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Bacterial and bacterial derivatives-based drug delivery systems: a novel approach for treating central nervous system disorders

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Abstract

Introduction: Bacteria and their derivatives show great potential as drug delivery systems due to their unique chemotaxis, biocompatibility, and targeting abilities. In CNS disease treatment, bacterial carriers can cross the blood-brain barrier (BBB) and deliver drugs precisely, overcoming limitations of traditional methods. Advances in genetic engineering, synthetic biology, and nanotechnology have transformed these systems into multifunctional platforms for personalized CNS treatment.

Areas covered: This review examines the latest research on bacterial carriers for treating ischemic brain injury, neurodegenerative diseases, and gliomas. Bacteria efficiently cross the blood-brain barrier via active targeting, endocytosis, paracellular transport, and the nose-to-brain route for precise drug delivery. Various bacterial drug delivery systems, such as OMVs and bacterial ghosts, are explored for their design and application. Databases were searched in Google Scholar for the period up to December 2024.

Expert opinion: Future developments in bacterial drug delivery will rely on AI-driven design and high-throughput engineering, enhancing treatment precision. Personalized medicine will further optimize bacterial carriers for individual patients, but challenges such as biosafety, immune rejection, and scalability must be addressed. As multimodal diagnostic and therapeutic strategies advance, bacterial carriers are expected to play a central role in CNS disease treatment, offering novel precision medicine solutions.

Keywords: Bacteria-mediated drug delivery; Brain-targeted delivery; Chemotaxis; smart drug delivery system; targeting mechanisms.