Opinion
Volume 17:04, 2025

Journal of Cancer Sciences and Therapy

ISSN: 1948-5956

Open Access

Liposomes: Targeted Delivery, Diverse Therapeutic Impact

Liam O Connor*

Department of Oncological Research and Therapy, Trinity College Dublin, Dublin 2, Ireland

Introduction

This article details how liposomes are advancing cancer treatment, improving drug solubility, prolonging circulation, and enabling targeted delivery. These nanocarriers enhance therapeutic efficacy by improving drug accumulation at tumor sites, supporting precision medicine in oncology [1].

Liposomal drug delivery extends beyond cancer, addressing non-cancerous conditions. This review highlights their capacity to improve drug efficacy and reduce systemic toxicity in treating infections, inflammatory, and neurological disorders. Research works on optimizing formulations for these diverse therapeutic areas [2].

Targeted liposomal drug delivery systems for cancer therapy use specific ligands or antibodies to direct liposomes precisely to tumor cells. This minimizes off-target effects and maximizes therapeutic payload at disease sites, overcoming biological barriers in cancer treatment [3].

Liposomes act as versatile delivery systems for vaccine adjuvants and antigens. They enhance vaccine efficacy by improving antigen presentation, stimulating immune responses, and ensuring sustained release. This holds potential for developing more effective and safer vaccines against infectious diseases and cancer [4].

This comprehensive review covers recent clinical applications of liposomal nanomedicines, detailing existing market drugs and those in advanced trials. It discusses their therapeutic benefits across various conditions, including cancer, infections, and inflammation, highlighting successes and challenges in translating formulations from research to clinic [5].

Liposomal delivery systems are explored for gene therapy, offering a safe and efficient non-viral method for delivering genetic material into target cells. They overcome viral vector challenges, with advancements in designing carriers for various nucleic acid therapeutics, including siRNA, mRNA, and plasmids [6].

Liposomes play a crucial role in combating infectious diseases. They improve the delivery of antibiotics, antivirals, and antifungals, enhancing efficacy and reducing toxicity. Challenges exist in developing stable liposomal treatments for various pathogens, yet prospects for global health are promising [7].

Progress in stimuli-responsive liposomal nanocarriers focuses on releasing payloads in response to specific triggers like pH, temperature, or enzymes. These 'smart' liposomes achieve highly localized drug delivery, enhancing therapeutic efficacy while minimizing systemic side effects, relevant for cancer and inflammatory conditions [8].

Advantages of liposomal formulations for pulmonary drug delivery are explored. Liposomes improve drug bioavailability in the lungs, provide sustained release, and reduce systemic toxicity, making them suitable for respiratory diseases like asthma, COPD, and lung infections. Design considerations for inhalable products are detailed [9].

Liposomes are crucial for overcoming the Blood-Brain Barrier to deliver therapeutic agents to the brain. Strategies include surface modification and specific targeting ligands to enhance accumulation in brain tissues for treating neurological disorders and brain tumors, addressing challenges in CNS drug delivery [10].

Description

Liposomal nanocarriers are transforming drug delivery by significantly improving drug solubility, extending circulation time, and enabling precise targeting to diseased tissues. This capability is particularly evident in cancer treatment, where liposomes enhance therapeutic efficacy by increasing drug accumulation at tumor sites and minimizing systemic side effects [1]. Specifically, advanced strategies involve incorporating ligands or antibodies onto liposomes to direct them specifically to cancer cells, a method that greatly refines targeted delivery and helps overcome inherent biological barriers within the tumor microenvironment [3]. The progress here translates into a promising avenue for precision medicine in oncology, demonstrating real potential for better patient outcomes. Ongoing comprehensive reviews detail how these liposome-based drugs are moving through clinical trials and even reaching the market, showcasing their benefits across various disease areas, including cancer [5].

Beyond cancer, liposomal drug delivery systems are effectively addressing a wide range of non-cancerous conditions. These systems can improve drug efficacy and substantially reduce systemic toxicity in treating infectious diseases, inflammatory disorders, and various neurological conditions [2]. For instance, their utility in combating infectious diseases is notable, as liposomes can enhance the delivery of antibiotics, antivirals, and antifungals, leading to improved effectiveness and reduced side effects. This research continues to tackle challenges in developing stable and effective treatments for diverse pathogens, promising significant advancements in global health [7].

Innovative liposomal designs are expanding their utility into cutting-edge therapeutic areas. In gene therapy, liposomal delivery systems provide a non-viral, safer, and efficient method for delivering genetic material into target cells. They overcome many challenges associated with traditional viral vectors, supporting the delivery of nucleic acids like siRNA, mRNA, and plasmids, which holds vast po-

tential for future treatments [6]. Moreover, the development of stimuli-responsive liposomal nanocarriers marks a significant step forward. These 'smart' liposomes are engineered to release their payload precisely when triggered by specific environmental cues, such as changes in pH, temperature, or enzyme activity. This targeted release mechanism enables highly localized drug delivery, which is particularly beneficial for conditions like cancer and inflammatory diseases, as it maximizes therapeutic impact while minimizing undesirable systemic exposure [8].

Overcoming physiological barriers is a critical aspect of effective drug delivery, and liposomes offer solutions for challenging anatomical sites. For pulmonary drug delivery, liposomal formulations improve drug bioavailability within the lungs, provide sustained release, and significantly reduce systemic toxicity. These characteristics make them ideal for treating respiratory conditions like asthma, Chronic Obstructive Pulmonary Disease (COPD), and lung infections, though their design requires specific considerations for inhalable products [9]. Similarly, a major area of focus involves utilizing liposomes to bypass the formidable Blood-Brain Barrier. Researchers are exploring strategies like surface modifications and specific targeting ligands to enhance liposome accumulation in brain tissues, aiming to deliver therapeutic agents for neurological disorders and brain tumors, thereby addressing a long-standing challenge in central nervous system drug delivery [10].

Additionally, liposomes are proving to be exceptionally versatile carriers for vaccine development. They function effectively as delivery systems for both vaccine adjuvants and antigens. By improving antigen presentation and stimulating robust immune responses, liposomes enhance vaccine efficacy. They also ensure a sustained release of vaccine components, contributing to the development of safer and more effective vaccines against a spectrum of infectious diseases and various forms of cancer [4].

Conclusion

Liposomal drug delivery systems represent a significant advancement in therapeutic strategies across various medical fields. These nanocarriers enhance drug solubility, prolong circulation time, and enable targeted delivery, improving therapeutic efficacy while often reducing systemic toxicity. Recent developments highlight their utility in cancer treatment, where liposomes are engineered for targeted delivery to tumor sites, minimizing off-target effects and maximizing payload accumulation. Beyond oncology, liposomes are proving effective in addressing non-cancerous conditions, including infectious diseases, inflammatory disorders, and neurological conditions, by optimizing drug delivery and reducing adverse effects.

Liposomes are also crucial for gene therapy, offering a non-viral alternative for delivering genetic material, and for vaccine development, where they enhance antigen presentation and stimulate robust immune responses. Innovations include stimuli-responsive liposomes, which release their cargo in response to specific environmental triggers, allowing for highly localized drug release. Efforts are also focused on overcoming biological barriers, such as the Blood-Brain Barrier for central nervous system delivery, and optimizing formulations for specific routes like pulmonary administration. The continuous progress in modifying and designing liposomal formulations underscores their broad potential in precision medicine and improving patient outcomes in diverse therapeutic areas. Clinical applications are rapidly advancing, translating these sophisticated delivery systems from research into market-ready treatments.

Acknowledgement

None.

Conflict of Interest

None.

References

1. Yu Qiao, Bingqian Jiang, Xuehan Shen. "Recent advances in liposomal drug delivery systems for cancer therapy." *J Nanobiotechnology* 21 (2023):377.
2. Wen-Kai Zhang, Ya-Lan Tang, Yu-Jun Wei. "Advances in Liposomal Drug Delivery Systems for Non-Cancerous Diseases." *J Biomed Nanotechnol* 18 (2022):3012-3029.
3. Yanan Sun, Jin Han, Qian Chen. "Targeted liposomal drug delivery systems for cancer therapy: an update." *Cancer Biol Med* 18 (2021):641-654.
4. Yi Ma, Hao Hu, Li Yan. "Liposomal delivery systems for vaccine adjuvants and antigens." *Vaccines* (Basel) 8 (2020):196.
5. Yu-Fang Shao, Wei-Yi Cai, Fang-Yuan Yang. "Recent Progress in Clinical Applications of Liposomal Nanomedicine: A Comprehensive Review." *J Nanomater* 2023 (2023):9789704.
6. Zahra Farajikhah, Zinat Sheykhsaran, Hadi Esmaeilzadeh. "Liposomal delivery systems in gene therapy: Current status and future perspectives." *Mol Ther Nucleic Acids* 29 (2022):603-625.
7. Yu Meng, Jing-Yu Dong, Wen-Tao Li. "Liposomes in infectious disease: developments, challenges, and prospects." *Signal Transduct Target Ther* 6 (2021):228.
8. Wenjun Xu, Xiaobing Sun, Yongchao Huang. "Stimuli-Responsive Liposomal Nanocarriers for Targeted Drug Delivery." *Pharmaceutics* 15 (2023):624.
9. Mohit Verma, Monika Gupta, Neha Sharma. "Liposomal Formulations for Pulmonary Drug Delivery." *Curr Pharm Des* 26 (2020):1546-1558.
10. Hani Almutairi, Abdulrahman E. Aldawsari, Abdulmajeed A. Alruwaili. "Liposomes for delivery of therapeutic agents to the brain: a review." *J Drug Deliv Sci Technol* 51 (2019):457-466.

How to cite this article: Connor, Liam O. "Liposomes: Targeted Delivery, Diverse Therapeutic Impact." *J Cancer Sci Ther* 17 (2025):715.

Address for Correspondence: Liam, O Connor, Department of Oncological Research and Therapy, Trinity College Dublin, *Dublin* 2, Ireland, E-mail: liam.oconnor@tcd.ie

Received: 01-Jul-2025, Manuscript No. jcst-25-174952; **Editor assigned:** 03-Jul-2025, PreQC No. P-174952; **Reviewed:** 17-Jul-2025, QC No. Q-174952; **Revised:** 22-Jul-2025, Manuscript No. R-174952; **Published:** 29-Jul-2025, DOI: 10.37421/1948-5956.2025.17.715