Spotting out the Cancerous Cells with Magnetic Nanoparticles using Microwave Imaging

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***Abstract*— The research in biomedical nanotechnology includes various applications using nanoparticles. The magnetic nanoparticle plays a vital role in medical diagnosis and treatment of cancer. This nanoparticles act as a biomarker for labeling the structures of cells, viruses and protein. One of the most noted medical applications using nanotechnology is Magnetic Drug Targeting (MDT). The MDT has the combination of chemotherapeutic drug and Magnetic Nanoparticles (MNPs), which are bounded together and surrounded near the tumor area by means of an external static magnetic field. The Microwave Imaging (MI) has been proposed as a corresponding diagnostic imaging technique mainly for cancer detection. This paper presents the approaches for spotting out the cancerous cells using the MDT and MI techniques.**

Keywords*— *Nanotechnology, nanoparticles, magnetic drug targeting, microwave imaging, biomarker.

I. INTRODUCTION

Cancer is the most dangerous disease, which affects human life and it leads to death as well. There are many tools and techniques for detecting cancerous cells. The most promising approach in medical diagnosis is the use of MNPs. The MNPs are made from particles of iron and carbon that can be attached to anti-cancer drug. The MDT and MI technique plays a vital role in early detection of cancer cells. The MDT has the combination of chemotherapeutic agent and MNPs, which are applied intra-arterially in the tumor cells. The MDT can keep a larger dose of the drug at the tumor site for a longer period of time and helps in protecting the healthy tissue from the side effects of chemotherapeutic agent. The MNP and the medical agent get surrounded in the tumor area by means of an external static magnetic field.

The visualization of the particles or the particle loaded tissue is done by MI technique. MI has been evolved from older detecting techniques (e.g. radar) in order to evaluate hidden or embedded objects in a structure using Electro Magnetic (EM) waves with frequency ranging from($\sim 300MHz - 300GHz$).

In this paper, the qualitative microwave imaging method is used to calculate a qualitative profile to represent the hidden object. This technique is used to approximately simplify the imaging problem and then back-propagation is used to reconstruct the unknown image profile. MI does not use ionizing radiations which involve relatively cheap and portable equipment's and offer minor patient discomfort.

II. REVIEW ON NANOPARTICLES FOR CANCER DETECTION

The MNPs have the advantage of allowing the use of low frequency magnetic fields, therefore minimizing the unwanted interaction with biological disease. The development of MNP as active Electromagnetic Fields (EMFs) components to improve the magnetic field hyperthermia and MI for medical applications [1].The gold nanoparticles (Au Np) based system in cancer imaging and therapeutic has stimulated the development of a liposome based system to enhance delivery of smaller nanoparticles to cells. The liposome based system was developed for intracellular delivery of small gold nanoparticles [2].The plasmonic nanoparticles are used to investigate the alternative gene splicing of BRCA1 (Breast Cancer) [3].In this progress, the DNA alteration is detected when nanoparticles are captured at the receiver. A sensing platform, consisting of a silica substrate with an array of thin gold patches is used for immobilization of DNA capture sequence by using Localized Surface Plasmon Resonance (LSPR) technique. The smart nanoparticles consisting of "signaling" and "receiving" modules that communicates through the cell signaling network within the body [14]. The most interesting development in the use of nano materials for gene therapy applications such as delivering DNA to cells in the body, for altering what protein they produce or for delivering gene silencing RNA, to shut down the production of a particular gene or protein of interest. The MNPs can be used as ultra sound contrast agent. These MNPs can be sonographically detected even in tissue that suffers from weak echogenicity [5]. In this progress, the particle loaded tissue resembling

phantom could be identified without using additional scattering media.

III. REVIEW ON CANCER CELLS IMAGING TECHNIQUES

Many imaging techniques are being implemented for cancer diagnosis such as X-ray, Computed Tomography (CT), Magnetic Resonance Imaging (MRI) and Positron Emission Tomography (PET). These techniques are termed as traditional techniques for imaging cancer. The detection of cancer cells can be done with the combination of nanotechnology with Superconducting Quantum Inference Devices (SQUIDs) [13]. The SQUID system helps in scanning the human body for early stage cancer. This system consists of 9 gradient coils which is used to intellect a tumor with a depth of approximately 10cm inside the body. The MI technique has been particularly used for diagnosis of nodular formation in breast cancer [3].The Localized Surface Plasmon Resonance (LSPR) technique is used to detect the DNA alteration [3]. Sonographic technique can serve as visualization technique for MDT.

IV. EXISTING WORK

The MNP has the advantage of allowing the use of low frequency magnetic fields reducing the unwanted interaction of biological disease [1]. The gold nanoparticles based system in cancer imaging and therapeutic has stimulated the development of a liposome based system to enhance delivery of smaller NPs to cells [2]. The liposome based system was developed for intracellular delivery of small gold nanoparticles. The plasmonic nanoparticles are used to investigate the alternative gene splicing of BRCA1 [4]. The smart nanoparticle consists of signaling and receiving modules that communicate within the body through cell signaling network [14]. The MNPs can be used as ultra sound contrast agents [5]. The tumor cells can be imaged by using various imaging techniques such as X-ray, CT, MRI, Positron Emission Tomography, SQUIDs, MI, Localized Surface Plasmon Resonance, Sonographic technique. These are the traditional and modest imaging techniques used so far for the detection of cancerous cells.

V. PROPOSED WORK

In this Research, the MDT is used for targeting the tumor cells. This MDT application is the most promising medical application for diagnosis of cancerous cell using MNPs. Compared to the traditional chemotherapeutic treatment; the MDT can keep a larger dose of the drug at the tumor site for a longer period of time and help in protecting the healthy tissue from the side effects of chemotherapeutic agent. The MDT has the combination of chemotherapeutic agent and MNPs which are applied intra-arterially in the tumor cells. The MNP and the medical agent get surrounded in the tumor area by means of an external static magnetic field. The magnetic force $\vec{F}(\vec{p},\mathrm{q})$ on a particle due to the magnetic field $\mathrm{M}(\vec{p},\mathrm{q})$ can be calculated by,

$$\vec{F}(\vec{p},\mathrm{q})=\frac{\chi W^{V}}{2\mu 0}\vec{\nabla}(|\mathrm{M}(\vec{p},\mathrm{q})|^{2})$$

Thus, the magnetic force $\vec{F}(\vec{p},\mathrm{q})$ depends on the spatial position $\vec{p}$ and the volume V of the nanoparticle, the vulnerability χW of the nanoparticle material and on the magnetic field gradient. It is to be noted that the volume V and the vulnerability χW in this case refer to the magnetic core. Since the whole particle consist of a magnetic core and biocompatible shell. The volume V of the magnetic core has a major impact on magnetic properties. The vulnerability depends on the material of the magnetic core of the particle. The selection of the materials affects substantially the magnetic force $\vec{F}(\vec{p},\mathrm{q})$ and thereby the measuring effect. Different magnetic field excitations have been analyzed and different evaluation algorithms have been investigated.

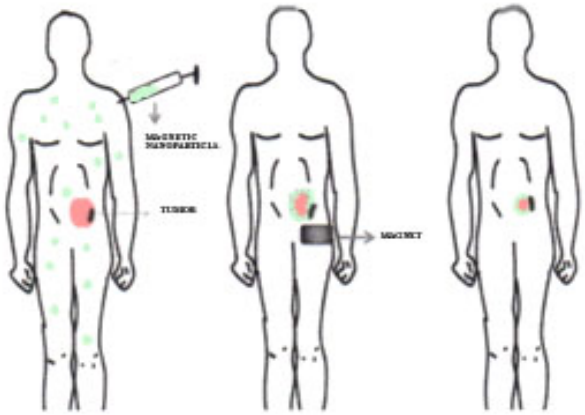

Fig. 1. Detection of tumors cells

Figure1: Indicates that the targeted nanoparticles moves due to the time variant magnetic force $\vec{F}(\vec{p},\mathrm{q})$ which get surrounded to the cancerous cells by MDT and the detection is made with the help of MI. Compared to X-ray and MRI techniques, MI does not use ionizing radiations. This targeting technique concentrates tumor with only a low amount of MNP. The MI system has two parts, hardware and software.Figure2.indicates the hardware and software components of MI. The hardware is responsible to collect data from the sample under test. Here we use a transmitter antenna which sends EM waves towards sample i.e., human body for medical imaging.

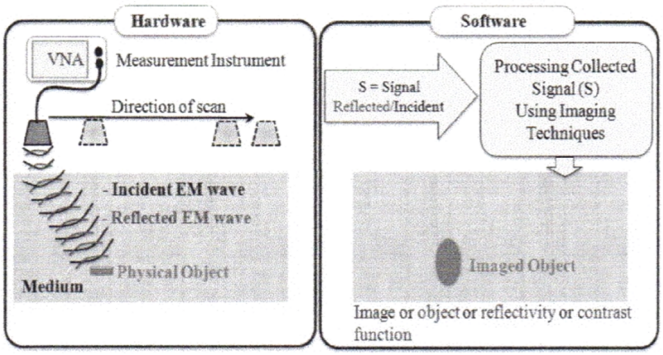

Fig. 2. The hardware and software components of microwave imaging

If the difference between the properties of anomaly and the surrounding medium is bigger, there will be a stronger reflection. This reflection will be collected and measured by the same antenna or by another receiver antenna. Later, the collected data which is termed as raw data is fed into the software part to get processed. Here, the qualitative microwave imaging method is used to calculate a qualitative profile to represent the hidden cancerous cells. This technique is used to approximately simplify the imaging problem and back-propagation is used to reconstruct the unknown image. Synthetic Aperture Radar (SAR), Ground-Penetrating Radar (GPR), and Frequency-Wave Number Migration (FWNM) algorithm are some of the most popular qualitative MI methods.

VI. DISCUSSION

In this paper, the MDT is used to target the tumor cells inside the human body. The MDT has the combination of chemotherapeutic drug and MNPs. The drug gets spread throughout the human body. And after applying an external magnetic force, the MNPs get surrounded to the tumor cell. The tumor cells can be detected using qualitative microwave imaging technique which is used to send EM waves. The signals are received through an antenna. This technique helps in finding out even the hidden cancer cells within the body through electric signals.

CONCLUSION

The combination of MDT and qualitative MI technique plays a challenging role in detecting the tumor cell even when they are in the hidden area. These technique, paves a way to increase the lifespan of humans who are affected by the very dangerous and life hunting cancer. Our future work is based on giving treatment for cancer cells using the MI technique.

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