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Recent advances in nanomaterial-based brain-targeted delivery systems for glioblastoma therapy

Mingyue Qu [1 2], Quan Wang [3], Xinying Wang [1], Jie Tang [1], Xiyao Dong [1], Chaoyue Zhao [1], Qingxiang Guan [1]

Affiliations

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Abstract

Glioblastoma (GBM) poses a formidable challenge because of its high morbidity and mortality. The therapeutic efficacy of GBM is significantly hampered by the intricate blood-brain barrier (BBB) and blood-brain tumor barrier (BBTB). Nanomaterial-based brain-targeted delivery systems have shown great potential for effectively delivering therapeutic agents for GBM treatment by overcoming the limitations of conventional drugs, such as poor BBB penetration, a short half-life, and low bioavailability. This review focuses on an in-depth analysis of the interplay between the BBB/BBTB and drug transport kinetics while analyzing innovative nanoparticle-mediated strategies for enhanced GBM treatment. Moreover, the delivery strategies of nanoparticle-based brain-targeted systems are emphasized, with particular attention given to biomimetic nanoparticles (BMNPs), whose unique advantages. The current challenges, translational potential, and future research directions in this rapidly evolving field are comprehensively discussed, highlighting advances in nanomaterial applications. This review aims to stimulate further research into GBM delivery systems, offering promising avenues for maximizing the therapeutic effects of gene drugs or chemotherapeutic agents in practical applications.

Keywords: Nanomaterials; biomimetic nanoparticles; blood-brain barrier; blood-brain tumor barrier; brain-targeted drug delivery systems; glioblastoma.