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The Development of Quantum Dot-Based Detection System for the Diagnosis of Breast Cancer

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ABSTRACT: Cancer is one of the most threatening diseases in the world which leads to death of the people. Although, several researches have been done for the diagnosis and treatment of cancer but its mechanism still remains unclear. Early detection of cancer is necessary as most of the tumors contain a large number of diseased cells which may have already metastasized. There are various diagnostic techniques such as medical imaging, tissue biopsy and ELISA (Enzyme-Linked Immunosorbent Assay) which are currently employed for diagnosing the cancer at an early-stage, but these diagnostic techniques are labor intensive, time consuming and expensive. So, here is very crucial condition for growth of cancer at an early-stage which is inexpensive and fast. The novel approach for the analysis of cancer nowadays is Quantum Dot (QD) detection system which is an easy, economical and rapid technology for cancer diagnosis. (QDs) are minute semiconductor small particles that have Opto - electronic property which, due to the quantum dynamics, vary from bigger molecules. Various biomarkers for the diagnosis of cancer have been identified and thus, the Quantum Dot-based diagnosis method using biomarkers is the most effective method for diagnosing cancer at an early-stage. The Quantum Dots have unique and excellent photo-physical properties which makes it different from the other methods of cancer diagnosis. This review mainly focuses on the development for the diagnosis and dealing of breast tumor by using the Quantum dot-based method.

KEYWORDS: Cancer, metastasized, medical imaging, tissue biopsy, ELISA, diagnosis, Quantum Dots, nanoparticles, biomarkers.

I. INTRODUCTION

Cancer is indeed a significant public health issue, resulting in an overall incidence of 12.7 million cancer patients and 7.6 million died from the disease in 2008 and an increase of cancer cases for 2009. Leading causes of cancer of mortality in the world. However, much progress has been made in terms of diagnosis and treatment for cancer but still the number of deaths is more in case of cancer as compared to the heart disease in the age less than 80-85 years of people. [1] The category is distinguished by the unregulated development of cells that are capable of destroying other organisms. Several researches have concentrated on restrictions on cell adhesion and particleboard as an intrusion of cancer and development process in recent decades. [2]

The control of cancer requires the substantial interventions of people in which the primary prevention reduces the cancer incidences in case of long-term but in case of short-term reduction of cancer incidences, there is a need for the early diagnosis and treatment. Till now, the doctors or clinicians are using the biomedical imaging technique for the diagnosis of various types of cancers. [3] The cancer invasion with the microenvironment of tumor is generally seen as a heterogeneous and adaptive process. The technological environment of the cancer, which includes cancer stromal components, host cells and associated tissue aid, is an important factor from its forward-going tumor progress and expansion. The elements of infected cells, including such fibroblasts, endothelial cells, and macrophages, may be activated and thus can be made available by a tumor microenvironment responding to the cancer triggering cell to promote and prevent cancer intrusion. The tumor cells then impact the micro - environment in trigger the cells. [4]

The main encounter is in what way treat the cancer in initial stages, so the new technologies are required for the fast and easy detection of cancer at early stage and in which the fluorescent nanomolecules such as QDs plays a major role for the diagnosis and management of cancer. [5-7]

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There are various techniques for the diagnosis of cancers such as calculated tomography (CT) scanning, [8] ultrasound scanning and optical imaging scanning, [9] etc. but these are very limited to detect abnormalities at microscopic level. The nanoparticle-based optical contrast is combined with the existing optical imaging technology for great-resolution cancer diagnosis. Nowadays, this technology has been proved to be the successful technique for diagnosing cancers or tumors.

1. Application of Nanotechnology for the Development of QD-Based Detection of Cancer

The detection of cancers using Quantum dots (QDs) was introduced in vitro in1998. The researchers have synthesized such probes which are cancer precise organs, antibodies for the diagnosis of tumor. The Quantum Dots – Immunohistochemistry (QD-IHC) is more relevant and accurate for the detection of cancer and can provide much information about the symptoms and effective treatment for cancer. [10]

Breast cancer (BC) is among the most prevalent cancers among women worldwide. In the last few decades' considerable improvements have been made in the field of showing gears and complete treatment for BC. BC is an extremely heterogeneous disease with specific biologic behavior at the same level of BC patients, has been widely accepted. Nanotechnology partakes recently arose as a hopeful tool for the investigation of biomedicine. Optical nanoparticles like (QDs) that have demonstrated exciting potential claims in cancer investigation, represent an important field of nanotechnology.

"The HER2 female epidermal development factor has been over-expressed in around 25-30 percent of individuals with BC and is a significant contributor to the development of cancer. HER2 is an epidermal development influence in the patients. The HER2 detection quality for breast cancer and prognosis has been validated recently. According to a researcher who labeled the HER2 on the cells of human breast cancer as well as mouse mammary tumor sections, the QD –based IHC has comparatively more advantages as compared to the fluorescence in situ hybridization (FISH). Several experimental studies have been conducted which stated the fruitful discovering for the BC by using the QD-HER2 detection method.

a) Physicochemical Properties of Quantum Dots (QDs)

The QDs are the "semiconductor nanocrystals" ranging from 2-10 nm in size, and are constructed of the crystal structure containing two groups containing II-VI atoms. If QDs are excited by ambient high-energy radiation, the inner electrons of QDs can turn from its floor into a greater degree. The electrons at the top level eases and drops to the field, and fluorescence generates a photon. The minimal power consumed for an electron to arouse from of the surface to the energy level is referred to as the group difference. The small size makes QDs to operate as a single entity using atoms or atoms that emit energy to illuminate high signal strength by the fluorescent process. [11]

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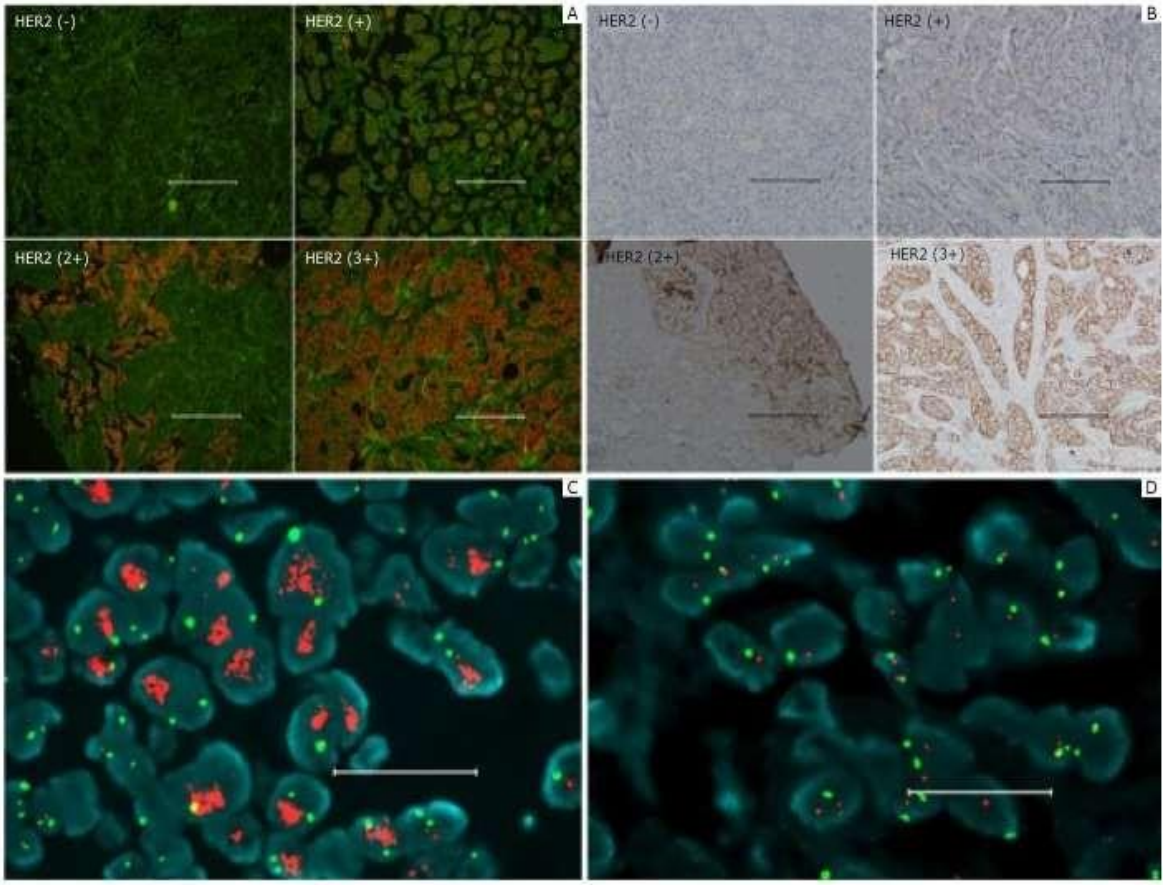

Fig.1. Precise QD-IHC HER2 check. A: QD-IHC samples of various HER2 IHC scores. B: traditional IHC monitoring for (A). C: Good FISH. D: Non-governable. bar scale: 100 microns for (A) and (B); 20 microns for (C) and (D).

In a study, it has been clearly demonstrated the detection of breast cancer through QD investigations which shows the inferior appearance levels of HER2 which can be sensed by the QD-IHC in comparison with the predictable IHC as shown in Fig. 1. The results showed that the breast cancer can be divided into the 5 subtypes having the survival rate of up to 5 years. QD multiplexed imagery thus provides additional information for individual tumor events, custom diagnosis, forecasting and treatment.

b) Applications of QDs-based imaging in Breast Cancer:

QDs have limited emission ranging from noticeable to close infrasound (NIR) beams, but a pulse-length of tunable exposures, and this special function allows for QD-based imaging which is common in vivo for tissue or BC studies (Fig . 2A). In tissue analysis, QD-based imaging is used to analyze biomarker associations (Fig. 2B) and test pathogenesis in predictive application (Fig. 2C). In vivo work on BC xenograftumor (Fig. 2E) and BC metastases has been performed using in vivo QD imager for the ALS (Fig. 2D) map. (Fig. 2F) [12]

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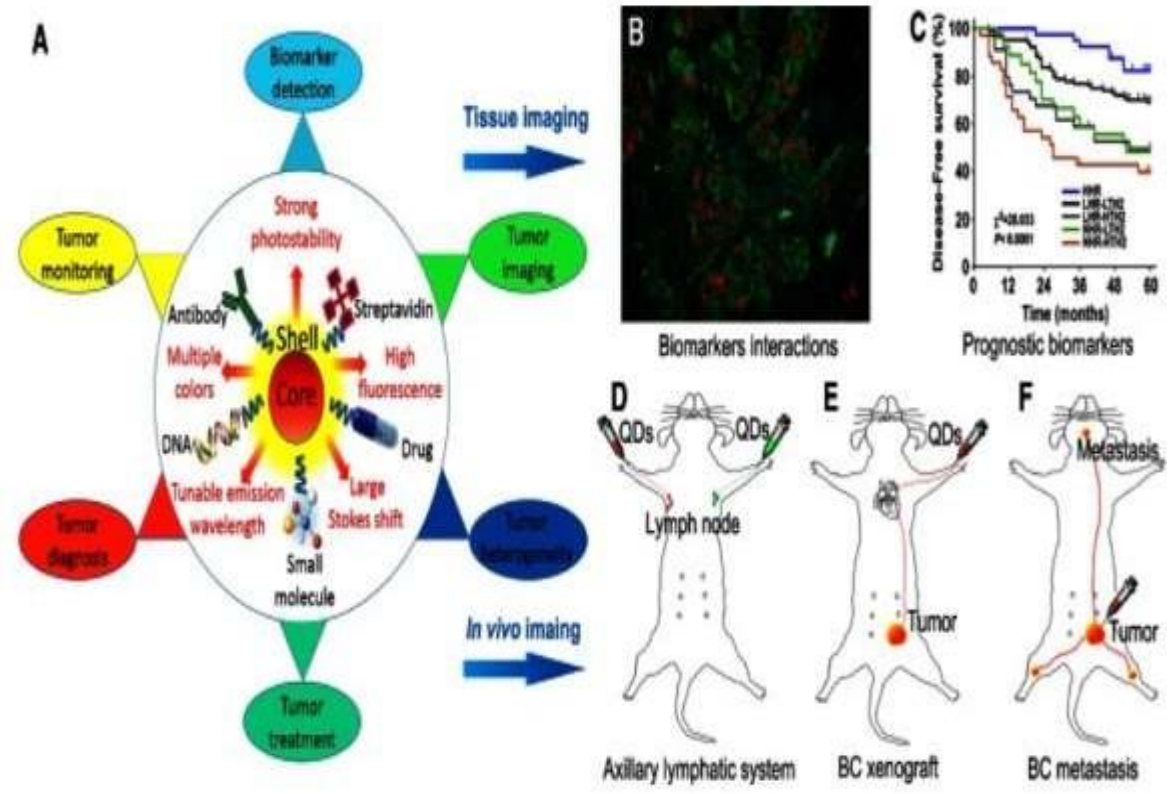

Fig.2. Optical characteristics in BC Analysis and useful to look of QDs. The core – shell configuration of amphiphilic polymers bearing chemical active groups is widely used for QD. The QDs exhibit superior optical properties (A) relative to conventional organic coloring dyes. Until being combined with bioactive compounds, QDs can be optimized for tissue imagery, such as examining biomarker associations (B) and testing prognostic biomarkers (C), and also for in vivo studies such as plotting ALS (D), displaying BC xenograft (E) and identifying BC stromal (F) in BC studies

2. Finding of BC metastasis founded on QD

The early diagnosis of cancer can help in proper and effective treatment, thereby reducing the mortality rate. The imaging techniques which are currently in use for the detection of cancer are not efficient enough as those imaging techniques only detects the growing tumors which change the structural features of the normal tissue. The newly developed Quantum Dots (QDs) – based imaging of cancer has achieved earlier detection of tumor cells in vivo. [13]

QDs are also helpful in distinguishing target cells from those of the non-target cells or tissues because of their property of "photo stability and strong fluorescence stability". In the The analysis of dual-handing and fast HE colors of QDs preoperative diagnostic micro-metastasisation and differentiated tumor cells for the BC salivary gland showed that fakes QD-based dual-handling has been much lower. In tracking the metastasis of cancerous cells, QD's were being used to observe the in-depth metastasisation cycle of BC mouse embryonic stem cells in live time which might observe four earlier phases of cancerous cells: cancerous cells well back in the tumors, near to the artery and blood flowing past the tumors cells in normal tissues. Therefore, the BC cell labeling and tracing of these cells in the MRI lymph System and optical scanning were performed using a multimodality complex consisting of iron oxide and QDs particles. Particularly, in the lymphatic nodes, single cancer cells can be detected clearly in real time.

3. 3. Metabolism and Poisonousness

QD is the hopeful in vivo biomedical Nano elements. It is important, rather than relying exclusively on ex vivo measurement and theoretical consideration, to evaluate their usefulness in vivo. The unspecified RES is a significant impediment to an in vivo QD analysis in the hepatitis, intestines and lymph gland. The composition

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of QDs ranges according to particle size , surface cover and PEG gyolution. Non-specific absorption can be significantly reduced by alteration of the QD surface with a suitable mask, which results in half-induced extended plasma.

4. Therapy of cancer by the use of Quantum Dots (QDs)

a) Anticancer drug delivery using Quantum Dots (QDs)

The novel multifunctional QD nanoparticles are developed for simultaneous imaging and therapeutic applications, capable of simply sensing therapeutic release due to an alteration on fluorescence of scanning process. One of the researchers had developed a conjugate for the delivery of anti-cancer drugs into the PCa cells of a human being and also has the property of sensing the drug delivery in the specific part or cell of the body, which is founded on the "fluorescence character vigor transmission device".

b) Quantum Dots (QDs) for phytodynamic therapy

According to a report, the QDs in the phytodynamic therapy can either act as the photo-sensitizers or as an energy donor to activate another photo-sensitizer. The vigor transmission among QD and cells particles could possibly produce responsive oxygen-class to persuade apoptosis in veins as a threefold oxygen reduction equivalent and pigment. The QDs have several features as a good photo sensor, like the continual structure, easy and inexpensive mixture, no poisonousness but possible cytotoxicity under UV radiation when there is nothing light on them.

II. CONCLUSION

QD-based imagery launched a new area in the breast cancer study as an optimal imaging technique. Potential application of breast cancer - based QD imagery in the future is mainly tissue analysis because of its optimum optical properties and quantitative biomarker knowledge, especially in BC molecular pathology. Therefore, before nanomaterials are used in clinical practice, all possible adverse reactions in human physiology must be studied carefully and tested. Advancing personalized medicine is a key for advancing in the progress against compound maladies like tumor and QDs appears as powerful stage for tomorrow's growth.

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