Utilizing Magnetic Nanoparticles in Cancer Theranostics: Focus on Glioblastoma Multiforme

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Introduction: Due to the complications associated with traditional cancer treatments, there is an increasing need for new therapeutic approaches. Magnetic nanoparticles (MNPs) represent one of these emerging methods. MNPs, which are nanosized particles ranging from 1 to 100 nanometers, consist of mainly of a magnetic core, a stabilizer coating, and targeting agents [Figure 1]. Recent advancements have emphasized targeted delivery methods, where therapeutic agents are carried by MNPs, offering promising potential for overcoming the side effects of traditional treatments. Glioblastoma multiforme (GBM) represents approximately 50% of central nervous system (CNS) tumors and has a poor prognosis, with a 5-year survival rate of only 7.2%. The tumor's high recurrence rate necessitates a combination of chemotherapy, radiation therapy, and surgery. Surgery is crucial for removing the tumor as safely as possible, but due to the infiltrative nature of GBM, it is challenging to distinguish tumor tissue from healthy brain tissue, creating significant treatment complications.

Methods: A comprehensive literature review was performed to gather and analyze the current state of magnetic nanoparticles (MNPs) and their utilization for the theranostics of GBM. The review includes a total of 52 peer-reviewed studies published between 2004 and 2024. The sources were selected based on their relevance to the applications of MNPs in GBM, focusing on drug delivery systems, magnetic hyperthermia, MRI contrast enhancement, and theranostic approaches.

Results: MNPs carry potential for cancer theranostic techniques, which combine therapy and diagnosis. In the case of glioblastoma multiforme (GBM), one of the most aggressive and infiltrative brain tumors, MNPs are employed in approaches such as hyperthermia and drug targeting. Magnetic fluid hyperthermia (MFH), in particular, offers potential for precise treatment of GBM [Figure 2].

Conclusion: MNPs, particularly when used in MFH, hold promise for improving the precision of treatments for glioblastoma multiforme. By targeting tumor cells more effectively, MNPs may help overcome the limitations of current therapeutic strategies and improve patient outcomes.

Figures

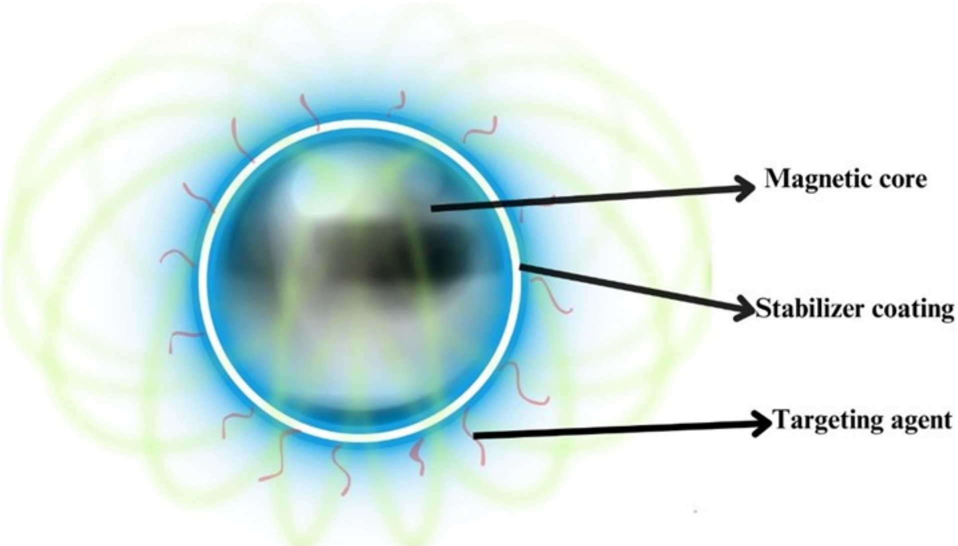

Figure 1. Configuration of functionalized MNP for clinical applications that nanoparticles are conjugated with therapeutic agents for target tissue (Flores-Rojas et al., 2022).

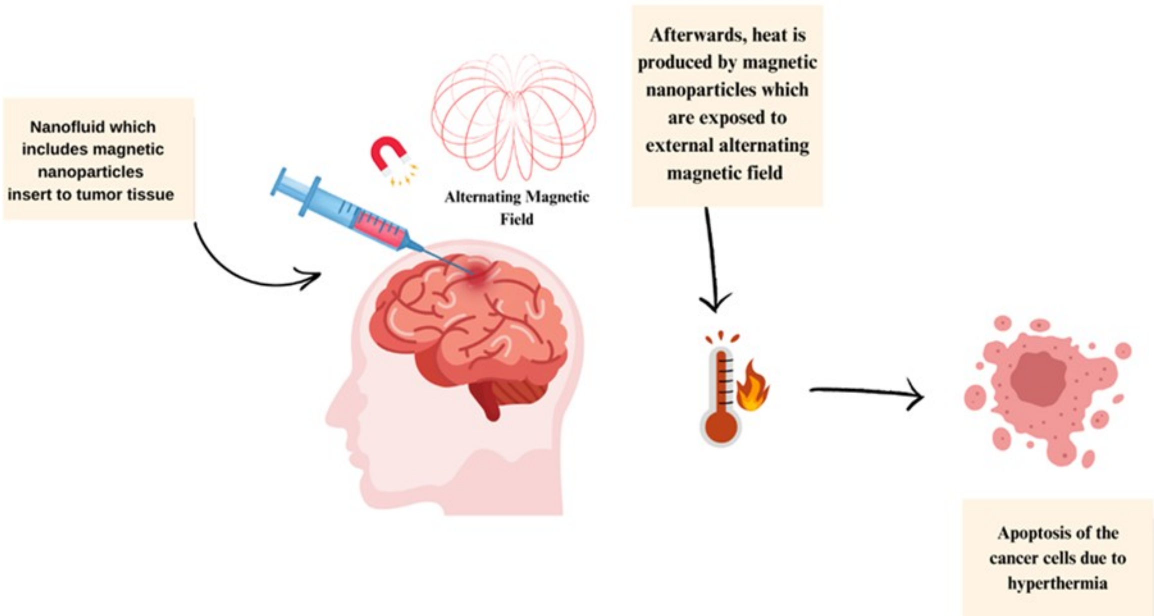

Figure 2. MFH is applied to target tumor tissue promotes apoptosis in cancer cells because of high temperature (Mofrad et al., 2024).