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Nanotechnology-Based Cancer Treatments

Editorial

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Nanoparticles, nanosecond pulses and other nanotechnolgy-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 chemo drugs. Nanoparticles are used to upload varius genes and drugs using several methods, including electroporation. Many nanopartciles and nano-sized materials are utilized in clinical studies in medical oncology, including breast cancer. Doxil and Abraxane are FDA approved nanoformulations 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 injectionable form evades the hypersensitivity reaction associated with the solvent (Cremophor EL) used for paclitaxel. Abraxane nanopartcile of 100nm size and has 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 becomes 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 nanopartilce or nanomolecular uptake compared to the conventional uptake (known as reversible and irreversible techniques) up to 1000x. The delivery of nanoparticles depend on the physic-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 routés 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 cancer deaths worldwide each year and the number is only growing. It is clear that all questions of the body cannot be answered by chemistry (drugs) only and the biochemical processes do not explain the electrical functions and electrostatic forces and their interactions in cell regulations and hence in deadly diseases like cancer. Our body possesses electrical mechanisms and use charges and electricity to regulate and control the transduction of chemical energy and life processes. Hence, there is a critical need for alternate/additional therapies and nanotechnology could pave a way towards this and the combination of nanosecond electrical pulses with (and without also) drugs offers other ways to treat some of the cancers that are refractory to the current standard of cure.