Astrocytes And Microglia In Homeostatic And Pathological Conditions: What Do We Know About Them?

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Abstract

In the last century, many different studies have shown the importance of glial cells in both homeostatic and pathological situations of the CNS. These cells were first described by Rudolf Virchow as a connective tissue that joins the different elements of the Central Nervous System (CNS) together, but in 1870s, neuroglia was distinguished from connective tissue by Camillo Golgi.

Four types of glial cells are classically considered in the adult CNS which are astrocytes, oligodendrocytes, microglial cells and ependymal cells. The following review summarize the role of astrocytes and microglia in CNS homeostatic and pathological conditions.

Materials and Methods

- Scientific literature search on PubMed database: recent papers and reviews of glial cells research were selected according to their quality and data of publication.
- Specialized books and reviews about neuroscience: glial cells and neuroimmunology chapters.
- Attendance to glial cells seminars at Medical Histology Unit (Faculty of Medicine, UAB).

Astrocytes In Homeostatic Conditions: characteristics and functions

- First described by Santiago Ramón y Cajal as a ‘spider-like’ cellular population which expand their processes throughout the CNS.
- Essential component of the blood brain barrier (BBB). These cells can regulate the accessibility of factors and molecules from blood (e.g. glucose via GLUT-1 transporters).
- Astrocytes regulate the maintenance and degeneration of synapses by expressing factors which trigger complement component expression in both microglia and neurons.
- They mediate neurotransmission as they present neurotransmitter receptors in their plasma membrane (e.g. AMPA, NMDA and P2X hemic purinoceptors).

Astrocytes In Pathological Conditions

- Astrocytes of adult rat spinal cord revealed by GFAP immunoreactivity:
  1. Astrocytes in normal unjured spinal cord.
  2. Homologous astrogliosis after injury: the degree of gliosis is characterized by astrogliosis hyperplasia with increased tissue mass.
  3. Anisomorphic astrogliosis after injury: the damaged CNS region is encapsulated and is characterized by interlacing astrogliotic processes making a dense plaque.

Microglia In Homeostatic Conditions: characteristics and functions

- Microglia are the smallest glial cells found in the brain and spinal cord.
- They are resident macrophages in the CNS and can suffer different morphological and functional changes under changes in the CNS microenvironment.
- Types of microglial cells are usually identified by their morphological differences and by their membrane-antigen variations.

Microglia In Pathological Conditions

- After CNS injury, different factors can activate microglial cells.
- One of the major factors which promote microglial cells activation is AQP (P2X receptors).
- Activation of microglial cells results in molecular, functional and morphological changes. All these changes depend on the type of CNS insult produced.
- Figure (A): Microglial cells spectrum of morphological changes after activation (Adapted from Graeber et al. 2011).

Conclusions

This review shows that the classical view of glial cells as “passive elements” into the CNS is not valid anymore. Both astrocytes and microglia actively participate in normal and pathological states of the CNS (e.g. neurotransmission, synapses remodeling, etc.). After injury, these cells have demonstrated to regulate the control and monitor the consequent response. Glial response is not always a harmful process as glial cells mediate the immune response in order to minimize possible damage in the CNS. Although many different aspects of the biology of these cells remain unknown, the crucial role that these cells play in CNS pathological process make them an interesting research area in order to develop new therapeutic targets for prevalent diseases such as Alzheimer disease, Parkinson disease or CNS trauma.

References

- Only relevant references are cited below. A detailed references list is available upon request for the committee: