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ADVANCES IN MEDICAL DIAGNOSIS AND THERAPY: THE ROLE OF PHYSICS TECHNIQUES

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ABSTRACT

The paper titled "Advances in Medical Diagnosis and Therapy: The Role of Physics Techniques" discussed the contributions of physics in medical science that enhanced the health standard of the people in Nigeria for national development. The paper looked at some critical and ever growing health challenges like cancer, tumor, mental cases, kidney problems among others, confronting the health science and the implications for the nation's development. Physics techniques have provided help in the field of medicine to face the ever growing challenges of the health science through diagnosis and therapy. The paper concluded that the intervention of physics in medical science helps in enhancing health standard of the people as bases for increase productivity leading to national development. Three recommendations were made, one of which is to encourage the development of physics-based technologies across the nation.

Keywords: Physics Techniques, Medical diagnosis and therapy.

INTRODUCTION

Physics technique is destined to be ever changing. it has emerged as a mechanism that is responding to technological and scientific problems faced in the medical field either by developing and introducing new imaging and treatment technologies, or by discovering and implementing new and existing methodologies over the years, medical physics techniques has had a profound impact on the medical practice, particularly in terms of improved diagnostics and treatment of the disease. This privilege dos not come for free however; it require medical physicists to have broad scientific internets, to constantly learn and acquire new knowledge, and always be ready for surprises that might change the direction of their work.

Developments in medical physics diagnostic technique sometimes strongly overlap with developments in related disciplines like biomedical engineer and biophysics. This paper focuses on current trends that are already impacting medical physics field it is by no means an exhaustive view of recent developments, but it is aimed to highlight some of the specific areas, which might have the most significant and profound impact on the long-term future of the field, in addition, it was aimed that even though predicting the future is not possible, general development of the field can be anticipated by review of the factors and forces that drive its development in medicine and other related fields.

DIAGNOSTIC TECHNIQUES AND THERAPY

Approach to disease diagnostics is also becoming more and more complex. Diagnostic procedures are becoming extensive, utilizing a variety of diagnostic tools, from imaging procedures to various Biomarkers testing, like genetic and molecular profiling (Jeraj, 2009). As a result of the complexity of diagnostic and treatment procedures, the term disease management has become much more a common, in addition to physicians team (e.g, radiation oncology + medical oncology + surgery teams), disease management often includes other interdisciplinary scientists, like pathologists, pharmacologists, molecular biologists, some of the major areas, of break through in medical physics diagnostics techniques which will be briefly discussed here, are;

1. Computerized tomography and x-rays lasers

2. Nanotechnology diagnostics technique

(i) Targeted (controlled)drug delivering

(ii) Radio therapy and cancer treatment

(iii) Nano-Biosensors

3. Matter /Antimatter collision imaging technique

4. Laser induced breakdown spectroscopy technique

COMPUTERIZED TOMOGRAPHY AND X-RAYS LASERS

X-Ray tomography is a branch of medical radiology, used as a diagnostic technique (El-Sherbini, 2016). It is well known that x-rays are not absorbed equally will by different parts of the body. Heavy elements in the body such as calcium are much better absorbers of x-rays than elements such as carbon, oxygen and hydrogen (Haisch, 2012). On an ordinary X-ray image the shadows of all the objects in the path of the x-ray beam are superimposed and thus the shadows of normal structures may mash or interfere with the shadows that indicate the disease (Chua, 2015). In order to distinguish shadows indicating diseases, x-ray images should be taken different directions, such as from the back the sides and under an oblique angle, taking x-ray images of slices of the body (body section radiography) is known as tomography" (Haisch, 2012), X-ray imagines was dramatically improved by the invention of the computerized tomography (CT) by Godfrey Hounsfield in 1972 (Hounsfield, 1973) this invention led him together with Allan Cormack to earn a Nobel Prize in medicine in 1979. The X-ray (CT) imaging is similar to that taken by a planar camera, however, with two additional features, firstly, the camera is constructed so that the head can rotate either stepwise or continuously about the patient to acquire multiple views. Secondly, it is equipped with a computer that integrates the multiple images to produce cross-sectional views of the organic liver, thyroid, brain, heart, kidney and other body organs

Computerized tomography (CT) X-ray imaging unveiled the mystery of the incidence and evolution of many diseases. For example, ct together with the development of appropriate computer algorithm, made it possible to locate micro calcifications in digitized mammograms, which led to the early detection of breast cancer. In fact, x-ray computed tomography had a fundamental impact on medicine. A few milestone in medical physics diagnostic technique is the introduction of optical topographic which is a form computed tomography (CT) that creates a digital volumetric model of an object by reconstructing images made from light transmitted and scattered through an object (Haisch, 2012). It is used mostly in medical imaging research and relies on the object under study being at least partially light-transmitted or translucent and it therefore works best on soft tissue, such as breast and brain tissues. Further developments in computed tomography were the invention of optical coherence tomography (OCT) that uses light to capture micrometer revolution, three-dimension images from within optical scattering biological tissues (Huang, et al, 1991). This medical imaging technique is based on low coherence interferometry, typically employing near-infrared light. The use of relatively long wavelength light allows it to penetrate into the scattering medium. The light sources employed in (OCT), include super-luminescent diodes, ultra short pulsed lasers and super-continuum lasers, this imaging technique has the ability of achieving sub-micrometer revolution over a wide range of wavelengths, 100nm, together with the advantage of high signal-to-noise ratio, permitting fast signal acquisition, nowadays, optical coherence tomography (OCT) in medical diagnostics is considered a prominent imaging technique that can give high resolution, cross-sectional and three dimensional images of bio-medical tissues in real time, using the coherence properties of laser lights (Huang, et al, 1991).

It has several and diverse applications in medical diagnostic, such as in ophthalmology and optometry where it can be used to obtain detailed images from within the retina (Fercher, Hitzenberger, Drexler, Kamp and Sattmann 1993). It has also been used recently, in interventional cardiology to help diagnose coronary artery disease (Bezerra, Costa, Guagliumi, Rollins and Simon, 2009). Moreover, it has been proven promising in dermatology to improve the diagnostic process and offers a potential option for imaging of the dermal structures with faster and deeper reaching systems (Phillip, 2014). OCT allows the reconstruction of the images from the upper skin layers, in a similar way as ultrasound does, but with much higher spatial resolution. It can be used to illustrate single layers and their vertical and horizontal expansion. Imaging depth is usually about 1mm, but is dependent on the specific properties of the tissues (Mogensen, Morsy, Thrane, and Jemec, 2008).

The advances in laser physics have also considerable impact on medicine and biomedical research, soon after the advent of lasers in 1960 they found their way into biomedical sciences and medical diagnostics applications, such as ophthalmology, dermatology, dermatology, cosmetic surgery, oncology, dentistry and many areas of medicine compared with the traditional light sources used in medicine, lasers operate within a very narrow wavelength range and the light emitted is coherent. They have much higher intensities and power densities and moreover, they are capable of operating at specific wavelength. These properties have led lasers to be used preferably in medical diagnose is and therapies

NANOTECHNOLOGY DIAGNOSTIC TECHNIQUE

The breakthrough that led to the practical realization of nanotechnology came in the 1980s. This was with the invention of the scanning tunneling microscopes (STM) in 1982, by Gerd binning and Heinrich Bohrer (Joachim, et al, 2014). Their invention sparked the growth of nanotechnology and was recognized with a noble prize in physics in 1986 (Joachim, et al, 2014). Soon afterwards, it was followed by the inventions of the atomic force microscope (AFM), by Gerd Binning and Calvin Quate in 1986, with both the (STM) and the (AFM) devices, it became possible to observed structures on the atomic scale, (Korin, et al, 2012).

The use of nanotechnology in medical science and applications, known as nanomedicine, is a rapidly expanding field. Although this field is still in its infant stage, there is a growing interest among the medical community for the medical application of nanomaterials diagnostics technique due to its ability to bring more progress and breakthroughs in diagnostics, therapies and prevention of diseases. (Boisse and Loubaton, 2014), nowadays nanotechnology and nanomaterials have a wide spectrum of medical applications, including targeted drug delivery, radio therapy and cancer treatment, nano-biosensors and nano-medical imaging,

Targeted (Controlled) Drug Delivery

This diagnostic technique is used for cancer, tumors or other types of diseases where the effect of drugs is optimized while toxic side effects are reduces, a technique that employ nanoparticles to deliver drugs to specific types of cells currently under development, with some applications already being used. Nanoparticles are controlled and attracted to diseased cells in the body which leads to a direct attack and treatment of those cells. This technique reduces damage to healthy cells in the body and allows for easier detection of the disease (Tiwari, et al, 2014). For example, nanoparticles that release drugs when subjected to shear force were tented and used to dissolve clots that blocked arteries (Wang, et al, 2012). According to Tiwari, et al (2014) researchers in Massachusetts institute of technology (MIT). And university of Illinois both in USA have demonstrated that gelatin nanoparticles can be used to deliver drugs to damaged brain tissues and nanoparticles can also be used to deliver vaccines; the nanoparticles protect the vaccine, allowing it more time to trigger a stronger immune response.

Radio Therapy and Cancer Treatment

The nanotechnology could play an effective role in radiation oncology. Nanoparticles less than 50nm in size are capable of entering cells, if they are less than 20nm, they can also transmit out of small blood vessel, they can be made of lipids, polymers, semiconductors or metals and may have the form of particles, shells, rods, tubes or quantum dots. Their nano-scale allows them to preferentially penetrate and be retained by biological cells and tissues. It is well known that tumors stimulate the growth of new blood vessels in their neighborhoods that can supply them with oxygen and other nutrients to sustain their rapid cell replication and growth. Thereby by loading the particles with chemotherapy drugs-established cancel. Killers-one can deliver the drugs to tumor cells without damaging healthy cells (Grossman and Mc Neil, 2012).

Nano-Biosensors

A biosensor is an analytical device used for the detection of analytical device used for the detection of an analyte, that combines a biological component with a physiochemical detector (Banica 2012, Zoraida, 2013). The field of nanobiosensing is quite promising, especially in areas that could not be accomplished by conventional bulk materials. The application of biosensors ranges from food quality assessment to environmental monitoring, medical applications and diagnostics. In medical applications and diagnostics nanomaterials are playing an important role in the development of efficient biosensors which can analyze the minute details of biological interaction with extreme precision and sensitively, there are numerous clinical applications that are concerned with the use of nanobiosensors in routine. These applications include the detection of glucose in diabetic patients the detection of urinary tract bacteria infections, the detection of HIV-AIDS and the diagnosis of cancer (Zoraida, 2013).

MATTER/ANTI-MATTER COLLISION IMAGING TECHNIQUE.

This is another rapidly growing technique used to detect diseases in people of all ages known as position emission tomography (PET), this technique uses short-lived radionuclide produced in cyclotrons. These nuclides are labeled to compounds such as glucose/testosterone and amino acids to monitor physiological factors1 including blood flow and glucose metabolism. These images can be crucial in detecting seizures, coronary heart disease and ischemia. In cancer are PET imaging is used to detect tumors and monitor the success of treatment courses as well as detecting early recurrent disease. The actual imaging technique sounds like a science fiction movie because it involves matter and antimatter annihilating one another. The short-lived radionuclide decay and emit particles known as positions while the antimatter is equivalent to electrons. These positions rapidly encounter electrons, collide, annihilate, and produce a pair of photons which move in opposite directions. These photons can be captured in special crystal and the images produced by computer techniques (Bardi, 2016),

LASER INDUCED BREAKDOWN SPECTROSCOPY TECHNIQUE

Laser induced breakdown spectroscopy (LIBS) is a form of optical emission spectroscopy (El-Sherbini 2016), it is a technique based on utilizing light emitted from plasma that is generated via interaction of high power laser beans with matter (solids, liquids, or gases), assuming that light emitted is sufficiently influenced by the characteristic parameters of the plasma, the atomic spectroscopic analysis of the emitted light shows considerable information about the elemental structure and the basic physical processes in plasmas, (Noll, 2012). There is a growing interest in LIBS, particularly in the last 20years due to its applications in industry, environment, medicine, forensic sciences and arts (bardi 2016). It provides a powerful tool for elemental analysis which surpasses in sensitivity of other traditional elemental analysis techniques; it offers a flexible and convenient technique for the rapid determination of the elemental composition of samples, together with the advantage of minor or no sample preparation. Recently, LIBS has been applied to biological and medical systems and extensively in the analysis of human tissue samples. The medical applications of LIBS can be namely classified into two categories (El-Sherbini, 2016).

- The analysis of human clinical specimens (e.g teeth, bones, urinary bladder and gall stones, liver tissues or other tissues samples)

- The analysis of microorganisms (e.g bacteria, moulds, yeasts and viruses). The LIBS technique includes but not limited to the followings
- It is a simple and promising technique capable of diagnosing malignant cell and tissues.
- It reduces the possibility of contamination as well as standard errors.
- It is capable of detecting trace elements with very low concentrations in the range of one part per million.
- It is a minimally invasive technique, since a small size sample can lead to good results,
- It gives online qualification for all trace elements in a tissue simultaneously.

IMPORTANCE OF PHYSICS TECHNIQUES IN MEDICAL DIAGNOSIS AND THERAPY

Many of the greatest inventions in modern medicine were developed by physicists who imported technologies such as x-rays, nuclear magnetic resonance, ultrasound, particle accelerators and radioisotope tagging and detection techniques into the medical domain. There they became magnetic resonance imaging (MRL), computerized tomography (CT) scanning, nuclear medicine, positron emission tomography (PET) scanning and various radiotherapy treatment methods. These contributions have in no small measure revolutionized medical techniques for imaging the human body and treating disease by extension enhanced the health status of the citizenry. Some of these cutting-edge technologies were developed in the physics laboratory, while others are board-certified health professionals who apply these technologies in the clinic and help diagnose illness and alleviate suffering for millions of people.

Virtually all hospitals in the country today have medical physics on staff to help administer radiation therapy treatment and to ensure quality in both radiation treatment and imaging techniques. There are numerous clinical applications that are concerned with the use of nanotechnology. These applications include the direction of glucose in diabetic patients the detection of urinary tract bacteria infections. (Banica, 2012) nanotechnology has the potential of yielding considerable progress I medical diagnostics, with the ultimate goal of identifying disease at the earliest stage possible (even up to the level of a single cell). In addition, it can offer diagnostic tools of better sensitivity, specify and reliability.

CONCLUSION

Approach to disease diagnostic is also becoming more and more complex. Diagnostic procedures are becoming extensive, utilizing a variety of diagnostic tools; from imagine procedures to various biomarkers testing, like genetic and molecular profiling. In addition, more and more therapies are being combinatory, combining traditional modes of therapy like radiation therapy, with molecular targeted therapies, the complexity of diagnostic and therapy procedures have made the term “team disease management” much more a common practice. In addition to physicians team (e.g, radiation oncology +medical oncology +surgery teams), disease management often includes other interdisciplinary scientists, like pathologists, pharmacologists, molecular biologists. In addition new technology like nanotechnology and stem cell engineering are likely to introduce dramatic changes to how medicine will be practiced. While medical physicists are good at solving this type of problems, it seems we have not really seriously tapped into them.

SUGGESTION

Three areas of particular importance to keep the field of medical physics bright as it is now is the suggestion that, new research initiatives be encouraged, education of more medical physicists be supported and the re-training of already existing medical physics personnel, this could lead to new generation of medical physicist in the country.

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