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Impact of bioinspired nanotechnology on brain diseases amelioration

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Abstract

Brain maladies are most complicated to cure due to the blood-brain barrier (BBB) selective nature. Nanotechnology has great potential to transpass the BBB and efficiently target the diseased or neoplastic cells within brain milieu. The bioinspired nanomedicine approach to brain diseases is more reliable and inert without autoimmune reactions. Moreover, the BBB is more amenable to biomimetic nanomedicine than exogenic one. Although nanotechnology is at initial stages to cure brain diseases, still their natural analogy to cell architecture makes them more suitable for biomedicine and may get access to clinical practice in near future.

Outlook

The central nervous system (CNS) physiology is unique from the rest of our body systems. The CNS is comprised of the brain and spinal cord. The peripheral nerves and CNS are protected by a specialized type of physiological barrier composed of non-fenestrated endothelial cells, basal membrane, and podocytes of astrocytes that are collectively called as blood-brain barrier (BBB) [1]. The BBB has a promising role in the maintenance of cerebral homeostasis and selective amenability to certain molecules, i.e., molecules having a size less than 400 Da or nine hydrogen bonding, or essential molecules viz glucose, alcohol, carbon dioxide (CO_2), and Oxygen (O_2,) etc., can readily pass the BBB [2] In addition to CNS homeostasis, BBB also protects it from potentially harmful molecules and substances, making its role more crucial in terms of brain ailments amelioration.

Overall, only a subtle amount of the available drugs can pass the BBB i.e. ~ 2%, [3] among them, only few drugs are efficient in the correction of various brain ailments, including Parkinson's Disease (PD), Alzheimer Diseases (AD), Multiple sclerosis and cancer, etc. For instance, Temozolomide is the only FDA approved drug for glioblastoma treatment. However, its compromised bioavailability (~50 %) and frequent drug resistance development have limited its potential in the cure of brain cancer. Moreover, the treatment of glioblastoma can merely add several months to post-diagnosis median survival of patients.

All the limitations mentioned above provide room for alternative and unorthodox approaches to cure brain maladies and advanced healthcare modalities to achieve the desired goals. From the last two decades, the nanotechnology implementation in biomedicine has improved the patient quality of life and increased the efficacy rate by efficiently targeting desired tissue to achieve therapeutic concentration, lowering adverse effects, inertness to vital organs, increasing drug plasma half-life and higher biocompatibility. Currently, liposome-based nanomedicines have efficiently been translated from bench to bedside and available in pharmacies to treat cancer and other diseases, more efficiently than free drugs itself, e.g., doxorubicin containing preparations named as Myocet, Doxil, Lipodox, etc. and daunorubicin containing drugs with the trade name of DaunoXome, and Irinotecan containing nanomedicine having trade name of Onivyde, whereas Rexin-G® is the nanoscale preparation of gene therapy for tumor resection. Moreover, the commercially available nanoparticles of paclitaxel are Paclitax NAB. Moreover, previously the metal nanoparticles having trade names of Endoterm™, Resovist®, Sinerem™, etc. have been employed in MRI as contrast agents [4, 5]. Likewise, NanoTherm® has been employed as an anticancer agent [6], whereas Feraheme® for iron deficiency treatment[7]. Similarly, Rapamune® is the trade name of a nanocrystalline drug aimed to prevent organ rejection after transplant.

The nanomedicine preparations are comprised of pH-responsive nano-drug delivery system [8, 9], nanosomes, and exosomes loaded with therapeutic drugs or RNAi[10, 11] and cell membrane camouflaged nanoparticles that can efficiently deliver the medications to brain milieu and selectively target diseased cells therein[12]. Although most of the nanotechnology-based brain disease treatments are at initial stages of clinical trials, still their results are promising and may be available soon for clinical applications.

In the recent past, the findings of Alvarez et al. provided an unprecedented avenue in the brain diseases theranostics by employing exosomes to deliver RNAi to the brain and ameliorate the AD. They reported a 62 % lowering of the BACS1 protein known as crucial for AD progression [13]. These results introduced exosomes as a more reliable nano-drug delivery system with biogenic nature [14] that provided bases for their extension to other diseases, including cardiovascular, musculoskeletal, excretory system, and cancer, etc. Likewise, the other bioinspired nanomedicine viz RBC membrane camouflaged nanoparticles have been repeated with excellent BBB crossing ability to ablate glioblastoma. Some other studies also reported the RBC and cancer cell membrane hybridized nanoscale spheroids to more efficiently target the glioblastoma tissue within brain milieu. Also, the whole-cell (stem cells therapy) and their engineered nanosomes or spheroids have been reported with excellent therapeutic efficacy in brain ailments.

Recently, another approach for glioblastoma treatment by implanting satellite engineered biodegradable wafers loaded with therapeutic agents in the brain tissue that, on the one hand, bypassed the BBB and, on the other hand, could control the drug release for successful resection of glioblastoma [15]. The irradiation after injection of nanomedicine to the animal model has also been reported with successful glioblastoma resection. The irradiation could open the BBB and successful drug accumulation within the glioblastoma was achieved that further mimicked initiated the cancer immunotherapy [16].

In summary, the applications of nanotechnology as a whole and biomimetic or bioinspired nanomedicine approach in particular for the brain aliments amelioration is plausible. The bioinspired nanomedicine is of biogenic origin, biocompatible, and having higher BBB amenability. In the future, they may gain closer attention of the biomedicine community and may get swiftly through clinical trials for patients' availability.

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References

[1] Abbott NJ, Rönnbäck L, Hansson E. Astrocyte–endothelial interactions at the blood–brain barrier. Nature reviews neuroscience. 2006;7:41.

[2] Furtado D, Björnmalm M, Ayton S, Bush AI, Kempe K, Caruso F. Overcoming the blood–brain barrier: the role of nanomaterials in treating neurological diseases. Advanced Materials. 2018;30:1801362.

[3] Mitragotri S. Devices for overcoming biological barriers: the use of physical forces to disrupt the barriers. Advanced drug delivery reviews. 2013;65:100-3.

[4] Wang Y-XJ, Hussain SM, Krestin GP. Superparamagnetic iron oxide contrast agents: physicochemical characteristics and applications in MR imaging. European radiology. 2001;11:2319-31.

[5] Schäfer R, Bantleon R, Kehlbach R, Siegel G, Wiskirchen J, Wolburg H, et al. Functional investigations on human mesenchymal stem cells exposed to magnetic fields and labeled with clinically approved iron nanoparticles. BMC cell biology. 2010;11:22.

[6] Taylor A, Wilson KM, Murray P, Fernig DG, Lévy R. Long-term tracking of cells using inorganic nanoparticles as contrast agents: are we there yet? Chemical Society Reviews. 2012;41:2707-17.

[7] Macdougall IC. Evolution of iv iron compounds over the last century. Journal of renal care. 2009;35:8-13.

[8] Wei X, Chen X, Ying M, Lu W. Brain tumor-targeted drug delivery strategies. Acta pharmaceutica sinica B. 2014;4:193-201.

[9] Zheng M, Liu Y, Wang Y, Zhang D, Zou Y, Ruan W, et al. ROS-Responsive Polymeric siRNA Nanomedicine Stabilized by Triple Interactions for the Robust Glioblastoma Combinational RNAi Therapy. Advanced Materials. 2019;31:1903277.

[10] Riazifar M, Mohammadi MR, Pone EJ, Yeri A, Lässer C, Segaliny AI, et al. Stem cell-derived exosomes as nanotherapeutics for autoimmune and neurodegenerative disorders. ACS nano. 2019;13:6670-88.

[11] Jia G, Han Y, An Y, Ding Y, He C, Wang X, et al. NRP-1 targeted and cargo-loaded exosomes facilitate simultaneous imaging and therapy of glioma in vitro and in vivo. Biomaterials. 2018;178:302-16.

[12] Zou Y, Liu Y, Yang Z, Zhang D, Lu Y, Zheng M, et al. Effective and targeted human orthotopic glioblastoma xenograft therapy via a multifunctional biomimetic nanomedicine. Advanced Materials. 2018;30:1803717.

[13] Alvarez-Erviti L, Seow Y, Yin H, Betts C, Lakhal S, Wood MJ. Delivery of siRNA to the mouse brain by systemic injection of targeted exosomes. Nature biotechnology. 2011;29:341-5.

[14] Zhu Q, Ling X, Yang Y, Zhang J, Li Q, Niu X, et al. Embryonic Stem Cells-Derived Exosomes Endowed with Targeting Properties as Chemotherapeutics Delivery Vehicles for Glioblastoma Therapy. Advanced Science. 2019;6:1801899.

[15] Lee J, Cho HR, Cha GD, Seo H, Lee S, Park C-K, et al. Flexible, sticky, and biodegradable wireless device for drug delivery to brain tumors. Nature communications. 2019;10:1-9.

[16] Erel-Akbaba G, Carvalho LA, Tian T, Zinter M, Akbaba H, Obeid PJ, et al. Radiation-induced targeted nanoparticle-based gene delivery for brain tumor therapy. ACS nano. 2019;13:4028-40.