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Neuroprotective Strategies during Radiation and Chemotherapy for Brain Tumors

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INTRODUCTION

Brain tumors, among the most challenging malignancies to treat, often require aggressive therapies such as radiation and chemotherapy. While these modalities are essential for controlling tumor growth, they also pose significant risks to healthy brain tissue, leading to neurocognitive decline, fatigue, and long-term neurological complications. Neuroprotection, aimed at preserving healthy neural structures and functions during treatment, has become a critical focus in improving the quality of life for brain tumor patients. Emerging strategies, from advanced delivery techniques to pharmacological interventions, offer promising avenues to mitigate these adverse effects. Radiation therapy, while effective at targeting tumor cells, often affects surrounding healthy brain tissue. Memory, attention, and executive function can be impaired due to damage to the hippocampus and other critical regions. Radiation can disrupt the integrity of white matter tracts, leading to long-term neurological deficits. Pro-inflammatory cytokines released during treatment exacerbate damage to the brain's microenvironment. Certain chemotherapeutic agents, such as temozolomide, can cross the Blood-Brain Barrier (BBB), affecting both tumor and normal brain cells. Side effects include "chemo brain," characterized by impaired cognition, and cumulative neurotoxic effects with prolonged treatment.

DESCRIPTION

Proton Beam Therapy (PBT) delivers radiation more precisely, reducing exposure to surrounding healthy tissues and minimizing neurotoxic effects. Stereotactic Radio Surgery (SRS) high-dose radiation is focused on the tumor with sub-millimeter accuracy, sparing adjacent healthy brain regions. Intensity-Modulated Radiation Therapy (IMRT) adjusts radiation dose delivery to conform closely to the tumor's shape, preserving critical structures like the hippocampus. Medications such as memantine, an NMDA receptor antagonist, have shown efficacy in reducing cognitive decline during and after radiation therapy. Dexamethasone and other corticosteroids mitigate neuro inflammation, although long-term use must be carefully managed due to side effects. Agents that promote neuronal growth and repair, such as erythropoietin, are being investigated for their neuroprotective potential. Advances in BBB modulation allow for targeted delivery of chemotherapy to tumors while protecting healthy brain tissue. Techniques such as focused ultrasound and nanoparticle-based drug delivery are promising. Emerging radiotherapy approaches specifically aim to spare the hippocampus, a region vital for memory and learning. Studies have demonstrated reduced cognitive decline with these techniques without compromising tumor control. Foods rich in antioxidants, such as berries and green leafy vegetables, combat oxidative stress induced by treatments. Regular physical activity improves neuroplasticity and reduces fatigue and cognitive impairment associated with therapy. Post-treatment neuro rehabilitation, including cognitive exercises and memory training, helps restore lost functions and improves patients' quality of life. Immunotherapies, including immune checkpoint inhibitors and CAR T-cell therapy, have the potential to target tumors with fewer off-target effects compared to traditional treatments. Combining these with neuroprotective strategies may enhance outcomes. AI models are being developed to predict individual patient responses to therapy, enabling personalized neuroprotective strategies tailored to minimize neurotoxicity while maintaining treatment efficacy [1-4].

CONCLUSION

The evolution of neuroprotective strategies during radiation and

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chemotherapy marks a significant step forward in brain tumor care. By integrating advanced technologies, pharmacological agents, and lifestyle modifications, it is possible to mitigate the neurotoxic effects of treatment and enhance patients' overall well-being. The ultimate goal is a holistic approach that not only extends survival but also ensures a better quality of life for brain tumor patients, making neuroprotection an indispensable aspect of modern oncology. Protecting healthy brain tissue without compromising tumor control requires precise calibration of interventions. Advanced therapies like proton beam therapy remain expensive and are not widely available. Incorporating new strategies into established treatment regimens requires rigorous clinical validation. Research should prioritize long-term studies to evaluate the effectiveness of neuroprotective interventions and their impact on survival and quality of life.

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CONFLICT OF INTEREST

The author declares there is no conflict of interest in publishing this article.

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