Chapter 20
Chitosan Polysaccharides: Modulation of Neuroinflammation

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ABSTRACT

Neuroinflammation is a complex, well-orchestrated process involving various groups of CNS glial cells and immune cells. Glial cells play a remarkable structural and functional role in the nervous system compared to neurons. However, neuroinflammation at the central level is a key player in various neurological disorders, including neurodegenerative diseases and CNS lesions. Therapeutic approaches to combat human neurodegenerative diseases must therefore restore neuronal and glial cell function. Natural resources are a source of potential therapeutic molecules for the treatment of neurodegenerative diseases. Currently, chitosan and its derivatives from arthropod exoskeletons are endowed with powerful anti-neuroinflammatory properties, as well as the ability to transport therapeutic substances across the BBB. This chapter discusses possible therapeutic options, the mechanism and role of chitosan in alleviating neuroinflammation at the central level, and the resulting diseases, in particular glial cell disorders.

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INTRODUCTION

Neuroinflammation is a feature of the central nervous system (CNS), shared by a range of disorders, spanning from acute injury to neurodegenerative diseases and neuropsychiatric conditions. These neuro-inflammatory disorders and their consequences contribute substantially to the global burden of morbidity and mortality, with remarkable economic repercussions on healthcare expenditure (Aarli et al., 2014).

While classical inflammation is a beneficial tissue repair response, prolonged or inappropriate inflammation can aggravate or even cause the death of neighboring neuronal and glial cells (Neher et al., 2012), (Brown & Vilalta, 2015). In the CNS, glial cells provide essential support and regulate the activity of neurons, which form the main signal transmission pathways in the nervous system. Ultimately, pathological neuroinflammation leads to the deterioration of axons and their supporting cells. In the presence of a localized lesion, microglial cells signal astrocytes to create a glial scar, causing them to differentiate, migrate, multiply and secrete carbohydrate-based fibrous matrices (Sabelström et al., 2013) (Meletis et al., 2008). This creates a physical and chemical barrier that isolates the lesion, hindering axon regeneration (Fehlings & Tighe, 2008). Microglia and astrocytes often dominate the environment within inflammation, creating cytotoxic conditions conducive to neuronal death. This dynamic leads to the loss of adjacent biological circuits, resulting in neuronal and cognitive disorders (Tsui et al., 2019).

Despite current treatments aimed at alleviating the specific symptoms of certain disorders, no cure is currently available for neuro-inflammatory conditions. Although the cause, pathology and symptoms of these disorders differ considerably, they all share a central inflammatory component. On the basis of neuroprotective mechanisms, several neuroprotective agents can be used to tackle neuroinflammation and the neurological disorders that result (Pellicciari et al.,1998), (K. Chandrasekaran, 2003) such as antioxidants (Pellicciari et al., 1998), (Behl & Moosmann, 2002) and agents with anti-inflammatory effects (Agnello et al., 2002), (Gao et al., 2003). However, one of the major challenges in the treatment of neurological disorders and neurodegenerative diseases lies in the fact that some drugs do not cross the blood-brain barrier (BBB) to reach brain tissue (Gao, 2017).

Consequently, it is very important to develop new drugs and approaches that have both anti-inflammatory properties and can easily cross the BBB to target these disorders. As a source of potential therapeutic molecules, bioresources have not received much attention in the treatment of neurodegenerative diseases, although they can play an important role. For example, the marine environment is known for its nooks and crannies in the structures of bioactive compounds with promising neuroprotective biological activities (Alonso et al., 2005). Currently, chitosan (CTS) and its derivatives as plausible molecules with powerful biological and therapeutic features to target neurodegenerative disorders are well documented in several studies (Hao et al., 2017; Hamdan et al., 2023). This chapter reviews recent advances in the use and applications of CTS and its derivatives for the modulation of central neuroinflammation and the prevention of neurological and neurodegenerative disorders. It will focus on the mechanisms and role of these marine derivatives in combination with other molecules for therapeutic use, forming effective preventive and curative approaches.

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