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Nanoparticles: improving the efficiency of drug administration across the blood-brain barrier

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Introduction

Nanoparticle or nanotechnology-based drug administration is analyzed by researchers for the potential opportunities and benefits they offer in drug delivery[1-3]. Nanoparticle guided drug delivery can cross the blood-brain barrier. Drug delivery across the blood-brain barrier was a challenging factor before. Drugs either delivered continuously over time ends up accumulating in the patient resulting in toxicity effects, like cytotoxicity in the case of a chemotherapeutic agent[4-10]. In other situations, the challenge of the blood-brain barrier could result in lowered efficacy of treatment.

In the treatment of psychosis, physicians lack precise knowledge of how the underlying mechanism of psychosis is caused or triggered. In this very fragile stage, very proper and controlled delivery of antipsychotics is believed to improve the psychotic state of the patient. This adequate and controlled delivery is possible with the use of nanoparticles, the size of 1-500 nm. At this size, they are capable of crossing the biological barriers like the blood-brain barrier. Sun et al.[11] identified in their research on antipsychotics that nanoparticle constructed from different polymers, dendrimers, solid-lipids, peptides and more can cross not only the blood-brain barrier but also offer provisions for more efficient release of the drug[12-15]. In the case of antipsychotic medication delivery, Sun et al.[7] identified that the hydrophobicity of antipsychotics had a negative effect. The antipsychotics by themselves pass through the BBB, but then they move too soon. The patients to whom the drug has been administered are not able to absorb the drugs and hence do not get relief from their condition[16-21]. In this context, nanoparticle drug delivery facilitates a more controlled release. In particular, the use of nanoparticle technology will release in slow release of the drugs. The nanoparticles encapsulate the drugs and enable this sluggish release behavior.

Kang et al.[8,22] argue that this very size and characteristics of the nanoparticle that renders it the capability to cross the blood-brain barrier is what makes it an ideal candidate for drug delivery in the case of malignant brain tumors. In malignant brain tumors like that of glioblastoma, the debulking surgery has to be followed up with targeted drug delivery[22-25]. Most chemotherapeutic drugs cannot cross the blood-brain barrier and end up accumulating, resulting in cytotoxicity. Nanoparticles offer high potential for targeted drug delivery. This is attributed to its capability to cross the blood-brain barrier. Sun et al. also show how the drugs will also be able to pass through complex tumor microvasculature, and this also holds many treatment benefits for psychosis conditions that are triggered because of the growth of a tumor[11,26,27].

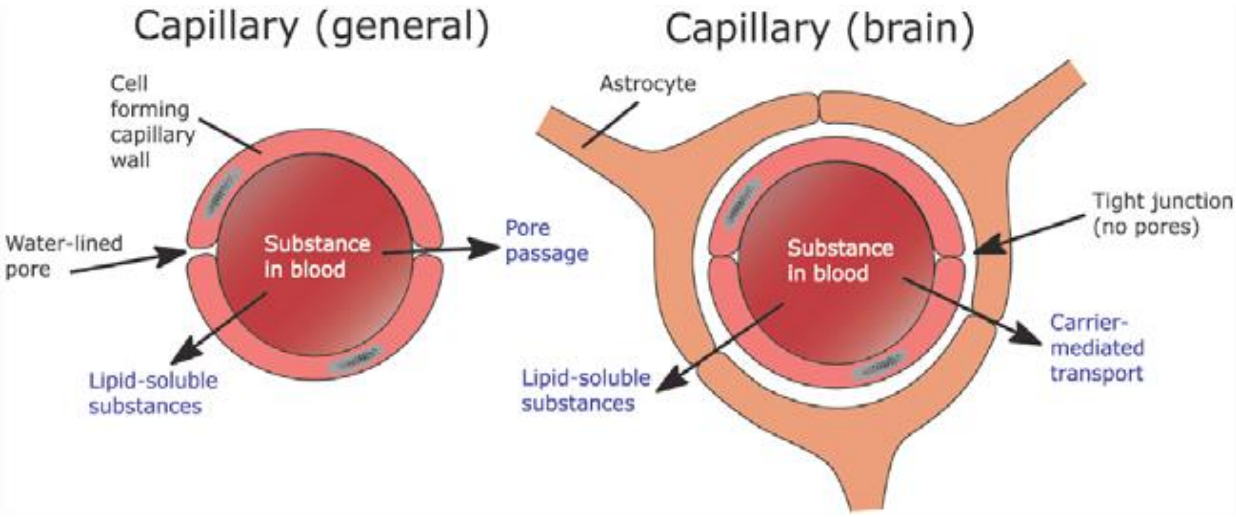

Figure 1: Capillary structure, the general capillary structure and the capillary structure of the brain is presented here. Different transportation mechanisms can be observed in the brand capillary and the general capillary[8].

Sun et al.[4] also argued that this feature of nanoparticles could also help reduce multidrug resistance. The research work was carried out to analyze two co-delivery aspects. The first was co-delivery of chemotherapeutics with MDR inhibitors, and the second was co-delivery of chemotherapeutics with sensitizers[28-31]. When therapeutic nanoparticles containing a combination of cytotoxic drugs are used with efflux pumps inhibitors, there is better potential to suppress MDR. Similarly, MDR alterations caused by the apoptosis pathways are handled better when sensitizer compounds are used with nanoparticle drug delivery method. Both these methods of co-delivery with re-sensitizations by either MDR inhibitor or by modulation of siRNA are observed to be effective[32-36]. As Sun et al.[33] identified, an enhanced permeability effect is observed when nanoparticles are used for drug delivery. The leakier nature of the tumor vasculature has led to the drug being dispersed outside the cells affecting cells other than the tumor cells. However, nanotechnology allows for higher intercellular toxicity that is effective against cancer cells.

The review sought to understand how nanoparticles are improving the efficiency of drug administration across the blood-brain barrier. Researchers identified the use of nanotechnology-based drug administration as being efficient for drug delivery across the blood-brain barrier. Firstly, in complex tumor vasculatures, drug delivery is affected. Secondly, when drug targeting tumors cross the blood-brain barrier effectively, they will have a better chance of being retained within the cells thus effectively targeting cancer. Thirdly, this would reduce the cytotoxicity and associated MDR effects of chemotherapeutic drug deliveries. Finally, in the case of antipsychotics, it is also possible to cause a slow release of a drug.

References

1. Kang, C., Qin, J., Osei, W. & Hu, K. Age-dependent Mitochondrial Targeting Of Protein Kinase C Epsilon In Cardioprotection. *The FASEB Journal* (2017).
2. Han, R., Sun, Y., Kang, C., Sun, H. & Wei, W. Amphiphilic dendritic nanomicelle-mediated co-delivery of 5-fluorouracil and doxorubicin for enhanced therapeutic efficacy. *Journal of Drug Targeting* **25**, 140-148 (2017).
3. Yan, G., *et al.* Application of Real-Time Cell Electronic Analysis System in Modern Pharmaceutical Evaluation and Analysis. *Molecules* **23**, 3280 (2018).
4. Sun, Y., *et al.* Co-delivery of dual-drugs with nanoparticle to overcome multidrug resistance. *European Journal of BioMedical Research* **2**, 12-18 (2016).
5. Liu, F., Sun, Y. & Kang, C. Controlling Amphiphilic Functional Block Copolymers' Self-Assembly: From Structure to Size. (2016).
6. Song, L., *et al.* Crocetin inhibits lipopolysaccharide-induced inflammatory response in human umbilical vein endothelial cells. *Cellular Physiology and Biochemistry* **40**, 443-452 (2016).
7. Sun, Y., Kang, C., Liu, F. & Song, L. Delivery of antipsychotics with nanoparticles. *Drug Development Research* **77**, 393-399 (2016).
8. Kang, C., *et al.* Delivery of nanoparticles for treatment of brain tumor. *Current Drug Metabolism* **17**, 745-754 (2016).
9. Xue, X., *et al.* Discovery of novel inhibitors disrupting HIF-1α/von Hippel–Lindau interaction through shape-based screening and cascade docking. *PeerJ* **4**, e2757 (2016).
10. Shuhong, X., *et al.* Dynamic expression of AQP4 in early stageof ischemia/reperfusion rats and cerebral edema. *Chinese Pharmacological Bulletin* **32**, 1433-1441 (2016).
11. Sun, Y., Kang, C., Yao, Z., Liu, F. & Zhou, Y. Peptide-Based Ligand for Active Delivery of Liposomal Doxorubicin. *Nano Life* **6**, 1642004 (2016).
12. Peng, J., *et al.* Enhanced Liver Regeneration After Partial Hepatectomy in Sterol Regulatory Element-Binding Protein (SREBP)-1c-Null Mice is Associated with Increased Hepatocellular Cholesterol Availability. *Cellular Physiology and Biochemistry* **47**, 784-799 (2018).
13. Yang, Z., *et al.* Functional exosome-mimic for delivery of siRNA to cancer: in vitro and in vivo evaluation. *Journal of Controlled Release* **243**, 160-171 (2016).
14. Kang, C., Hernandez, V.A. & Hu, K. Functional interaction of the two-pore domain potassium channel TASK-1 and caveolin-3. *Biochimica et Biophysica Acta (BBA)-Molecular Cell Research* **1864**, 1537-1544 (2017).
15. Waller, A.P., *et al.* GLUT12 functions as a basal and insulin-independent glucose transporter in the heart. *Biochimica et Biophysica Acta (BBA)-Molecular Basis of Disease* **1832**, 121-127 (2013).
16. Li, Q., *et al.* Identification by shape-based virtual screening and evaluation of new tyrosinase inhibitors. *PeerJ* **6**, e4206 (2018).

17. Chen, Y., *et al.* Identification of 4-aminoquinoline core for the design of new cholinesterase inhibitors. *PeerJ* **4**, e2140 (2016).
18. Kang, C. & Hu, K. Impact of hypoxia in the expression and regulation of the TASK-1 potassium channel in cardiac myocytes. *The FASEB Journal* **30**, lb598-lb598 (2016).
19. Kang, C. *Ion channels, protein kinase C and caveolae in cardioprotection*, (The Ohio State University, 2015).
20. Yung, B.C., *et al.* Lipid nanoparticles composed of quaternary amine–tertiary amine cationic lipid combination (QTsome) for therapeutic delivery of AntimiR-21 for lung cancer. *Molecular pharmaceutics* **13**, 653-662 (2016).
21. Cheng, X., *et al.* Lipid Nanoparticles Loaded with an Antisense Oligonucleotide Gapmer Against Bcl-2 for Treatment of Lung Cancer. *Pharmaceutical research* **34**, 310-320 (2017).
22. Kang, C., Sun, Y., Wang, M. & Cheng, X. Nanosized camptothecin conjugates for single and combined drug delivery. *European Journal of BioMedical Research* **2**, 8-14 (2016).
23. Kang, C. & Hu, K. Modulation of the two-pore domain potassium channel TASK-1 by caveolin-3. *The FASEB Journal* **29**, 845.814 (2015).
24. Davis, M.E., Chen, Z.G. & Shin, D.M. Nanoparticle therapeutics: an emerging treatment modality for cancer. *Nat Rev Drug Discov* **7**, 771-782 (2008).
25. Qiao, H., *et al.* Orally delivered polycurcumin responsive to bacterial reduction for targeted therapy of inflammatory bowel disease. *Drug Delivery* **24**, 233-242 (2017).
26. Liu, F., Sun, Y., Kang, C. & Zhu, H. Pegylated Drug Delivery Systems: From Design to Biomedical Applications. *Nano LIFE* **6**, 1642002 (2016).
27. Yeh, C.Y., Hsiao, J.K., Wang, Y.P., Lan, C.H. & Wu, H.C. Peptide-conjugated nanoparticles for targeted imaging and therapy of prostate cancer. *Biomaterials* **99**, 1-15 (2016).
28. Qiao, H., *et al.* Redox-triggered mitoxantrone prodrug micelles for overcoming multidrug-resistant breast cancer. *Journal of drug targeting* **26**, 75-85 (2018).
29. Kang, C., Qin, J., Osei, W. & Hu, K. Regulation of protein kinase C-epsilon and its age-dependence. *Biochemical and Biophysical Research Communications* **482**, 1201-1206 (2017).
30. Sun, Y., *et al.* RGD Peptide-Based Target Drug Delivery of Doxorubicin Nanomedicine. *Drug development research* **78**, 283-291 (2017).
31. Kang, C. & Hu, K. Role of caveolin-3 in adenosine-induced increase in mitochondrial PKCε. *The FASEB Journal* **27**, 1191.1197-1191.1197 (2013).
32. Cheng, X. & Lee, R.J. The role of helper lipids in lipid nanoparticles (LNPs) designed for oligonucleotide delivery. *Adv Drug Deliv Rev* **99**, 129-137 (2016).
33. Sun, Y. & Kang, C. Self-Assembly of Peptides into Hydrogel. *Journal of Organic & Inorganic Chemistry* **2**, 5 (2016).
34. Yao, Z., Sun, Y. & Kang, C. Structure and self-assembly of multicolored Naphthalene Diimides Semiconductor. *Nano LIFE* **6**, 1642007 (2016).
35. Cheng, X., *et al.* T7 Peptide-Conjugated Lipid Nanoparticles for Dual Modulation of Bcl-2 and Akt-1 in Lung and Cervical Carcinomas. *Molecular pharmaceutics* **15**, 4722-4732 (2018).
36. Zhong, X., Sun, Y., Kang, C. & Wan, G. The theory of dielectrophoresis and its applications on medical and materials research. *European Journal of BioMedical Research* **2**, 7-11 (2017).