

The aim of the study is to discuss every aspect of DNs in a way to avoid it within experimental neuropathology. DNs have been argued to possess plasticity nature at the time when the dark neurons adopt normal morphology. However, plasticity has been illustrated in terms of peerless ability within the brain that helps in recognising and changing certain responses towards changes within the environment. In case of studying the vulnerability of dark neurons in some of the animal studies, it has been found that vulnerability within "***neuro-glial defense protective mechanism***" has been in harmful paradigms [2]. However, even with this issue, it has been seen that neuron tries its distinct abilities that further promotes viability and survival of those organisms.

LITERATURE REVIEW

Dark Neurons and Neuropathology

"Dark nonshrunken brain neurons" are described as some cells associated with "hyperchromic cytoplasm" while sizes of these DNs have been varied in comparison with the normochromic neurons. [3] opined that DNs have been found to be rare and it accounts to around 1% of the respective cells. The DNs can only be seen in experimental treatments while the path that is used for modeling subhepatic cholestasis helps in incrementing the total number of those DNs to over 6% that further increases to around 16% within the cerebellar cortex. However, Hyperchromic dark neurons have also been considered as some cells containing protein synthesis that eventually die through apoptosis as a consequence of intense exposure to certain unfavourable conditions or due to genetic abnormalities. The DNs can be produced through post-mortem manipulation or through trauma within the brain tissue.

e-ISSN: 2582-7480

Neurocosm International Journal (NIJ)
Vol-2, Issue-2, June 2021

Figure 1. Neuropathology while studying the brain tissue for Alzheimer's disease
(Source: [4])

Neuropathology can be described as the certain disease related to the brain, spinal cord as well as nerves by evaluation of the tissue that has been eventually removed during the time of the autopsy and also biopsy. [4] argued that the researchers dealing with neuropathology have always been looking for some vital signs related with diseases and also with the disease progression and may simultaneously identify whether transformation within the brain has an association with protein accumulations as per Alzheimer's disease. The research on neuropathology has been considered to be important as neuropathology helps in the identification of the biological changes namely, biomarkers.

Pharmacologic analysis of production of dark neuron within cerebral cortex

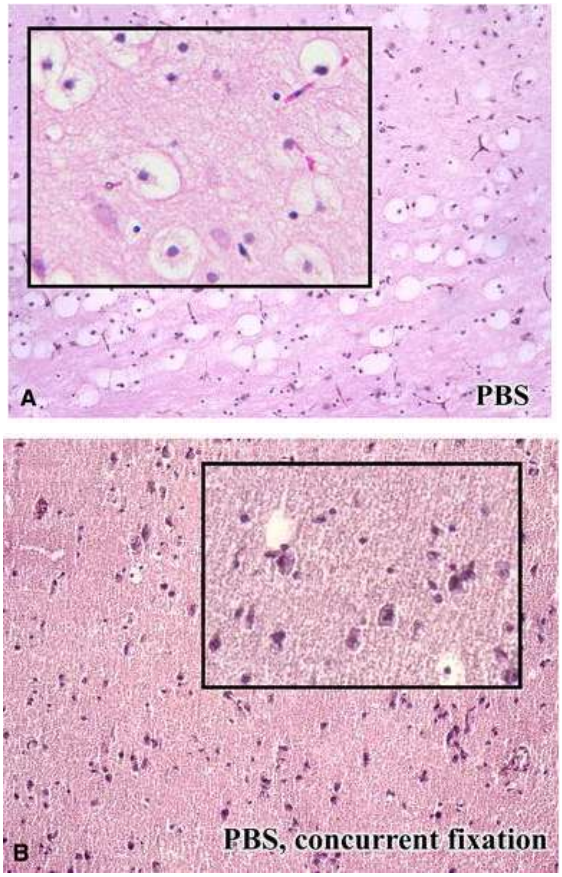

Figure 2. Phosphate-buffered saline and formaldehyde fixation prepared from saline
(Source: [5])

DNs have been observed for the first time within the neurosurgical biopsies and not in the autopsy. [5] opined that due to appearance of the DNs in the aftermath of delayed fixation or mechanical trauma within the brain prior to some fixation, there is a mechanical force related with stress that has been hypothesised for producing dark neurons. DNs is also seen to have appeared in some conditions in absence of trauma or certain mechanical forces that have been applied in the brain. There are some diseases related to the "central nervous system" such as epilepsy that produce dark neurons in accordance with excellent fixation. On the other hand, Hypoglycemia also tends to produce DNs that take recovery for several hours which indicates "reversibility of dark neuron formation".

"Phosphate-buffered saline treatment" have resulted in swelling of the "neuronal cytoplasm" along with preservation of "pyknotic nucleus" that eventually gets displaced to a specific side with the help of watery cytoplasm. The admixture containing saline and formaldehyde have not yielded DNs. Immersion fixation related with "excised cortical biopsies" have resulted in producing large amounts of DNs. [5] argued that there has been a delay in formaldehyde penetration over the center of the cell deaths that has led to the formation of the DNs. The tissue that seems to have been exposed to "noncompetitive NMDA antagonist" namely "MK-801" have led to abolishment of DNs.

Protective mechanism or rather a mode of death through DNs

DNs have been found in different experimental conditions, normal animals and others. [7] mentioned that immunocytochemical (use of antibodies for checking antigens within samples containing cells) methods have been created for identifying DNs. DNs sustainability has been associated with either "cationic" or "anionic" dyes. Cationic dyes include "Mayer's hematoxylin and toluidine blue" while anionic dyes include "acid fuchsin and eosin" and others that have been utilised for demonstrating "basophilia", "argyrophilic" and others in relation with DNs. The classification of DNs have been performed on the basis of "moribund", "recovering", "dead" and others. It has been found that "freshly produced DNs" display intense basophilia and also argyrophilic however, the DNs that have been entering into recovering phase lose argyrphilia and also basophilia while reappearance of normal basophilia. The appearance of "dark brown dots" within the DNs cytoplasm in connection with cationic dyes have been assumed to be recovering DNs. However, Moribund or dying DNs have been seen to be losing out normal basophilia in a few hours.

NEUROCOSM
e-ISSN: 2582-7480
Neurocosm International Journal (NIJ)
Vol-2, Issue-2, June 2021

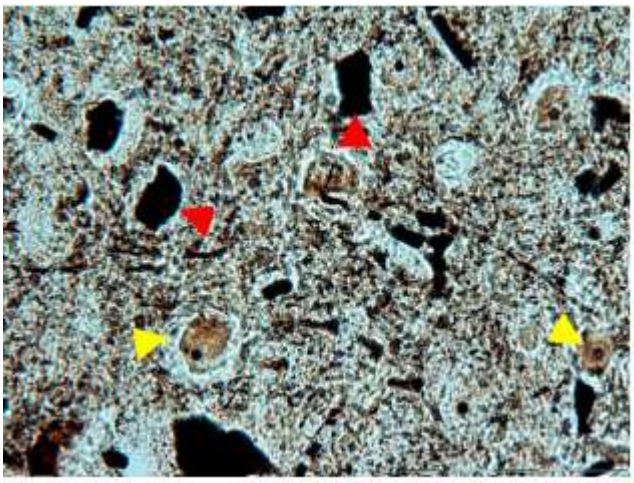

Figure 3. DNs possessing sharp contour
(Source: [7])

The survival time of the DNs have been considered where 1 hour of survival time indicates basophilia while 48 hours confirms about argyrophilia. Conversely, in 4 hours, it has been witnessed that d acidophilia has become more intense. [7] argued that DNs undergo a transient change within the electrical properties that have been connected with reversible compaction. The staining properties found in the DNs are an indication of the conformational changes within the proteins. DNs have been witnessed to be entering into the recovery phase where around 90%-99% always begin in the reverse scenario that is charcaterised through "mitochondrion sized dot" within the soma and also dendrite. Over 1-10% of the respective DNs have been entering into the irreversible process where cellular changes have been leading towards chromatin fragmentation and at the end, become as dead neurons. There is a development of DNs within the CNS. It has been further estimated that DNs become exhausted neurons after a certain period.

DNs in case of healthy conditions can be the condition of postnatal development is synonymous with "naturally occurring dark neuron" (NODN) whereas DNs have been occurring through an aging process that has been assumed to be neuronal death. [8] mentioned that there is a grave controversy over the "mode of death" that has been occurring along with the fate of those DNs. However, it is impossible to categorise DNs in terms of either necrotic or apoptotic death. Conversely, there is a similarity that has been witnessed between "apoptotic death" and also "mode of death" within the dead DNs. Thus, it is clear that DNs die with the increase in the aging process which has an indication of avoiding it within the experimental neuropathology. The CNS will stop working as well with the death of the DNs.The diseases which have been studied under neuropathology will deteriorate with the death of DNs with the increase of age within an individual.

Phenomenon of DNs within experimental neuropathology

The phenomenon of DN formation is considered to be self-spreading throughout the dendrites and also soma. It is the DNs phenomenon that will provide the reasons behind the significance of avoiding such DNs for experimental neuropathology. [9] opined that DNs have the power to propagate towards the close neurons with the help of the dendrite connections. Furthermore, it has been estimated that "amygdaloid kainite lesion" substantiates the formation of DNs within the anatomical areas by neuronal projection. The association between two close neurons takes place within the synaptic region. There is a formation of Ergo DNs that have been associated with spatio-temporal arrangement associated with neuronal connections. There can be some direct associations among those juxtaposed neurons that seem as "sine qua non" which have been spreading that DN phenomenon. This specific connection helps in fast and synchronous brain activity in the wake of conscious processing or certain ECG.

Presence of "presynaptic" and also "postsynaptic membranes", associated with dendrites have been linked through "β neurexin" and "neuroligin". [10] argued that the adhesion through β neurexinneuroligin have an influence on the cytoskeletons in connection with the adjacent neurons. "Cell adhesion molecules neurexin" in the form of "presynaptic" and also "neuroligin" in the form of "presynaptic" have established a connection with the "cytoskeleton" with the he;p of "actinbinding protein 4.1" or through "microtubule-binding protein CRIPT". This type of connection has been helpful for providing intracellular connections that have resulted in "actin polymerisation" between two neurons.

The importance of adhesion through "β neurexin-neuroligin", "polymerization of actin" along with the transition phase consisting of the spread of the neurons while impacting the neighboring neurons. [11] opined that the formation of DNs have been revolving around reversible and self-propagate response towards transient alteration within the "extracellular physic-chemical milieu". As most of the DNs have been associated with regaining the normal morphology that may not be assumed to be helpful. 10% of the DNs have been witnessed to be entering into an "irreversible degenerative process" therefore, DNs occurrences cause a herald towards neuronal loss.

METHODOLOGY

There has been a silver method that has been proposed for the purpose of reproducible demonstration of those DNs which are found to be in frozen state. However, the sections associated with vibratome along with paraffin have been cut down at a thickness of around 5 to 200 μm from that "aldehyde-fixed brains". It is the "Golgi-like staining" within the dendrites that have enabled the assorting of the DNs in accordance with the characteristics and neuron classification [12]. Golgi staining is an important method where silver nitrate has been used for staining a particular neuron that includes both the dendrite as well as axon branches. The experiment involved a staining procedure where esterification related with 1-propanol have been considered

for the purpose of treatment with acetic acid in diluted form and also for development. The esterification has increased argyrophilia in respect of the DNs and also mitochondria. There has been an unwanted co-staining related with mitochondria that has been suppressed with the help of treatment through acetic acid. There is a unique developer that has been utilised which is basically used for rendering staining controllable.

This specific method has been applied towards experimental neuropathology that has been demonstrated through Golgi-like staining associated with DNs within the brain of the rats that has been exposed in advance of the "transcardial perfusion-fixation" and also delayed the autopsy associated with different pathological conditions such as "ischemia", "status epilepticus", "hypoglycemia", "colchicine" and others [12]. Therefore, there has been disruption that has been prevalent during this method where tests related to pathological conditions. In a further experiment, it has been seen that the neurons have collapsed down within the "lateral striatum" and also in the "adjacent cortex" where it is seen that DNs have been grouped together in patterns [13]. These collapsed neurons have been seen to be detected within the "reticular thalamic nucleus", "hippocampus" and others that have been distant to each other within the ischemic core. This experiment has also fetched out a result where it can be witnessed that pathological conditions will get affected because of detecting the DNs therefore, it is feasible to avoid it within the experimental neuropathology. It is an essential insight that has been triggered through "transient focal cerebral ischemia".

FINDINGS AND DISCUSSION

Findings

The staining from "Argyrophil III" has been assumed to be an effective method for detecting those DNs that have been reflected through cytopathic features in the earlier stage. The DNs have been examined and further it has resulted into some stressful exercises within the rat through the help of the rat model. There have been certain exercises that have been related to swimming within a pool, and running over a treadmill where it has been found that after finishing off the swimming, there have been some DNs that have been detected within the "hippocampus", "entorhinal cortex", "habenular nucleus", "striatum" and others [14]. It is only after running for some time, the appearance of the DNs can be obtained within the "visual cortex", "motor cortex", "somatosensory cortex", "hippocampus" and others.

The glimpse of the DNs have been detected within the limbic structure in the aftermath of the swimming and also within the limbic structure that is seen in motor-related regions and also in the visual cortex in the aftermath of the running. The distribution of the DNs have been interrelated with strength and duration that have been associated with the exercises. It can be better illustrated that the distribution of DNs over a specific region is dependent on those strength and duration associated with swimming and running exercises on the pool and treadmill. The "hematoxylin-eosin (H-E) staining" has been found to be different from the Golgi-like staining which have been spoken to a great extent above. "Hematoxylin-eosin (H-E) staining" is also another method where two types of dyes such as hematoxylin and eosin have been utilised for fetching out the results within this rat model [14]. It is the "pycnotic cells" often called as "dark stained soma" have been detected within "CA1 hippocampus" that contains the "argyrophil positive cells" that have been found in abundance. "Picnotic cells" is seen in abundance in those areas where DNs have been detected. It is the essential data that has been provided which has an indication that it is the DNs that has been induced through stressful exercises.

Dark Neurons(DN) rose to undergo a series of morphological characteristics that includes volume reduction shrinkage and create a dependency on the rapid reaction of cytoskeleton elements. This factor helps to transmit microphysical in the variety of different noxae that share a common target for understanding bound in the cell membrane. The presence of DN develops questions about the occurrence of DN and its impact on the healthy body in continuing the experimental neuropathological study. This experimental process highlights that apoptotic neurons have less than 10% of dark neurons in the death phase in maintaining the daily function of neurotransmitters in the brain [15]. The reversibility of DNs determines the particular shrinkage and surface reaction by understanding neuroplasticity that refers to the peerless ability of the brain in changing and reorganizing the changes in the environment. Neuroplasticity helps to develop the formation of new synapses, sporting dendrites spines, simplification, and retraction of dendrites that support the reduction of the dendritic spines activity in stressful circumstances.

The reductive response helps to combine various engineering Pathways and hormones such as dopamine, and glutamate in understanding the rational reaction of DN. This factor guides in simplifying the density and the spine reduction by applying a protective mechanism for neuron production against neural Darwinism [16]. The previous literature shows that glycoproteins assists in maintaining the cell behaviours such as cell-to-cell interaction, stabilisation, and protective function in limiting the regeneration capacity of the central nervous system (CNS). On the other hand, the reduction of glycoprotein helps to decrease the sensitivity of neurons in glutamate excitotoxicity and damage that can activate the mechanism of dark neuron production. Sometimes, changes in the vibrating situation of glycocalyx assist to understand the transient increment of intercellular pressure that creates an impact on the volume reduction process. These changes affected the connection between cytoskeleton elements and the nucleus membrane that develops intercellular pressure and affected the nucleus and chromatin effectively.

The reversibility of chromatic clamping and margination created a dependency of returning glycocalyx vibration state in a specific defined regional range with the help of actin depolymerization. Moreover, ultrastructure and light microscopy helps to find out the cytoskeleton complex contribution to the death neuron formation process and present neurofibrillary tangles that contribute to dark neurons [17]. This factor highlights the way the glycocalyx-cytoskeleton complex works as a mechanotransducer in the stringing process of cytoskeleton reaction. The changes of physical or chemical in the extracellular milieu affected the definition of limited glycocalyx-cytoskeleton that leads to the darkening of the neurons efficiently.

Discussion

From the above literature, neuropathology helps to describe certain diseases related to the brain and spinal cords and evaluate the condition of nerve tissues that are removed due to the autopsy or biopsy process. This evolution process helps to determine the location of dark neurons and their impact on the nerves and the stimulation of neurotransmitters. The development of the experiment treatment helps to utilize the subhepatic cholestasis model for the increment of a total number of DN measuring processes and understand the development of DN in the cerebellar cortex part [18]. Dark neural formation indicates the self-spreading process with the help of dendrites and stoma that demonstrates axonal involvement in neural activity. This factor helps to understand the argument neurons by examining the dendrite connections and indicates "amygdaloid kainite lesion" affected the dark neuron formation process in the anatomical area for the neural projection process. The relation between proximity neurons creates a synaptic region for DN formation in a spatiotemporal and indicates the connection with the neural activities.

This direct connection guides the neurons to collect information about the "sine qua non" in the trading process of death neurons that are responsible for fast, synchronous, and coherent brain action in the conscious process of electroencephalogram (EEG). The EEG helps to record the brain activity and the trace process uses small sensors that are attached to the scalp for picking up the electrical signals produced by a brain in identifying the density of DN. This factor helps to understand the presence of a physical connection in the synaptic region for determining the link between the presynaptic and postsynaptic membrane of the dendrites [19]. The β neurexin and neuroligin influence the function of the cytoskeleton in the two adjacent neurons and dominants the intercellular of the utilized protein. This factor helps in establishing a connection between the presynaptic domino zone(PDZ) and postsynaptic density (PSD) in two adjacent neurons. The adhesion molecules of cells lead to neurexin and neuroligin indirectly linked with synaptic proteins in the cytoskeleton with the help of spectrin actin-binding (SAB) protein 4.1.

This SAB protein assists to determine through the alternative splicing exon for encoding the 21 amino acid (aa) and constitutive exon 59 amino acid (aa) that strengthen the cell membrane. The binding protein allows for maintaining the population of assembly-ready actin monomers such as profiling and regulating the state of polymerization of filament [20]. This factor helps to regulate acting given assembly that provides independence of the modern protein in controlling the functionality of bacterial cytoskeleton. The burning protein helps to develop the microtubule-binding protein connection that helps to provide fast intercellular connection and provide actin polymerization of two closely situated neurons. This factor develops concerns about the β-neurexin-neuroligin protein in the translation page from one neuron that affected other neurons. The majority of dark neurons get their normal formation for dealing with more formation of a variety of conditions with the help of actin-binding protein [21]. The previous literature highlights that dark neurons had seen cortical biopsies, experimental ischemia, hypoglycemia, and epilepsy that affect glutamate release and the neural transmembrane ion fluxing process.

This factor stimulates the neurosurgical production of dark neurons for identifying the role of glutamate and blocked N-methyl-D-aspartate (NMDA) and non-NMDA in controlling the production of formaldehyde. For example, the inhibition of the Na+–K+ ATPase pump causes dark neurons and indicates epilepsy that affects the neurotransmitter of the brain in the fixation situation [22]. On the other hand, the excessive release of neurotransmitters in epilepsy, produces excitatory aspartate in hyperglycemia, and the formation of glutamate in ischemia assists in understanding the mechanical origin of dark neurons. The mechanical origin of dark neurons helps to determine the different receptors of glutamate receptor subtypes in the production of DN and blocking the sodium channels for maintaining the passive water movement in the cell membrane. This factor reflects the result of phosphate buffer silent treatment in identifying the swelling of neural cytoplasm in the preservation process and displaying pyknotic nuclei with the help of watery cytoplasm.

The immersion fixation helps to exercise biopsy in dark neurons for understanding occurrences of tendency at the age of president that represent deleted format delayed formaldehyde penetration of dead cells [23]. The hyperchromatic dark neurons are defined as some cells containing the protein synthesis process and died through apoptosis due to exposure to certain circumstances or genetic abnormality.

CONCLUSION

Experimental neuropathology assists in histological artifacts of the brain that helps to determine the presence of dark neurons that helps to resolve the studying process of different diseases related to the nervous system. This factor helps to associate with the epileptic seizure for DN formation

in the cortex part of the brain that determines the swelling rate of mitochondria. The dominance of DN assists to establish a tiny minority within the brain that is to find out DNs presence in clinical and experimental neuropathology. The DN is mostly present in the outer layer of the cerebellum that causes the building of maintenance issues of neurons. The phosphate buffer surrounding the treatment process helps to understand the swelling of neural cytoplasm in preserving the nucleus for displaying the specific side of water cytoplasm. This factor helps to mention immunocytochemical that are used as antibodies for checking antigens in the continent's cells for determining the creation process of DN.

The DN has to demonstrate “basophilia”, “argyrophilic” and others in establishing cytoplasm with the connection of kinetic dice that helps to recover the dead neurons with the normal basophilia in some hours. The straining process of dice helps to indicate the date neurons in conformation changes with the help of protein that helps to enter the recovery face for categorizing “mitochondria size dot”. The DN in experimental neuropathy helps to provide the reason of significance in avoiding death neurons for identifying the close neurons with the help of dendrite connection. Ergo DN allows in associating spatio-temporal arrangement with connection for spreading of DN phenomenon and this connection helps in fast and synchronous brain activity of certain ECG. The collapsed neurons had been detected with the reticular thalamic nucleus and hippocampus for distance each other in the ischemic core with the help of pathological conditions.

REFERENCES

[1] *Notes (no date) Princeton University. The Trustees of Princeton University*. Available at: https://press.princeton.edu/ideas/the-dark-neuron-problem-or-mind-reading-at-90-accuracy (Accessed: December 28, 2022).

[2] S. Ahmadpour, A. Behrad, and I.F Vega. Dark Neurons: A protective mechanism or a mode of death. *Journal of Medical Histology*, *3*(2), pp.125-131, 2019

[3] S.M. Zimatkin. Dark neurons of the brain. *Neuroscience and behavioral physiology*, pp.1-5, 2018

[4] J.A. Schneider. Neuropathology of dementia disorders. *CONTINUUM: Lifelong Learning in Neurology*, *28*(3), pp.834-851, 2022

[5] Z.S. Kherani, and R.N. Auer. Pharmacologic analysis of the mechanism of dark neuron production in cerebral cortex. *Acta neuropathologica*, *116*(4), pp.447-452, 2008

[6] A.S. Fix and R.H. Garman. Practical aspects of neuropathology: a technical guide for working with the nervous system. *Toxicologic pathology*, *28*(1), pp.122-131, 2000

[7] S. Ahmadpour, A.Behrad,and I.F. Vega. Dark Neurons: A protective mechanism or a mode of death. *Journal of Medical Histology*, *3*(2), pp.125-131, 2019

[8] J.B. Brierley, B.S. Meldrum, and A.W. Brown. The threshold and neuropathology of cerebral anoxic-ischemic cell change. *Archives of Neurology*, *29*(6), pp.367-374, 1973

[9] J. Cammermeyer. Is the solitary dark neuron a manifestation of postmortem trauma to the brain inadequately fixed by perfusion?. *Histochemistry*, *56*(2), pp.97-115, 1978

[10] J.S. De Olmos, C.A. Beltramino, and S.D.O. De Lorenzo. Use of an amino-cupric-silver technique for the detection of early and semiacute neuronal degeneration caused by neurotoxicants, hypoxia, and physical trauma. *Neurotoxicology and teratology*, *16*(6), pp.545-561, 1994

[11] F. Gallyas, G. Zoltay and W. Dames. Formation of “dark”(argyrophilic) neurons of various origin proceeds with a common mechanism of biophysical nature (a novel hypothesis). *Acta neuropathologica*, *83*(5), pp.504-509, 1992

[12] F. Gallyas, F.H. Güldner, G. Zoltay and J.R. Wolff. Golgi-like demonstration of “dark” neurons with an argyrophil III method for experimental neuropathology. *Acta neuropathologica*, *79*(6), pp.620-628, 1990

[13] A. Czurkó, and H., Nishino. ‘Collapsed’(argyrophilic, dark) neurons in rat model of transient focal cerebral ischemia. *Neuroscience letters*, *162*(1-2), pp.71-74, 1993

[14], K. Ishida, C. Ungusparkorn, H. Hida, N. Aihara, K. Ida and H. Nishino. Argyrophilic dark neurons distribute with a different pattern in the brain after over hours treadmill running and swimming in the rat. *Neuroscience letters*, *277*(3), pp.149-152, 1999

[15] M.A.E,Mohamed, R.F.,Abdel-Rahman, S.S.,Mahmoud, M.M., Khattab, and M.M., Safar . Metformin and trimetazidine ameliorate diabetes-induced cognitive impediment in status epileptic rats. *Epilepsy & Behavior*, *104*, p.106893, 2020.

[16] M., Rabiei, A., Khorshidi, and J., Soltani-Nabipour. Production of Yttrium-86 radioisotope using genetic algorithm and neural network. *Biomedical Signal Processing and Control*, *66*, p.102449,2021.

[17] Y.Y., Fathy, L.E, Jonkman, J.J., Bol, E., Timmermans, A.J., Jonker, A.J., Rozemuller, and W.D., van de Berg, Axonal degeneration in the anterior insular cortex is associated with Alzheimer’s co-pathology in Parkinson’s disease and dementia with Lewy bodies. *Translational Neurodegeneration*, *11*(1), pp.1-19,2022.

[18] P.,Picone, T., Sanfilippo, R., Guggino, L., Scalisi, R., Monastero, R., Baschi, V., Mandalà, L., San Biagio, M., Rizzo, D., Giacomazza, and C., Dispenza. Neurological consequences, mental health, physical care, and appropriate nutrition in long-COVID-19. *Cellular and Molecular Neurobiology*, pp.1-11, 2022.

[19] M., Aljalal, S., Ibrahim, R., Djemal, and W., Ko. Comprehensive review on brain-controlled mobile robots and robotic arms based on electroencephalography signals. *Intelligent Service Robotics*, *13*(4), pp.539-563, 2020.

[20] E.L., Van Nostrand, G.A., Pratt, B.A., Yee, E.C., Wheeler, S.M., Blue, J., Mueller, S.S., Park, K.E., Garcia, C., Gelboin-Burkhart, T.B., Nguyen, and I., Rabano. Principles of RNA processing from analysis of enhanced CLIP maps for 150 RNA binding proteins. *Genome biology*, *21*(1), pp.1-26, 2020.

[21] J.J., Dowling, C.C., Weihl, and M.J., Spencer. Molecular and cellular basis of genetically inherited skeletal muscle disorders. *Nature Reviews Molecular Cell Biology*, *22*(11), pp.713-732, 2021.

[22] T.S., Tumanova, T.N., Kokurina, G.I., Rybakova, and V.G., Aleksandrov, . Dexamethasone attenuates the modulatory effect of the insular cortex on the baroreflex in anesthetized rat. *Canadian Journal of Physiology and Pharmacology*,

e-ISSN: 2582-7480

100(4), pp.334-340, 2022.

[23] M.N., Yv. Effect of hypoxia on morphofunctional characteristics of brain neurons and molecular markers of ischemic hypoxia. *Вестник Смоленской государственной медицинской академии*, *20*(1), pp.51-57, 2021.