Diagnostic and therapeutic values of nanotechnology in cancer management

Jeelani. S, R. Amirthaa Priyadharscini, P. Duraiselvi
Department of Oral Medicine and Radiology, Sri Venkateshwaraa Dental College, Puducherry, India

Abstract
The early diagnosis and successful management of cancer have always been a challenge. The emerging field of nanotechnology is valuable both with respect to early diagnosis at the most incipient stages and highly targeted harmless treatment which makes this technology an undisputed unique landmark in the milestone of cancer management. This paper reflects a triangular trap approach for cancer therapeutics using nanotechnology-based nanomaterials such as dendrimers, quantum dots (QDs), and nanobubbles. The dendrimers serve as targeted anticancer therapy sparing the adjacent normal cells. The concept of encapsulation and conjugation helps in trapping the drug molecules and targeting them to the specific sites and ultimately releasing them. QDs are nanometer-sized semiconductor crystals which serve as early detection tools of cancer. They are composed of cadmium selenide. They possess the ability to glow when they are subjected to ultraviolet light. They play a significant role not only in the early diagnosis of cancer but also in target destruction of the cancerous cells. Nanobubbles are plasmonic (gold) nanoparticles. They cause the destruction of cancerous cells by means of tiny explosions.

Keywords
Cancer, dendrimers, nanobubbles, nanotechnology, quantum dots

Introduction
Cancer is one of the leading causes of death. Early detection of cancer plays a significant part in cancer prognosis. Carcinogenesis is initiated when the harmony in checkpoint mechanism of cell division is hampered which results from various exogenous and endogenous factors leading to uncontrolled proliferation of cells (cancer). The word cancer is derived from the Greek word Karkinos which means crab. It was historically related to crab by Hippocrates due to the fact that persistence and spread of cancer simulate a crab. This paper reflects a triangular trap approach grabbing and trapping the crab cancer using nanotechnology.

Nanotechnology
Richard P Feynman introduced nanotechnology in 1959. It was pioneered by K Eric Drexler in 1980’s. The word nano means dwarf. Nanotechnology is the field of science and engineering that deals with synthesis, designing, and application of materials whose dimension is on the nanometer scale or one billionth of a meter in at least one dimension. By virtue of its nanoscale dimension, these nanomaterials possess better control over fundamental molecular structure which in turn results in better compatibility and control over the macroscopic chemical and physical properties.

Nanotechnology and cancer

Dendrimers
Dendrimers are nanostructures that serve as a nano tool in cancer management by adapting the principle of Trojan horse strategy. This strategy helps in transporting the anticancer agents specifically to the diseased target sites without involving and injuring the healthy adjacent regions.

Dendrimers play a pivotal role by virtue of their properties such as encapsulation and conjugation. They have a spherical branching structure. The structure is composed of nitrogen atom to which carbon and other elements are added by repeated series of chemical reactions. This hyper-branching structure of dendrimers which proceeds from the center toward the periphery leads to a characterized void-based design that can physically encapsulate the anti cancer agents such as 5 fluorouracil, 5 aminosalicylic acid, pyridine, mefenamic acid and diclofenac, paclitaxel, docetaxel, and the anti-cancer agent 10 hydroxycapecitabine, thereby making it harmless to the outside.
The delivery of the encapsulated drugs takes place when the dendrimer undergoes hydrolytic degradation, thus releasing them at the desired site.\(^{[14]}\)

Conjugation is fulfilled by ligand inclusion which binds to cells. By virtue of the fact that membrane-bound folate receptor being expressed excessively on diverse cancer, it is prudent to consider folate as the tumor targeting ligand. Folate also has the advantage of good solubility binding to its receptor. They have a high affinity when conjugated with diverse conjugates such as radioactive imaging agents, magnetic resonance imaging contrast agents, and gene transfer vectors.\(^{[15-19]}\)

**Quantum Dots (QDs)**

QDs are made up of cadmium selenide. They are semiconductor crystals whose dimension is nanometer sized. They have the property to glow when exposed to ultraviolet light and hence are considered to be fluorescent nanoparticles. They play a dual role both as part of diagnostics and therapeutics in early identification of detection of cancer and targeted destruction of them.\(^{[20]}\) The diagnostic techniques in current practice lack maximum specificity and adequate sensitivity. They are less cost effective, more time consuming and involve cumbersome procedure. In contrary, the QD technology is less expensive and enables easy and quick screening of cancer and thus serves as unique cancer markers. The relevance of early cancer detection is to prevent metastasis and nanotechnology-based substances such as QDs perform it well in advance before the cancer mass multiplies and contains millions of cells. The advantages of QDs are stable and intense fluorescence ability for prolonged period of time, increased molar extinction coefficient, adequate photobleaching resistance, and efficiency in absorbing and emitting light in a stable and quick manner.\(^{[21-25]}\) As part of conjugation benefit, a single QD can be conjugated to various molecules since they have a large surface area-to-volume ratio. As a consequence, they can be linked covalently to various biomolecules which include antibodies, nucleic acids, peptides, and other ligands associated with fluorescence-probing applications.\(^{[26]}\) Notably, they also play a prime role in vivo molecular imaging.\(^{[27]}\)

**Nanobubbles**

Nanobubbles are diagnostic and therapeutic nano tools useful in singling out individual cancerous cells. They are composed of plasmonic (gold) nanoparticles. They serve as tunable thermal nano probe in cancer identification and destruction. They perform destruction of cancer with tiny explosions.\(^{[28]}\) The uniqueness of these particles is that they are transient nanobubbles and their generation is initiated by optical excitation with short pulses of laser which leads to heating and consequent evaporation of environment. The absorption of optical energy and followed by heating occurs within 3-5 fs. Then, vapor nucleus formation occurs within 30-100 ps. The vapor is a layer of nanometer thickness rather than a bubble. However, within a fraction of nanoseconds to microseconds, vapor expands and results in nanobubble. This occurs when the temperature of the nanoparticle is excessive enough so that the pressure inside the vapor layer exceeds beyond the outer pressure. After acquiring the maximal diameter, the bubble collapses back once again to the nanoparticle. The plasmonic nanoparticle accumulates heat from the collapsing nanobubble.

The applications of nanobubbles are diverse which include early identification and treatment of residual cancer cells on a thin surface, identification, and ablation of metastasis in deep tissues. They are also useful in imaging, gene therapy, cell level treatments, and microsurgery.\(^{[29]}\)

**Conclusion**

The value of nanotechnology is a challenging remedy in the management of cancer. Dendrimers, QDs, and nanobubbles play a significant part of nanomaterial both serving in early diagnosis and targeted therapeutics. Since cancer is a significant leading cause of death, the emergence of nanotechnology-based substances is a boon to cancer affected patients. Early diagnosis at the most incipient stages and highly targeted harmless treatment is the undisputed unique landmark of this technology, thus making them an ideal Nanotrap for the cancer crab.\(^{[30]}\)

**References**


How to cite this article: Jeelani S, Priyadharscini RA, Duraiselvi P. Diagnostic and therapeutic values of nanotechnology in cancer management. J Adv Clin Res Insights 2017;4:103-105.