Research and Reviews: Drug Delivery

Targeted Drug Delivery System at different Sites of the Body and its Response

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Opinion Article

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ABOUT THE STUDY

The method of transporting a drug to the desired location of action and releasing it there utilizing either local (environmental) or peripheral control means is known as targeted drug delivery. Drugs are normally covalently or non-covalently coupled with a targeting moiety, and then guided to the target location using passive or active techniques. By limiting nonspecific interactions with nontarget organs, tissues, and cells, passive targeting tries to maximize the ratio of medicine reaching the target location compared to the nontarget site. Active targeting is delivering a medicine to a specific target spot utilizing ligands that bind to overexpressed receptors on target cells. The drug will either become internalized into cells after being released from its carrier due to environmental factors or a peripheral trigger, or the combined drug/carrier (CNT) complex will become internalized, the latter being more efficacious, once it reaches the desired target site.

Because of their high aspect ratio, or long thin/tubular structure, Carbon Nanotubes (CNTs) have been found to traverse cell membranes and become ingested by endocytosis as well as endocytosis-independent pathways such as insertion and diffusion across lipid bilayers.

Drug delivery targeting could lead to fewer adverse events, less side effects, and improved tolerance to powerful medications. Due to its capacity to contain drug molecules within the core of the CNT, which protects it from the surrounding environment and vice versa, CNTs are suitable for targeted drug administration. CNTs' intrinsic optical and magnetic capabilities will allow them to be triggered by an external source, allowing for drug release

stimulation. Because of the strong nature of cytotoxic and the severe adverse events they cause, most of the focus of drug delivery with CNTs has been on cancer therapy, necessitating the need to administer them in a more specific and targeted manner.

CNTs have been created to produce energetically favorable physical conditions for drug uptake within the core of CNTs, according to mathematical modelling approaches. This technique was used to establish the needed radius and maximum suction energy for the anticancer medication Cisplatin, and it might be applied to other molecules or nanoparticles. The Enhanced Permeability Retention effect (EPR) displayed by solid tumours can be used to get CNTs to concentrate within them. As a result, as has been established for pegylated SWNTs, the concentration of CNT in tumours will be several-fold higher than in plasma. As a result, CNTs containing medicine in their core will gently release their contents in a targeted and sustained manner over lengthy periods of time, avoiding damaging effects on other organs and tissues.

Functionalizing the surfaces of CNTs with antibodies of overexpressed antigens present on cancerous cell surfaces, or using ligands specific to cancer cell surface receptors, of which folic acid receptors are the most commonly expressed in a wide range of cancer types, can increase the propensity for CNTs to accumulate at tumour sites. Another medicine that has been conjugated to SWNTs is paclitaxel, which has demonstrated to be more effective at reducing breast tumour growth in animal models than taxol alone. This is due to the capacity to functionalize the CNT with targeting groups like monoclonal antibodies, as well as the EPR effect of tumours, which causes the CNT to accumulate in tumour locations. Compared to non-CNT-conjugated cisplatin, SWNT-conjugated Epidermal Growth Factor (EGF) targeted squamous carcinoma with the medication cisplatin and showed higher efficacy. In vitro, the CNTs internalized quickly, confirming one of the key characteristics of CNTs: their ability to traverse cell membranes quickly and effectively.

CNTs have also demonstrated lesser immunogenicity compared to conventional protein carriers, as well as the capacity to easily translocate across cell membranes, including nuclear membranes, and into the nucleus of cells. As a result, a tool for targeted delivery of protein and genetic components for vaccine delivery and gene therapy is now available. Conjugating MWCNT with tumour lysate protein significantly improved the efficacy of anticancer immunotherapy in a mouse model with the H22 liver tumour. The electrostatic interactions between the positively charged cytosine-cytosine+ base pairs and the carboxyl groups on SWNTs have been found to promote i-motif stability by binding to the main groove of the human telomeric i-motif (a tetrameric DNA structure). Given that the i-motif is a desirable target for cancer treatment and gene transcription modification, it is a useful tool for drug targeting.

It has been shown that interactions between CNT and membrane-bound cellular proteins can modulate cellular signal transmission. SWNT-COOH has been demonstrated to block the Smad-dependent bone morphogenetic protein signalling pathway, resulting in Id protein down regulation (proteins that contribute to multiple steps of tumorigenesis, thus a key target for the therapy of various cancers). It is obvious that carbon nanotubes have the potential to improve the efficacy of new and existing chemotherapeutic treatments by allowing for targeted and regulated drug release. However, there is still a lot of work to be done in the preclinical arena before clinical trials can begin, with much of it focusing on the characterization and toxicity of CNTs.