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Targeted Drug Delivery, Liposomes and Pharmacokinetics

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Editorial

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Introduction

Targeted drug delivery is a modern therapeutic approach designed to direct drugs specifically to diseased tissues while minimizing exposure to healthy organs. Conventional drug administration often results in widespread distribution throughout the body, leading to reduced efficacy and increased side effects. Targeted delivery systems aim to overcome these limitations by improving drug concentration at the site of action. Among various carrier systems, liposomes have gained significant attention due to their biocompatibility and versatility. Understanding pharmacokinetics is essential in this context, as it explains how drugs are absorbed, distributed, metabolized, and eliminated when delivered through advanced systems such as liposomes [1,2].

Discussion

Pharmacokinetics plays a central role in determining the therapeutic success of any drug delivery system. It describes the time course of drug concentration in the body and helps optimize dosage regimens. In conventional therapy, rapid clearance and nonspecific distribution often limit drug effectiveness. Targeted delivery systems modify pharmacokinetic behavior to prolong circulation time, enhance tissue accumulation, and reduce toxicity [3].

Liposomes are spherical vesicles composed of phospholipid bilayers that can encapsulate both hydrophilic and lipophilic drugs. Their structural similarity to cell membranes allows them to interact favorably with biological systems. Liposomes protect drugs from degradation in the bloodstream and can be engineered to release their contents in a controlled manner. By altering size, surface charge, and lipid composition, scientists can tailor liposomes to achieve desired pharmacokinetic profiles [4].

One major advantage of liposomes is their ability to improve drug distribution through passive and active targeting. In passive targeting, long-circulating liposomes accumulate in tumors due to the enhanced permeability and retention effect, where leaky tumor vasculature allows nanoparticles to enter and remain in tumor tissue. In active targeting, ligands such as antibodies or peptides are attached to the liposome surface to bind specific receptors on target cells, further increasing selectivity [5].

These strategies significantly influence pharmacokinetics. Liposomal formulations often show prolonged half-life, reduced clearance, and altered volume of distribution compared to free drugs. For example, liposomal anticancer drugs demonstrate lower accumulation in healthy tissues such as the heart, thereby reducing cardiotoxicity while maintaining high tumor concentrations.

However, challenges remain in large-scale production, stability during storage, and variability in patient responses. Immune recognition and rapid uptake by the reticuloendothelial system can also limit effectiveness, although surface modification with polyethylene glycol has helped reduce these issues.

Conclusion

Targeted drug delivery seeks to maximize therapeutic benefit while minimizing adverse effects by directing drugs to specific sites

in the body. Liposomes represent a powerful carrier system capable of modifying pharmacokinetics to enhance efficacy and safety. Through controlled drug release and selective tissue accumulation, liposomal formulations have transformed the treatment of several diseases, particularly cancer. Continued advancements in liposome design and pharmacokinetic understanding will further strengthen their role in precision medicine.

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