

Review

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Transforming brain cancer therapeutics: unlocking the power of blood-brain barrier-targeting strategies for superior treatment outcomes and precision medicine

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Abstract

The treatment of brain tumors is significantly hindered by the Blood-Brain Barrier (BBB), a selective barrier that restricts the passage of therapeutic agents to the brain. Recent advancements in BBB-targeting therapies offer promising strategies to overcome this challenge, providing new avenues for the effective treatment of brain cancer. This article reviews innovative approaches, including Convection-Enhanced Delivery (CED) and RNA-based therapeutics, which enhance drug delivery directly to tumor sites, bypassing the BBB and reducing systemic toxicity. Additionally, the use of theranostic nanoparticles and CRISPR-Cas9 gene editing presents novel opportunities for real-time monitoring and precision-targeted therapy, respectively. Techniques such as magnetic nanoparticles, intranasal drug administration, and focused ultrasound with microbubbles are also being refined to improve drug penetration across the BBB. Furthermore, peptide-based delivery systems and small molecules designed to mimic endogenous transport pathways are accelerating the discovery of more effective therapies. The exploration of combination therapies that synergize BBB-penetrant drugs with conventional chemotherapeutic agents or immunotherapies holds the potential to enhance treatment efficacy and patient outcomes. Continued research and interdisciplinary collaboration are essential to develop predictive models, personalized treatment strategies, and alternative delivery methods that ensure the long-term safety and effectiveness of these novel therapies. Advancements in BBB-targeting therapeutics are poised to transform the landscape of brain cancer treatment, offering renewed hope for improved survival rates and quality of life for patients.

Keywords: Blood-brain barrier (BBB); Brain tumors; Drug delivery; RNA-based therapeutics..

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