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Is Cancer Treatment Through Targeted Delivery a Better Solution?

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In medical field, scientists are trying to understand the molecular basis of human biology to address intricate problems on cancers of various kinds in order to find causes and remedies. More recently, research efforts have led to the utilization of concepts and principles of nanotechnology and biotechnology with the development of personalized medicine. Nanobiotechnology, which is a fusion between nanotechnology and biotechnology, utilizes the combined knowledge of a large number of biotech products to develop useful delivery devices to the cancer tumor cells.

The treatment of cancer has thus greatly improved in recent times. As per the National Cancer Institute, the overall incidence has declined since 1999. Despite these facts, most patients see the diagnosis of cancer as synonymous with a high probability of death and potentially drastic treatments including aggressive surgery, radiotherapy and chemotherapy, etc., posing severe side effects like vomiting, hair loss, post-surgical deformation that can seriously impair the quality of life. Scientists have been working on developing newer approaches to that can directly target the tumor, without damaging the normal tissue to decrease the side effects-indeed a formidable problem!

A new therapy developed recently uses carbon nanotubes (CNTs) for drug delivery and these devices are in nanoscale that can deliver high concentrations of drugs to the interior of cancer cells without affecting normal cells. The nanoparticles also increase the time a drug stays inside a cell, compared with other therapies. Another new therapy uses a non-thermal irreversible electroporation (N-TIRE). The principle behind this therapy has been known since 1898, which is now used in the treatment of cancer. N-TIRE is the application of electrical fields to a targeted tissue area for permanently opening the pores in the membranes of a cell, causing cell death. The destruction of cells by this approach is not due to thermal injury and it allows elimination of tumor cells. Some studies are underway at few laboratories combining N-TIRE and CNTs, where N-TIRE is used to treat the tumor, while CNTs to selectively target cancer cells inside a tumor. By this way, injected nanoparticles improve the targeting ability.

In general, most studies report minimal side effects in the treatment with N-TIRE, but there are some concerns about therapies with CNTs, since researchers have seen some effects like excessive inflammatory response and formation of free radicals. However, it looks like N-TIRE can be safely used and whenever it is combined with another therapy, one should be careful with the choice of nanoparticle to ensure no toxicity to the body. There reports that N-TIRE was used for the first time in humans in 2008 for prostate cancer treatment, with good results. New trials are being made for the treatment of lung, kidney, hepatic and other cancers. However, use of CNTs though very promising for the cancer therapy, but more research is needed to address toxicity issues.

Some reports mention that combined therapy of CNTs along with N-TIRE can be useful to treat any type of cancer including brain, prostate, kidney, liver and pancreas. It is reported that this new combined therapy may be better for patients suffering from cancer, using minimally invasive procedures to increase the quality of life and decrease the risk of metastasis.

Personalized medicine is another newer approach that is concerned with the prescription of specific therapeutics best suited for an individual. For example, a personalized cancer therapy is based on our better understanding of the disease at the molecular level. Nanobiotechnology-based drug delivery systems are indeed the important basic components of a personalized medicine that are used in the treatment of cancers. Limitations in current diagnostic techniques depend on nanomedicine to minimize possible damage to body by using nanoparticles as diagnostic and therapeutic tools under the principles of theranostics that will certainly offer greater sensitivity for early detection and successful treatment of cancers.

Our own research efforts has led to developing nanoparticle (NP) based systems for various biomedical applications such as diagnostic imaging of cancers. The two factors are important in the intra-cellular delivery of therapeutic drugs: one is the size of the NP probe and the other is the biocompatibility toward a biological system. In this regard, ultra-small NPs may be particularly useful as fluorescent probes and therapeutic devices for theranostic applications for tumors. These nano devices have numerous advantages. However, there are only handful reports that describe the preparation of biodegradable and biocompatible polymeric ultra-small NPs.

We have recently reported a method for the production of ultra-small (~10 nm) deoxycholic acid conjugated polyhydroxybutyrate–polyethylene glycol (DOCA-PHB-PEG) NPs. We used a simple synthetic protocol for the preparation of DOCA-PHB-PEG as well as a simple and robust procedure based on a modified solvent diffusion and evaporation method to produce ultra-small NPs. Natural polyhydroxybutyrate (PHB) is the most commonly used homopolymer of the polyhydroxyalkanoate family as it is stored as intracellular granules in a variety of bacteria as a carbon and energy source produced as a result of metabolic stress due to a limited availability of nutrients. These systems loaded with 5-fluorouracil were suitably used in the effective treatment of the colon cancer, based on our *in vitro* and *in vivo* experiments on cancer model animals.

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