Chapter 8
Astrocytes Functions and Their Involvement in Brain Injury:
A Focus on the Biomaterials' Role in Mitigating Traumatic Brain Injury

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ABSTRACT

Brain injury is damage to the brain caused by external forces. They are the leading cause of death and ill health in young men, with a high incidence worldwide. Glial cells make up the majority of central nervous system cells and play a key role in the brain's response to brain injury. Astrocytes play a crucial role in maintaining the brain's ionic and water balance, energy metabolism, regulation of the blood-brain barrier and immune response. In response to brain injury, astrocytes undergo morphological and behavioral changes that modify their protein expression. To sustain astrocytic responses in certain severe

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situations, therapeutic strategies that make use of biomaterials represent a significant advance in the field of regenerative medicine, as they create a microenvironment more conducive to nerve tissue regeneration. This chapter examines the behavior and responses of astrocytes to brain injury in the context of traumatic brain injury (TBI), as well as looking at the implication of biomaterials in the treatment of TBI.

INTRODUCTION

Restoring neural tissue after damage caused by injury or disease remains a complex challenge that has yet to be resolved. Traumatic brain injury (TBI) is responsible for a significant number of deaths and disabilities worldwide, usually occurring as a result of an external mechanical force such as a road traffic accident, armed conflict, object penetration, explosion, among others (Blennow et al., 2016). TBI can be categorised as mild, moderate or severe based on clinical indicators such as state of consciousness, presence of amnesia, and other neurological symptoms (Blennow et al., 2016). Currently, it is generally recognised that repeated head trauma can lead to long-term effects, including the risk of accumulating neurodegenerative diseases such as Parkinson's disease, Alzheimer's disease (AD), chronic traumatic encephalopathy (CTE), among others (Kamins and Giza, 2016).

In the central nervous system (CNS), glial cells occupy more than half of the brain volume compared with neurons (Jessen, 2004). Several types of glial cells can be identified, including astrocytes, microglia, oligodendrocytes and oligodendrocyte progenitor cells (Peters, 2004). Astrocytes play a crucial role as response cells to disease and injury in the CNS. Astrocytes can detect lesions caused by head trauma and react by becoming reactive astrocytes, thus participating in damage and repair processes through their interactions with other cell types (Michinaga and Koyama, 2021; Vainchtein and Molofsky, 2020). TBI not only affects neuronal function but also disrupts brain function. The significant presence of neuroinflammation observed in TBI, as well as the demyelination of white matter pathways, highlights the essential role of glial cells in these traumatic brain injuries. Sometimes, astrocytes require assistance and support to cope with brain trauma. Scaffolds made from biomaterials can also be supported in the damaged region of the brain to facilitate and support the action of glial cells in creating an environment conducive to nerve regeneration (Gopalakrishnan et al., 2019). In this context, this chapter will look at astrocyte behavior and function in the context of brain injury as well as in the subsequent repair phase. We also examine the use of biomaterials to provide support to astrocytes in the treatment of these injuries.

ROLE OF ASTROCYTES IN BRAIN HEALTH

Astrocytes are a type of glial cell in the CNS that play a crucial role in maintaining brain health and supporting the function of neurons. They are highly versatile and perform a wide range of functions to ensure the proper functioning of the brain (Jessen, 2004). Here are some of the key functions of astrocytes:

1. Neurotransmitter Regulation

One of the important functions of astrocytes is the regulation of neurotransmitter levels in the brain (Kim et al., 2019). Neurotransmitters are chemicals that transmit signals between neurons, and astrocytes