Review Clin Transl Oncol. 2025 Apr 14. doi: 10.1007/s12094-025-03909-x.

Online ahead of print.

The therapeutic efficacy and application prospects of tumor-treating fields (TTFields) in resolving malignant tumors of central nervous system

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Affiliations PMID: 40227534 DOI: 10.1007/s12094-025-03909-x

Abstract

Purpose: Malignancies in the central nervous system (CNS) are among the most prevalent and lethal tumors. Tumor treating fields (TTFields), a physical therapeutic strategy, show significant potential in treating CNS tumors by inducing cell apoptosis, cell-cycle arrest, immune activation, and enhancing anti-PD-1 therapy efficacy. Additionally, TTFields can increase blood-brain barrier (BBB) permeability, further supporting their application in CNS malignancies. This review aims to summarize the advances and mechanisms of TTFields in CNS tumor treatment while addressing its current limitations and challenges.

Methods: We reviewed existing literature on TTFields, focusing on their effects on glioma and brain metastasis (BM)-related primary tumors. The mechanisms investigated included mitosis and cell cycle interference, inhibition of cell migration and invasion, promotion of apoptosis and protective autophagy, activation of immunogenic cell death (ICD) and immune responses, and modulation of BBB permeability.

Results: TTFields demonstrate inhibitory effects on CNS malignancies, particularly in glioma. They also suppress brain metastasis from primary tumors such as lung cancer, breast cancer, melanoma, and colorectal cancer. Mechanistically, TTFields act through multiple pathways, including disrupting mitosis, impeding cell migration and invasion, enhancing apoptosis and autophagy, activating immune responses, and increasing BBB permeability.

Conclusion: TTFields exhibit therapeutic potential in CNS malignancies, especially glioblastoma (GBM), through diverse biological mechanisms. Their ability to enhance BBB permeability and target metastatic tumors suggests promise for broader clinical applications, including brain metastasis treatment.

Keywords: Biological mechanisms; Central nervous system (CNS); Clinic application; Malignant tumors; Tumor-treating fields (TTFields).

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