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Review Article

Cutting–Edge Physics Driven Advancements in Medical Industry

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Abstract

Science contributed to technology by serving as a direct source and creation of ideas for new knowledge. Technology emerged from the application of this knowledge in terms of products, processes and services. Nowadays, due to the multidisciplinary application of physics, medical technology and radiation treatment has begun and widely accompanied within a technology based medical diagnosis and treatment due to the development of physics. In this paper a detailed description and analysis of scientific achievement and technological advancements of physics in medical industry has been clearly reviewed. The application of physics principles to medical sector has made an outstanding contribution in the diagnosis and treatment of diseases. Many extraordinary tools, those could have played a great role in diagnostic and treatment methods, have appeared as a result of physics discoveries in the last century. This description of physics applications in medical technology and principles has mainly based on comprehensive review of the literature, contributes to suggest the novel ideas used for the innovation of modern medical technologies. This journal paper anecdote the fundamental physical principles used for the innovation of these technological advances, emphasizing their applications to the practice of modern medical industry based on comprehensive review of the literature.

Keywords

Physics, Diagnostics, Innovation, Technology, Medical Industry

1. Introduction

In the science, technology and innovation era new technologies have the potential to create great influence and making a huge difference because of achievements by improving the ancient innovation with the recent ones. From these improvements that have shown a dramatic change in medical industry, we can look at the technological innovations from the development of physics research.

It is becoming increasingly evident that the recent developments and technological enhancements, that could exert a great influence on medical technology and practice, are a result of physics [1, 2]. The basic physics principles have made an astonishing contribution to medical sector for the diagnosis and treatment of many diseases especially since the discovery of medical devices, radioactivity and radioisotope. The synergetic application of physics principles for medical disciplines has been a driving force in the development of innovative diagnostic tools, therapeutic interventions, and personalized healthcare solutions, ultimately improving patient outcomes and transforming the medical industry. Currently, due to the multidisciplinary application of physics, the

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work of physicists diverted from general knowledge in to skill based profession up to employed in hospitals concerned with medical applications of radiation, diagnostic imaging tasks. Medical technology and radiation treatment has begun since the nineteenth century, and widely accompanied within a radiation-based medical diagnosis and treatment due to the development of physics [1].

Since the discovery of the natural and artificial radioactivity the radioisotopes have been used for diagnosis and therapy. In therapy case require the principle of nuclear properties of the nuclides, to control sufficient radiation dose to the cancer tissue or cancer cells without damage of the surrounding healthy tissue [3-5].

The scope of physics principles have wide range of activities which are applicable in medicine like for the prevention, diagnosis, treatment of disease and for the development of medical technologies like in radiotherapy, diagnostic radiology, nuclear medicine, and radiation protection to have a central role in assuring the safe and effective use of radiation, quality control and radiation safety. All these activities rely either due to the basic principle of physics or physics driven researches for innovational technologies. The development of technology could open the doors of an extraordinary methods and novel innovations and great applications in all aspects of human life and led in to a new era [4, 5].

A systematized way of acquiring knowledge of the natural world which is based upon the belief that events in the world of nature occur not randomly but according to an orderly, in a uniform pattern. When scientists discover knowledge, they attempt to fit what they have learned about nature in to an orderly, organized and interrelated system. This acquisition of scientific knowledge is looked upon as a step by step mapping out of the part of the system.

Science contributed to technology by serving as a direct source and creation of ideas for new knowledge and technology, which is the output of science, is the application of this knowledge to meet one's needs and goals in terms of products, processes and services that benefit human kind. Invention yields technology from the practical applications of scientific laws and theories. The electric motor, transistor, radio, different modes of transportation, modern home appliances, disease detect instruments are more technological applications of physics and obey the laws of electromagnetism derived from the basic principle of physics [5].

2. Physics Driven Ground-Breaking Achievements in Medical Industry

In the medical service environment, many stake holders can participate and involve like the medical physicist, nuclear medicine physicians and medical technologists, plays a significant role in the multidisciplinary team needed for medical diagnosis and treatment. In addition to scientific involvements in experiments and measurements, the physicists are responsible for instrumentation performance, radiation dosimetry and radiation protection for treatment of patients, accuracy of the data analysis [6].

The medical industry has witnessed groundbreaking advancements driven from physics based principles and technologies. Here are some of the most impactful and innovative applications that have revolutionized the medical industry.

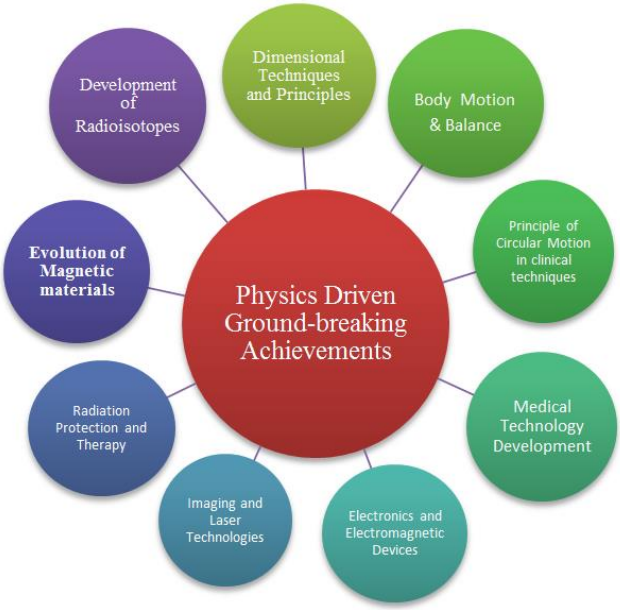

Figure 1. *Cutting–Edge Physics Driven Advancements in Medical Industry.*

2.1. Dimensional Techniques and Principles in Medicine

Quality of measurements is essential way of any scientific communication for reporting measurement results to clients based on international standards and guidelines to have a common understanding of basic terms [7].

The characteristic of all the sciences is deal with the statements and principles up on which everyone can agree, which is called universal agreement. As knowledge increases worldwide, there will likely be fundamental scientific progress and that would lead to dramatic changes for the innovation of state of the art materials, devices, and systems are understood and contributed to the innovation of technologies [1].

Physics is fundamentally a science of measurement and the development of accurate and reliable measuring instruments and systems, which are widely applying in medical practice, have been a major accomplishment of physics those enabled precise, reliable, and standardized medical technologies, instruments and principles like temperature, length measurement, blood flow/pulse rate, radiation dose and so on [4].

Recent investigations have arrived up to controlling indivisible microscopic atoms at the order of beyond the

Nano-scale and able to design and study the properties of materials with novel properties for specific applications with the basic principle of physics. These techniques have emerged as a mechanism that is responding to technological and scientific problems either by development and introducing new technologies, or by discovering and implementing new and existing methodologies [8].

2.2. Body Motion and Balance for Effective Interventions and rehabilitation

The assimilation of physics principles related to body motion and balance has been prominent in advancing medical technologies for improving patient outcomes and enhances the quality of healthcare delivery.

In the medical sector the principles of physics related to body motion and balance are essential for understanding the biomechanics of human movement, assessing forces acting on the body, and designing interventions for rehabilitation and treatment. Among key physics principles that are applied in the medical industry starting from Newton's laws of motion, to explain how forces affect the body during movement, assessing muscle strength for designing exercises or interventions to improve joint stability and balance. The principle of center of gravity used for assessing balance impairments, designing effective interventions for rehabilitation, injury prevention, and improved functional outcomes [8, 9].

By incorporating these physics and science principles into medical practice and treatment, healthcare professionals can effectively diagnose, treat, promote functional recovery, manage various musculoskeletal and balance-related conditions to improve patient outcomes and optimize overall well-being.

2.3. Principle of Circular Motion in Clinical Techniques

The history of science of physics is the history of motion. An understanding of the concept of motion gives a better care and appreciation of precautions and a means of reducing risks and accidents. Starting from the velocity of blood moving in the body, exchange of substance in the capillary that can flow slowly, blood in large vessels flows rapidly, blood flows from arteries to capillaries with decreasing velocity rate and flows in increasing velocity rate from capillary along to the heart [1, 9].

The continuous integration of principles derived from physics in circular motion has enabled plentiful advancements in medical imaging, radiation therapy, and biomechanical applications for augmenting patient care in medicine.

In the case of circular motion of centrifuge, a device for whirling substances in the test tubes in a circular path at high speed, that could replace the old fashioned hand powered centrifuge. A blood will separate in to layers, bottom and top, contained particles at high speed rotations. Using centrifuge microscope possible to separate components of cells in to layers of different densities (lighter and heavier portions at extremely high acceleration). For microbiologists, for concentrating microorganisms to shake down large number of thermometers at one time, in diaries to separate the heavier milk from lighter cream, clothes dryer dry wet laundry by spinning at high speed [10-12].

2.4. Medical Technologies Development

The continuous progression of medical technologies, driven by multidisciplinary collaborations and the integration of principles from various scientific fields, especially from physics, has significantly improved the quality, accessibility, and personalization of healthcare services for enhancing patient outcomes and transforming the way medicine is delivered for enabling pioneering solutions that address unmet medical needs and effective medical interventions. Modern clinical practice and research are heavily dependent on technology, and hospitals are equipped with physics based devices for clinical measurement, diagnosis, and treatment [1, 12].

Based on the basic principle of electricity, magnetism, wave and optics, laser and photonics; the efforts of physicists have contributed for the innovation of medical imaging technologies from the knowledge of physics based on the principle of electromagnetic spectrum and magnetic energy. Radioactive tracers have been widely used fruitfully for diagnostic purposes and treatment of diseases in the medical field. Such use is generally known as nuclear medicine [11, 12].

Radioisotopes have applications in diagnosis; therapy and health care include radiopharmaceuticals. It is surely possible to say that in medical centers the modern diagnostic and treatment machines can operate using the basic principle of electromagnetism and electricity [8-11].

Medical technologies those used for a study of treatment and diagnosis areas need the fundamental knowledge of physics at the levels of atomic, nuclear, relativistic, and quantum physics as well as electromagnetic theory. Physics could be a profession and a tool rather than a science after the development of diagnostic technologies like Radiography that used the ionizing electromagnet radiation after the discovery of x-ray, Computed tomography uses a combination of x-ray equipment with a computer and a cathode ray tube display to produce images of cross sections of the human body [9]. Similarly, Magnetic Resonance Imaging uses magnetic and radio frequency fields to image the body tissues have main components working on magnetism principle [13, 14].

2.5. Electronics and Electromagnetic Devices

The application of physical principles in the medical profession in the late 19th century and rapidly became the foundation of the practice of diagnostic technology. The efforts of physical scientists have continued to extensive inno-

vation in medical imaging through a progression of medical technologies for over all examination of human organs. The use of high frequency sound waves, processing and transfer of medical images, the discovery of x-rays, the use of radiation on living tissue without cutting the tissues, the measurement of radiation and its interaction with matter and its effects have developed from the basic principle of physics. The basic knowledge of the structure of the atom, the nature of electromagnetic radiation and the production of x-rays is fundamental to the understanding of the physics and application in medical technologies [12].

The invention of the transistor, a major contributor to the development of computers, was the advent of solid state electronic devices, specifically the coming of the transistor, which was announced by Bell Telephone Laboratories in late 1947. The use of transistors also made circuitry much more reliable and caused a boom in solid-state electronics and produced the growth of an industry in which many of the major companies supported active research laboratories. Integrated circuits followed in the late 1950s and then microprocessors in the late 1960s and 1970s then we arrived at the year of nanotechnology and nanomaterials used for medical purposes. These inventions and emerging of new technologies provided employment for many physicists [15, 16].

In a magnetic material, an item of information can be recorded by locally orienting the magnetization in either of its two possible directions to form a binary storage system. Recording is the area of applied magnetism in which technological progress has been most spectacular over the last fifty years [8, 15, 17, 18]. These great progresses in magnetic technologies have played a vital role for medical sector for diagnosis, treatment and prevention mechanism of diseases.

2.6. Imaging and Laser Technologies

The knowledge of the structure of the atom from elementary nuclear physics, the nature of electromagnetic radiation and the production of x-rays have taken the lion's share for the fundamental understanding of physics in medical imaging and radiation protection role [19, 20]. The study and use of ionizing radiation in medicine started after the important discoveries of x-rays by Wilhelm Conrad Roentgen, natural radioactivity by Henri Becquerel and Radium by Pierre Curie and Marie Curie [8, 13, 14].

It is interesting that physics discoveries from the 1900's helped to develop imaging techniques and designed the field of diagnostic imaging in medicine, but that technological advances in the diagnostic domain contributed to many useful applications in medicine [1, 8, 15, 16].

It has no doubt that, in radiation medicine, the physics professional needs to understand the physical principles involved and application to medical practice. Due to the scientific development of physics has played an important role in safe, efficient, and cost-effective use of high technology in diagnosis and treatment of disease, for the technological development of equipment used for imaging [14].

Lasers are used for many purposes in medical applications like for cutting tissue, vaporizing tumors, removing unwanted or harmed tissues without affecting the normal tissues, for vision correction and cosmetic treatment of wrinkles is often accomplished using infrared lasers. Lasers are extensively used in medicine and surgery starting with the first practical application for eye surgery, and to remove certain forms of cancerous growth within knifeless and bloodless surgery [9, 17-19].

In the treatment of gastrointestinal cancer using endoscope of laser energy is used to destroy neoplastic tissue while preserving bowel wall integrity. With the development of optical fibers lasers are being used for heart surgery, treatment of bleeding ulcers, used to rapidly heat and fragment urinary stones in the kidney, for dental treatment by charring tooth decay through a painless process called laser glazing [4, 15, 18, 19].

2.7. Development of Radioisotopes for Medical Applications

The medical industry has been greatly influenced by the development of radioisotopes for imaging techniques, dosimeter and radiation protection. Recently artificially produced radioactive isotopes used in medicine have taken from immediate discovery of the natural and later artificial radioisotopes for several medical applications [3, 9, 21].

The medical technologies that are using for the treatment and diagnostics applications have started from the invention of x-rays and radioactivity that could open a new era of nuclear medicine which is the way of using radionuclides and radioisotopes for diagnosis and treatment of diseases. All such technological innovations have been developed and can only be practiced safely with a clear understanding of the behavior and principles of radiation sources and radiation detection based on the principle of physics [22-24].

The continuous advancement in the understanding and application of physics principles has been instrumental in the development and refinement of radioisotope-based technologies in the medical industry, leading to improved diagnostic capabilities, more effective treatments and enhanced patient safety.

In nature there many radioisotopes that have many medical applications by developing nuclear science and technology. Radioactive tracers have been widely used fruitfully for diagnostic purposes and treatment of diseases in the medical field. Such use is generally known as nuclear medicine. Radioisotopes have applications in diagnosis, therapy and health care include radiopharmaceuticals [3, 14].

Many of the technical breakthroughs that have contributed to national development have their roots from basic physics research and are largely significant and constantly growing today more than as they were before. From the beginning of discoveries of atoms, from the ideas of the Greek philosophers,

goes to the discovery of natural radioactivity at the end of nineteenth century, then the understanding of the structure of atoms, the discovery of elemental Isotopes and finally the discovery of radioactive decay have played the critical roles in the functioning of nuclear medicine and technology. Finally the discovery of artificially induced radioactivity led to the discovery of uranium fission [25-27].

So, for the evolution of new technologies in the medical industry with the immense contribution of scientists, physics played its crucial role and will take the lions share.

2.8. Evolution of Magnetic Materials for Medical Industry

Physics principles are also essential for various medical imaging techniques, such as x-ray radiography, Ultrasound, computed tomography, Magnetic Resonance Imaging, and Nuclear Magnetic Resonance. Physicists contribute to the design, optimization, and maintenance of these imaging systems, ensuring the production of high-quality images that aid in accurate diagnosis and treatment planning [28, 29].

Materials have tremendous potential for the development of advanced devices for a specific purpose. The synergistic combination of materials and innovative engineering techniques holds great promise for the development of devices with enhanced performance, efficiency, and sustainability to make significant contributions for a definite technological edge.

Until we are living in a material world, the importance of materials is highly important that has been becoming as the heart of most critical economic, environmental and developmental issues to bring benefits [30].

The choice of magnetic material depends on the specific application and its requirements, such as magnetic properties, biocompatibility, and cost-effectiveness. Ongoing research in the field of magnetic materials for medical applications aims to develop new and improved materials, as well as to expand the range of medical applications [30, 31]. By leveraging the unique physical properties and versatility of magnetic materials, the medical industry can develop innovative diagnostic tools, therapeutic approaches, and medical devices that contribute to improved patient outcomes and advancements in healthcare [32].

Because of magnetic field can play an important role in diagnosis, imaging, and therapy, magnetic materials hold great promise for disease treatment and have gained increasing attention for medical applications. They would exhibit unique physical properties, they are widely used in the medical industry to generate, detect, and interact with magnetic fields. These unique properties make them well-suited for the ability to manipulate, measure, or interact with biological systems for a crucial application [23, 33].

2.9. Radiation Protection and Therapy

For safety and quality assurance in the use of radiation for medical purpose target to reduce unnecessary radiation risks [31, 32]. Physics played a pivotal role in the development of imaging and treatment of disease with ionizing radiation and provided the scientific base, initially for the understanding of the production of radiation (its interaction with matter, its measurement and dose) for the technological development of medical equipment [33, 34].

Radiation technology has attracted a much broader base of professionals and is a rapidly growing field based on the principle of physics to provide a wide applications in medicine for radiation protection, radiation therapy, diagnostic imaging, treatment of human disease, radiation oncology, radiation safety and radiation dosimeter programs. The discipline of radiation has changed enormously especially after the discovery of x-rays and radioactivity. Due to an active involvement and immense contribution of physicists in developing radiotherapy treatments and protocols, many expert names have emerged such as radiation physicist, clinical physicist, medical physicist, radiologists and others because of their importance in medical sector [31, 33, 34].

In addition to these professional experts numerous international organizations (represent more physicists) have established for well-developed medical disciplines regionally, nationally and internationally (International Organization for Medical Physics, International Radiation Protection Association, International Atomic Energy Agency, World Nuclear Association, International Commission on Radiological Protection) and many more [25, 29, 31, 33, 34]. These professional organizations work collaboratively for ensuring the safe and effective use and scientific understanding of radiation, for providing guidance and standards to regulatory bodies, for promoting education and professional development as well as in shaping the safe and responsible use of radiation with the standard of physics [35]. In addition, academic and research work dissemination journals and accreditation organizations have recognized as official publications of the scientific works related to the peaceful usage and standard of radiation.

3. Conclusion

These are a plenty of examples that how physics-driven innovations have filled critical gaps and enabled transformative advancements in the national development especially in the medical industry. The persistent assimilation of physics principles with biology, chemistry, and engineering will undoubtedly lead to further breakthroughs in healthcare. Overall, the intersection of physics and the medical industry presents a vast and exciting frontier for innovation, with the potential to significantly improve human health and well-being.

From the great milestones of twentieth century physics has been playing an important role from the discovery. Until we

are living in competitive world the character and importance as well as role of technology has been changing rapidly. New applications and technologies are emerging with increasing frequency with great potential and wide impact on scientific, education, health, medicine, national security, and economic growth.

Physicists and medical physicists laid the cornerstone in the diagnosis and treatment of cancer for today's medical practice. In this paper a descriptive analysis of the different medical technologies from great scientific achievement and techniques used in medicine those have basically derived from physics principles. Due to the scientific development of physics has played an important role in safe, efficient, and cost effective use of high technology in diagnosis and treatment of disease, the latest technological development and state of art medical equipment have been using for treatment and diagnosis of diseases.

In addition to scientific involvements in experiments and measurements, the physicists are responsible for instrumentation performance, radiation dosimetry and radiation protection for treatment of patients, accuracy of the data analysis. For moving the one's country ahead and to have a highly technology enriched environment the government should develop and implement a strategy for investment in basic physics research to maintain strong economic growth driven by new physics-based technologies for expanding scientific opportunities.

Author Contributions

Wubshet Getachew Mengesha is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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