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Sonodynamic therapy for adult-type diffuse gliomas: past, present, and future

Sydney E Scanlon¹, Regan M Shanahan¹, Othman Bin-Alamer¹, Alexandros Bouras¹, Milena Mattioli¹, Sakibul Huq¹, Constantinos G Hadjipanayis²

Affiliations

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Abstract

Background: Intra-axial brain tumors persist as significant clinical challenges. Aggressive surgical resection carries risk of morbidity, and the blood-brain barrier (BBB) prevents optimal pharmacological interventions. There is a clear clinical demand for innovative and less invasive therapeutic strategies for patients, especially those that can augment established treatment protocols. Focused ultrasound (FUS) has emerged as a promising approach to manage brain tumors. Sonodynamic therapy (SDT), a subset of FUS, utilizes sonosensitizers activated by ultrasound waves to generate reactive oxygen species (ROS) and induce tumor cell death.

Objective: This review explores the historical evolution and rationale behind SDT, focusing on its mechanisms of action and potential applications in brain tumor management.

Method: A systematic review was conducted using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Results: Preclinical studies have demonstrated the efficacy of various sonosensitizers, including 5-aminolevulinic acid (5-ALA), fluorescein, porphyrin derivatives, and nanoparticles, in conjunction with FUS for targeted tumor therapy and BBB disruption. Clinical trials have shown promising results in terms of safety and efficacy, although further research is needed to fully understand the potential adverse effects and optimize treatment protocols. Challenges such as skull thickness affecting FUS penetration, and the kinetics of BBB opening require careful consideration for the successful implementation of SDT in clinical practice. Future directions include comparative studies of different sonosensitizers, optimization of FUS parameters, and exploration of SDT's immunomodulatory effects.

Conclusion: SDT represents a promising frontier in the treatment of aggressive brain tumors, offering hope for improved patient outcomes.

Keywords: Brain tumor; Clinical trial; Focused ultrasound; Glioma; Sonodynamic therapy.

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