A NEW REVOLUTION FOR CANCER DIAGNOSIS USING CLINICAL ADVANCES IN NANOTECHNOLOGY

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ABSTRACT:
Cancer remains the most devastating disease and the major cause of mortality worldwide. Although early diagnosis and treatment are the key approach in fighting against cancer, the available conventional diagnostic and therapeutic methods are not efficient. The development of new effective cancer treatment methods has attracted much attention, mainly due to the limited efficacy and considerable side effects of currently used cancer treatment methods such as radiation therapy and chemotherapy. Nanotechnology is gaining significant attention worldwide for cancer treatment. Nano-biotechnology encourages the combination of diagnostics with therapeutics, which is a vital component of a customized way to deal with the malignancy. Nanoparticles are being used as Nanomedicine which participates in diagnosis and treatment of various diseases including cancer. The unique characteristic of Nanomedicine i.e. their high surface to volume ratio enables them to tie, absorb, and convey small bio-molecule like DNA, RNA, drugs, proteins, and other molecules to targeted site and thus enhances the efficacy of therapeutic agents. The development of nano-materials marks a significant step forward in photo-thermal therapy of cancers. Hence in this work, a new revolution approach for cancer diagnosis using clinical advances in nanotechnology is presented. This approach will improve the survival rate of cancer patients.

KEYWORDS: **Cancer, Nano-Biotechnology, Nanoparticles, Photo-Thermal Therapy (PTT).**

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I. INTRODUCTION

Cancer is a leading cause of death and a global health burden. Cancer is caused due to the uncontrolled division of abnormal cells. One of the most common features is the potential to spread to other parts of the body. It has the capacity to destroy healthy cells and tissues which has proved to be fatal over the years. Among the various types of Diseases, Cancer is considered as one of the deadly diseases in the world.

Lung, Prostate, and Breast Cancer are some of the Cancer types that are contributing most to the Mortality Rate. Normal cells are transformed into tumor cells when genetic factors of a person interact with some external agents like physical, chemical and biological carcinogens which are a multistage process. In the present days the number of cases of cancer patients is rising steadily, mainly caused by over diagnosing and over treating patients. These mistakes are caused by the poor decisions the doctors make when they analyze the imaging. The highest survival chances, on any type of cancer appear when the cancer is detected in its early stages [1].

Medical Image Processing is a relatively a new research field. This field is based on the application of computer vision techniques to data sets acquired using medical imaging modalities. These modalities include ultrasound, MRI (Magnetic Resonance Imaging), CT (Computed Tomography), SPECT (Single Photon Emission Computed Tomography), PET (Positron Emission Tomography) and fundus photography.

In the last few years, the popularity of MIP (Medical Image Processing) has been increased a lot The most widely used imaging techniques, such as X-ray, magnetic resonance imaging (MRI), computed tomography (CT), endoscopy, and ultrasound, can only detect cancer when there is a visible change to the tissue. By that time, thousands of cancer cells may have proliferated and even metastasized. In addition, current imaging methods cannot distinguish benign lesions from malignant lesions. Therefore, the development of technologies for detecting cancer at an early stage, before metastasis, presents a major challenge.

Medical science yields huge amount of data on daily basis from research and development (R&D), physicians and clinics, patients, care givers etc. n. A lot has been said during the past several years about how precision medicine and, more concretely, how genetic testing is going to disrupt the way diseases like cancer are treated [3].When the cancer is in an advanced stage or the tumors are deemed inoperable, other treatment strategies must be utilized. Radiation therapy and chemotherapy have been used to eradicate the cancer cells and inhibit them from spreading in the body (metastasis) after the surgical procedure.

Conventional therapeutic approaches to treat malignant tumors such as surgery, chemotherapy, or radiotherapy often lead to poor therapeutic results, great pain, economic burden, and risk of recurrence and may even increase the difficulty in treating the patient. These approaches have also significant drawbacks such as irreversible damage to healthy tissues, limited therapeutic efficacy, and reduced patient's quality of life. Finding an efficient and safe cancer treatment method with reduced side effects has therefore attracted considerable attention among researchers [2].

Long-term drug administration and systemic drug delivery for cancer chemotherapy would be accompanied by drug resistance or unpredictable side effects. Thus, the use of photothermal therapy, a relatively rapid tumor elimination technique that regulates autophagy and exerts an antitumor effect, represents a novel solution to these problems [9].

As a result of their unique compositions and properties, nano-materials have recently seen a tremendous increase in use for novel cancer therapies. By taking advantage of the optical absorption of near-infrared light, researchers have utilized nanostructures such as carbon nanotubes, gold nanorods, and graphene oxide sheets to enhance photo-thermal therapies and target the effect on the tumor tissue.

Nanomedicine is the current field of technological innovation, which embraces the use of nanomaterial and nanoelectronic biosensors. The application of nanomedicine in cancer involves both diagnosis and therapy. For cancer diagnosis, nano-particles are being applied to capture cancer biomarkers, such as cancer-associated proteins, circulating tumor DNA, circulating tumor cells, and exosomes. An essential advantage of applying nano-particles for cancer detection lies in their large surface area to volume ratio relative to bulk materials. Due to this property, nanoparticle surfaces can be densely covered with antibodies, small molecules, peptides, aptamers, and other moieties. Photothermal therapy (PTT) is a process in which a photo-sensitive nanomaterial facilitates the non-invasive conversion of light to heat, is one of several newer cancer therapeutic approaches [10].

This work presents a novel revolutionary approach for cancer diagnosis using clinical advances in nanotechnology. The rest of the work is organized as follows: The section II describes various cancer diagnosis techniques. The section III presents a novel revolutionary approach for cancer diagnosis using clinical advances in nanotechnology. The section IV evaluates the result analysis of presented approach. Finally the work is concluded in section V.

II. LITERATURE SURVEY

Devdatta Basu**,** Sheetal Kashid**,** Sanjay Pawar**,** Debabrata Datta et. al., [6] presents An Integrated Detection and Treatment Recommendation Framework for Breast Cancer Using Convolutional Neural Networks and TOPSIS. This paper explores regression using Convolutional Neural Networks (CNN) to pin-point the probable abnormal region in mammograms and calculate several morphological, texture and histogram features associated with it. The recommendation is based on the extracted features and therefore constitutes a Multi-Criteria Decision Making (MCDM) problem. To implement this type of decision making rightfully, the paper makes use of the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) where the identified features are used as criteria and experts' opinion are used as alternatives to obtain ranked recommendations. The methodology proposed in the paper is capable of recommending the correct treatment with an accuracy of 81.5%.

Oscar Knights, Steven Freear and James R. McLaughlan, et. al., [7] described Improving Plasmonic Photothermal Therapy of Lung Cancer Cells with Anti-EGFR Targeted Gold Nanorods. In this study, the use of pulsed lasers for photothermal therapy was investigated and compared with continuous wave lasers for gold nanorods with a surface plasmon resonance at 850 nm, which were functionalised with anti-EGFR (Epidermal Growth Factor Receptors) antibodies. Photothermal therapy was performed with both laser systems, on lung cancer cells (A549) in vitro populations incubated with untargeted and targeted nanorods. It was shown that the combination of pulse wave laser illumination of targeted nanoparticles produced a great reduction of in the cell viability compared with control exposures, which demonstrates a possible application for minimally invasive therapies for lung cancer.

Naji Khosravan, Ulas Bagci et. al., [11] describes Semi-Supervised Multi-Task Learning for Lung Cancer Diagnosis. A 3D deep multi-task CNN (Convolutional Neural Network) is presented to tackle these two problems jointly. We tested our system on LUNA16 dataset and achieved an average dice similarity coefficient (DSC) of 91% as segmentation accuracy and a score of nearly 92% for FP reduction. As a proof of the hypothesis, authors showed improvements of segmentation and FP reduction tasks over two baselines. The results support that joint training of these two tasks through a multi-task learning approach improves system performance on both. We also showed that a semi-supervised approach can be used to overcome the limitation of lack of labeled data for the 3D segmentation task.

Liangran Guo, Daisy D. Yan, Dongfang Yang, Yajuan Li, Xiaodong Wang, Olivia Zalewski, Bingfang Yan, and Wei Lu et. al., [13] presents Combinatorial Photothermal and Immuno Cancer Therapy Using Chitosan-Coated Hollow Copper Sulfide Nanoparticles. They presents a design of a near-infrared light-induced transformative nanoparticle platform that combines photothermal ablation with immunotherapy. The design is based on chitosan-coated hollow CuS nanoparticles that assemble the immunoadjuvants oligodeoxynucleotides containing the CytosineGuanine (CpG) motifs. The experimental results indicated that combined photo-thermal immunotherapy is more effective than either immunotherapy or photo-thermal therapy alone against primary treated and distant untreated tumors in a mouse breast cancer model. These hollow CuS nanoparticles are biodegradable and can be eliminated from the body after laser excitation.

N. Werghi**,** C. Donne**,** F. Taher; H. Alahmad et. al., [17] presents Segmentation of sputum cell image for early lung cancer detection. They presents a framework for the detection and segmentation of sputum cells in sputum images using respectively, a Bayesian classification and mean shift segmentation. Our methods are validated and compared with an other competitive technique via a series of experimentation conducted with a data set of 88 images.

Jui-Teng Lin, Yueh-Sheng Chiang, Guang-Hong Lin, Hsinyu Lee, and Hsia-Wei Liu et. al., [18] describes In Vitro Photothermal Destruction of Cancer Cells Using Gold Nanorods and Pulsed-Train Near-Infrared Laser. They presents a novel pulsed-train near-IR diode laser system with real-time temperature monitoring of the laser-heated cancer cell mixed in gold nanorod solution. Near-IR diode laser at 808 nm matching the gold nanorod absorption peak (with an aspect ratio about 4.0) was used in this study. Both surface and volume temperatures were measured and kept above 43◦C, the temperature for cancer cells destruction. The irradiation time needed in our pulsed-train system with higher laser fluence for killing the cancel cells is about 1–3 minutes, much shorter than conventional methods (5–10 minutes). Cell viabilities in gold nanorod mixed and controlled solutions are studied by green fluorescence.

III. A NEW REVOLUTION FOR CANCER DIAGNOSIS

A novel revolutionary approach for cancer diagnosis using clinical advances in nanotechnology is presented in this section. Nanotechnology and more accurately nanomedicine could progress rapidly and replaced with the traditional therapeutic methods with the new and more effective systems to win in the fight against diseases. Nano-medicine could solve lots of problems in cancer therapy by maximizing drug targeting and minimizing drug side effects. In addition to these advantages, the real miracle of nanotechnology is to change the war strategy. The resistance of bacteria and cancer cells after a period of treatment by the existing drugs forced us to improve the generation and potency of medicines. Perhaps in the opposite side the microbes and cancer cells are also fighting with human for their survival. Thus, the field of nanotechnology could change this cycle in our favor by providing new and advanced treatments. In this analysis gold nano particles are used. The generalized block diagram of gold nano-particles applications.

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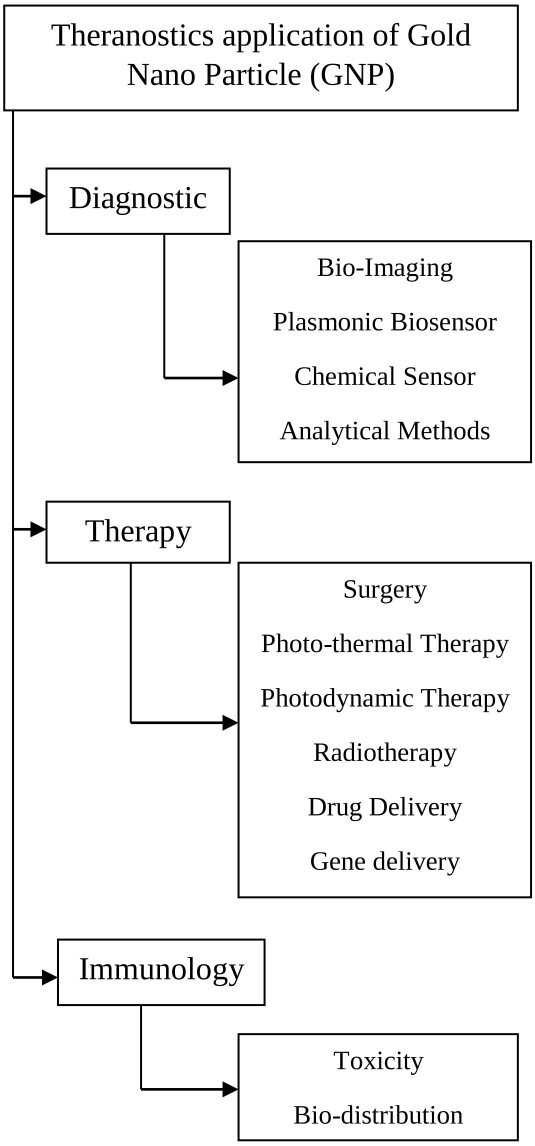

Fig. 1: Generalized Applications of Gold Nano-Particles

The use of nanotechnology in cancer therapeutics has been to improve the pharmacokinetics and reduce the systemic toxicities of chemotherapies through the selective targeting and delivery of these anticancer drugs to tumor tissues. The term “theranostics” describes any “material that combines the modalities of therapy and diagnostic imaging” into a single package. Nowadays, nanomedicine theranostics for cancer is progressing with the design of multifunctional platforms that consist of colloidal NP ranging in sizes from 10 to 1000 nm in which the diagnostic and therapeutic agents are adsorbed, conjugated, entrapped or encapsulated. Theranostic nanoparticles are multifunctional nanosystems, which are well-designed for more specific and personalized disease management by combining diagnostic and therapeutic capabilities into one single biocompatible and biodegradable nanoparticle Theranostics methods may be applied in treatment of esophageal cancer, prostate cancer, breast cancer, in treatment of actinic keratosis, actinic cheilitis and Bowen's disease and in treatment of basal cell epithelioma and macular degeneration. Theranostics is essentially the coupling of diagnostic and therapeutic tools related to the same specific molecular targets, enabling more accurate patient selection, prediction of treatment response and tissue toxicity, and response evaluation, with the goal of better outcomes.

Due to the immense progress of photonic science and new findings on the unique features of gold in the optic and plasmonic field it is expected that photonics will have special contribution in the future medicine and GNPs play unique role in the field of diagnosis and therapy.

Gold nanoparticles (GNPs) can be designed to have strong surface plasmon resonance in the Near-Infrared (NIR) region, which have the best optical window for biomedical imaging and therapy owing to the low optical attenuation coefficients of water and other tissue chromophores in this spectral range (700-900 nm). Therefore, GNPs can be used for Drug delivery, gene delivery and photothermal therapy (PTT) and photodynamic therapy (PDT) for therapeutic applications and surface-enhanced Raman spectroscopy (SERS), multiphoton microscopy, x-ray computed tomography (CT), magnetic resonance imaging (MRI), positron emission tomography (PET), and single-photon emission computed tomography (SPECT) for imaging purposes. GNPs play unique role in the field of diagnosis and therapy. The Fig. 2 shows the workflow diagram of presented approach.

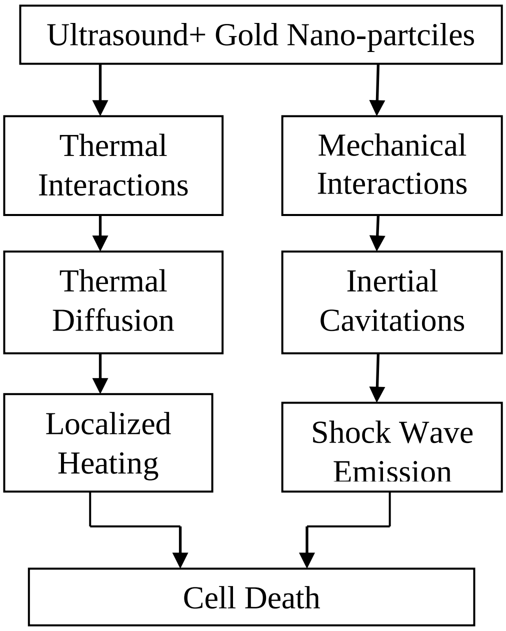

Fig. 2: Workflow diagram of Presented Approach

Ultrasound is as an external source of energy that can be used to heat cancer cells and offers selected intrinsic advantages over other heating sources. Heat induced by ultrasound can be remotely focused at any depth of the body. As a result, localized heating of the tumor with reduced thermal damage to the surrounding healthy tissues is achievable via ultrasound.

High intensity focused ultrasound, referred to as HIFU (0.1-1 kW/cm^2), is a non-invasive treatment modality that has been used for treatment of both benign and malignant diseases. Uterine fibroids, benign prostatic hyperplasia, prostate cancer, breast cancer, brain tumors, and liver and kidney malignancies are the main diseases in which HIFU plays a critical therapeutic role nanoparticles play the role of sensitizers and enable the tissue to absorb the energy of ultrasound waves and eventually heat the tumor.

The presence of gold nano-particles in the acoustic field affects both the thermal and mechanical interactions of ultrasound with tissues and might lead to enhancement of both ultrasound-induced heating and cavitation. The thermal interactions of ultrasound with a medium loaded by gold nanoparticles depend on the attenuation coefficient and the thermal conductivity of the gold nanoparticles.

(i) Ultrasound attenuation coefficient: Through absorption and scattering of ultrasound waves, nanoparticles induce additional attenuation of the acoustic waves and cause additional thermal dissipation. It has been demonstrated that larger nanoparticles can attenuate the acoustic waves more extensively than small nanoparticles. Additionally, in the presence of the same-sized nanoparticles, higher intensities and frequencies of ultrasound are more extensively attenuated by nanoparticles.

(ii) Thermal conductivity: Due to their high thermal conductivities, metallic nanoparticles can enhance the effective thermal conductivity of a tumor loaded with such gold nanoparticles. Therefore if a tumor loaded by gold nanoparticles is irradiated with ultrasound, it exhibits an increased heating rate compared with the surrounding tissues. According to the literature and comparisons with nanoparticles with low thermal conductivity, it is now clear that a tumor will be heated more rapidly if loaded with gold nanoparticles with higher thermal conductivity. Additionally, it is obvious that smaller nanoparticles have a higher thermal conductivity because of their higher surface to volume ratio. A characteristic feature of nanoparticle thermal diffusion by which it differs from the thermal diffusion of gas molecules is the dependence of the thermal diffusion coefficient and other parameters on the nanoparticle size. Naturally, the thermal diffusion coefficient decreases with increasing nanoparticle size.

Local hyperthermia is used to heat a small area like a tumor. Very high temperatures are used to kill the cancer cells and destroy nearby blood vessels. In effect, this cooks the area that is exposed to the heat. Hyperthermia is a type of treatment in which body tissue is heated to as high as 113 °F to help damage and kill cancer cells with little or no harm to normal tissue. Hyperthermia to treat cancer is also called thermal therapy, thermal ablation, or thermotherapy.

Tumor cavitation defined as a change of the density of the tumor mass with appearance of air-filled cavity inside the lesion and concomitant decrease of the solid component. Shock waves also sensitize tumor cells for adjuvant chemotherapy and increase its antitumor activity. During treatment, the clinician holds a shockwave device next to the skin. The device sends shockwaves into the injured tissues, stimulating increased blood flow and growth hormones to the area, promoting new tissue growth.

By decreasing the cavitation nucleation threshold, nanoparticles as the nuclei in an acoustic field can enhance the degree of cavitation. It is well known that the jet formation and shock wave emission that results from inertial cavitation causes mechanical damage to the cell membrane, and eventually cell lysis occurs. A type of cell death in which a series of molecular steps in a cell lead to its death. This is one method the body uses to get rid of unneeded or abnormal cells. Taken together, the thermal and mechanical interactions of acoustic waves can be enhanced in the presence of Gold nano-particles, and such enhancement eventually increases the amount of ultrasound-induced cell death.

IV. RESULT ANALYSIS

In this section, A novel revolutionary approach for cancer diagnosis using clinical advances in nanotechnology is implemented. In this analysis, gold nano particles are used. The presence of gold nano-particles in the acoustic field affects both the thermal and mechanical interactions of ultrasound with tissues and might lead to enhancement of both ultrasound-induced heating and cavitation which can leads to more number of cell deaths. As a result effective cancer therapy is provided. The performance of presented approach is evaluated in terms of cell death rate and tumor efficacy. The Table 1 shows the performance evaluation of presented approach in terms of cell death.

Table 1: Performance Evaluation

Approaches	Experiment Medium	Nanopartciles used	Cell Death (%)
Porous silicon nanoparticles as efficient sensitizers for sonodynamic therapy of cancer	Cancer cell	silicon	80
A novel revolutionary approach for cancer diagnosis using clinical advances in nanotechnology	Cancer cell	Gold	98

Compared to silicon nanopartciles, presented approach using GNPs and ultrasound has high cell death (%). The graphical representation of cell death comparison is shown in Fig. 3.

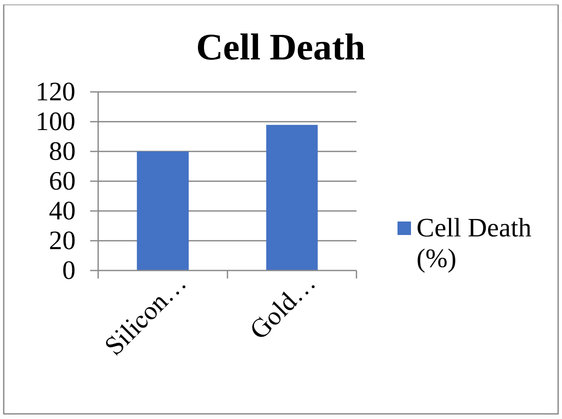

Fig. 3: Comparative Graph for cell Death

Presented approach has high percentage of cell death than conventional approach using silicon nano particles. As a result the survival rate of cancer patients will be improved. The fig. 4 shows the Quantitative measurement of tumor volumes after different treatments.

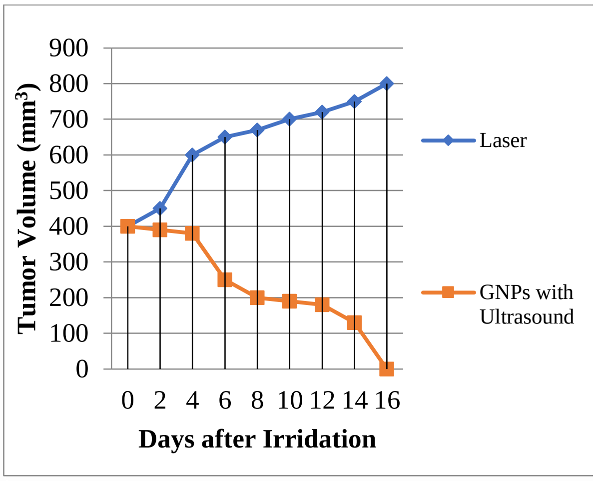

Fig. 4: Quantitative Measurement of tumor volumes

From fig. 4 it is clear that presented approach has excellent anti-tumor efficacy under the NIR light irradiation. With its high sensitivity, specificity, and multiplexed measurement capacity, nanotechnology provides great opportunities to improve cancer diagnosis, which will ultimately lead to an improved cancer patient survival rate.

V. CONCLUSION

In this work, A novel revolutionary approach for cancer diagnosis using clinical advances in nanotechnology is implemented. First in this approach the generalized applications of Gold Nano-Partciles (GNPs) are discussed in detail. Gold nanoparticles (GNPs) are designed to have strong surface plasmon resonance in the NIR region, which have the best optical window for biomedical imaging Ultrasound is as an external source of energy that can be used to heat cancer cells. The presence of gold nano-particles in the acoustic field affects both the thermal and mechanical interactions of ultrasound with tissues and leads to enhancement of both ultrasound-induced heating and cavitation. The thermal and mechanical interactions of acoustic waves are enhanced in the presence of Gold nano-particles, and this eventually increases the amount of ultrasound-induced cell death. As a result cancer patients survival rate is improved. The performance of presented approach is evaluated in terms of cell death rate and tumor efficacy. Compared to conventional methods, presented approach has high cell death percentage and better tumor volume efficacy. Advanced nanotechnology provides great opportunities to improve cancer diagnosis, which will ultimately lead to an improved cancer patient survival rate.

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