Nanotechnology-Based Cancer Treatments

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Received: October 10, 2012
Published: November 20, 2012


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Nanoparticles, nanosecond pulses and other nanotechnology-based systems could help enhance the efficacy of cancer therapies. For example, high intensity, nanosecond pulses have been used for prostate cancer treatments, without any drug and they have also been used with chemotherapeutic drugs. Nanoparticles are used to upload various genes and drugs using several methods, including electroporation. Many nanoparticles and nano-sized systems are utilized in clinical studies in medical oncology, including breast cancer. Doxil and Abraxane are FDA approved nanocarrier systems currently available in the market for cancer treatment. Doxil is a long circulating liposomal formulation of the anticancer drug doxorubicin, which has shown significant improvements over its traditional counterpart doxorubicin. Abraxane is used for metastatic breast cancer. It is an albumin-bound nanoparticle formulation of paclitaxel. The injectable form evades the hypersensitivity reaction associated with the solvent (Cremophor EL) used for paclitaxel. Abraxane nanoparticles of 100nm size and have the ability to convert insoluble or poorly soluble drugs, avoiding the use of toxic solvents. The attractive benefit of nanoparticles is their greater surface area for a given volume. Because reactions occur on the surface of a chemical substance, the greater the surface area the greater the reactivity. As particles become smaller in size, their surface area/volume ratio increases more and extend the benefits. Nanoparticles could be engineered to have surface modifications or be conjugated with folate, antibodies, adjuvants, ligands, antigens, enzymes, pH-sensitive agents, and other substances. Nanoparticles including gold and magnetic ones, could also be uploaded using electrical pulses of parameters, 1200V/cm, 100µs to 200V/cm, 20-40ms. By varying the number of pulses and the interval between the pulses or pulse trains, and with and without drugs, it is possible to enhance nanoparticle or nanomolecular uptake compared to the conventional uptake (known as reversible and irreversible techniques) up to 1000x. The delivery of nanoparticles depend on the physico-chemical factors, including the particle size, surface charge, protein absorption ability, surface hydrophobicity or hydrophilicity, drug loading and relative kinetics, stability, degradation of carrier systems, hydration behavior, electrophoretic mobility, porosity, specific surface characteristics, density, and crystallinity. In addition, it also depends on the dose and the administration routes (oral or parenteral, including delivery routes such as intravenous, pulmonary, transdermal and ocular, in the case of in vivo). Electrical pulse-mediated nanoparticles is a less conventional one, but has promising potential when applicable. Also, for biomedical application, their toxicity is an important concern and they should be stable at room temperatures in water or at neutral pH, they should not aggregate, and should be biocompatible. Their surface coating should be physiologically well tolerated.

Cytotoxicity limits the potential of high molecular weight cationic polymers in gene delivery. About 100 years ago, this realization in the western world led to the study of biochemical interactions; a major change in the prevailing paradigm used to explain cellular functions and disease progression. The pharmaceutical industry eventually became very successful in using chemicals to develop a series of drugs and transformed medicine into a huge multibillion business selling drugs. All the research dollars and effort are mostly directed towards understanding the chemistry of the body and developing drugs to alter that chemistry. Yet many biological questions remain unanswered as evidenced by the millions of dollars and effort. The pharmaceutical industry eventually became very successful in using chemicals to develop a series of drugs and transformed medicine into a huge multibillion business selling drugs. All the research dollars and effort are mostly directed towards understanding the chemistry of the body and developing drugs to alter that chemistry. Yet many biological questions remain unanswered as evidenced by the millions of dollars and effort.