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Advancements in Diagnostic Technology: Transforming Clinical Laboratory Practices

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Abstract

Background: Technological advancement in the field of clinical laboratory science has improved the diagnostic value of tests and their throughput. New methodologies include, the Next-generation sequencing (NGS), CRISPR-Cas9 gene editing, artificial intelligence (AI) and the point of care testing (POCT).

Aim: This study seeks to explore the evolution of clinical laboratory science, enhanced diagnostics and personalization through the use of new technologies.

Methods: The subsequent discussion of recent advancements in diagnosis field was based on the analysis of the articles and clinical reports on NGS, CRISPR-Cas9, AI, POCT.

Results: Computational platforms including NGS/CRISPR-Cas9 has advanced genetic diagnostics and AI has advanced the data analysis while point of care technologies [POCT devices have made the diagnosis faster at the site of testing.

Conclusion: New advancements are changing the ways clinical laboratories work, improving the diagnosis and making efficient the treatment. All these are potential enhancements that are in line to help enhance healthcare.

Keywords: Clinical laboratory science, technologies, diagnostic precision, NGS, CRISPR-Cas9, Artificial intelligence, POCT, personalized medicines.

1. Introduction

The advancement of clinical laboratory science has been on the rise in the recent past, primarily as a result of a change in technology. These new and advanced technologies are a major boon in the field of diagnostic procedures since they seek to enhance precision, speed and indeed the quality of service to clients. From molecular diagnostics to the application of an AI, new instruments are allowing laboratories to deliver more accurate, individual diagnosis. These technologies are not only increasing the speed of diagnosing, but also broadening the range of what can be diagnosed and treated, in case of such technologies as next-generation sequencing (NGS), CRISPR-Cas9 gene editing, POCT and lab-on-a-chip devices. This research is intended to find out how these new innovation will affect clinical laboratory science, to help elucidate how diagnostic accuracy and laboratory efficiency will be enhanced and whether they can play a cardinal role in shaping the personalized medicine world [1].

Revolutionizing Laboratory Diagnostics Through Technology

Looking at the specifics of laboratory diagnostics, it should be noted that the subject has seen a truly radical change in the last several decades, the main driving force for the change being the speed of technological development. They have periodically changed the ways diseases are diagnosed, screened and managed, thereby transforming the traditional clinical laboratory. Standard MAM treatments and approaches that used up to recent past relied on a set of diagnostic modalities that took lot of time, energy and often, human errors crept in. The use of sophisticated instruments for molecular diagnostic, systems integration and automation, artificial intelligence, and digital pathology have boosted the precision, speed, and precision of the diagnostic industry. These have not only fast forwarded the time that it takes to get results but also increased the number of samples which can be handled by laboratories while maintaining quality of services to the patients' care. Perhaps the most revolutionary innovation has been automating in clinical laboratories is something that has been embraced. The samples that are tested include blood chemistry, hematology, and other tests that are now done by automated analyzers with little human input. These

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systems eliminate as much variability in results as possible and allow laboratory professionals to better focus on other tasks, such as data interpretation and more elaborate analysis. Precision instruments such as the Polymerase Chain Reaction (PCR) and the Next Generation Sequencing (NGS), trialed innovative modes in detecting genetic mutations and pathogens specifying disease diagnostics at molecular levels. For example, such technologies contributed immensely in identifying and managing COVID-19 pandemic and are very essential during disasters. [2,3]

Health informatics, artificial intelligence and machine learning provide the much needed hand by analyzing massive volumes of data faster and with greater accuracy. It is also quite obvious that AI can analyze test scores and recognize signals of diseases like cancer and cardiovascular diseases. However, pathology in which high-resolution images of tissue samples are scanned and analyzed for diagnosis of diseases, can provide remote consultancies and second opinions deleting the geographical hindrances that can prevent patients from getting the best possible medical care. [4,5] AI has facilitated the progression of personalized patient treatment plans, by analyzing an individual's genetic and molecular profiles while cross-referencing an already available database**(Figure 1)**

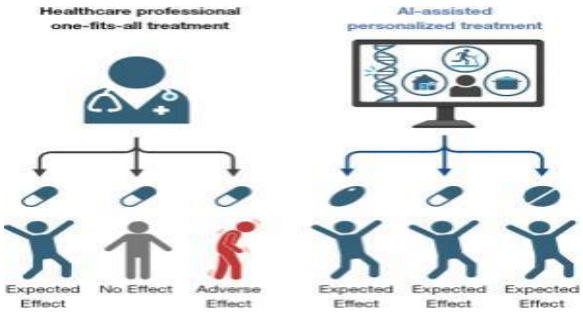

Figure 1: AI-assisted and traditional tailored care. Artificial intelligence, or AI.

It has to be noted that there has been more than one problem associated with these technologies. There remain fundamental issues of high initial costs of implementation, requirement of staff training and the ethical issues that surround the use of AI diagnostics.. However, the advantages can dwarf these challenges as will be elaborated below. The on-going advancements in diagnosis technology bring great potential to transform the healthcare system all over the world and make significant changes in patient's outcomes and also open the door to tailor-making medicine. Since advancement in technology is seen to be increasing, clinical laboratory is supposed to continue operating as a major driver of innovation in medicine particularly in the area of disease prevention and control.[4,5,6]

Diagnostic Tools: Past, Present and Future

Diagnostic tests in today's modern world are one of the most revolutionary improvements of the medical field. From the simple diagnostic procedures that dated back to several hundred of years, to today's advanced high-tech methods, this has brought about a big change in the diagnosis and control of diseases. Previously, diagnostic procedures depended on clinicians' assessment and identification of diseases, pathology, and symptoms, germ theory, signs, patient history, and simple physical assessment, which caused misconceptions and unproductive diagnosis. However, demand for better diagnostic methods and ability of identifying diseases earlier promoted the creation of new sophisticated diagnostic technologies that improved the overall results of healthcare.[7,8] As with many fields, the invention of the microscope in the 17th century had a large impact on medical diagnostics for the first ever ability to see microorganisms and cellular structures. This pioneering work paved the way to the development of Microbiology and Histopathology as specialization within clinical pathology. In the 19th and early 20th centuries the next inventions were made, such as the X-ray picture, which brought improvements in diagnosing internal pathologies, without making an incision on the body, offering the view on the skeletal system and organs. The later introduction of methods such as ultrasound, computed tomography scanning, magnetic resonance imaging further enriched diagnostics by offering morphological, detailed, noninvasive pictures of human bodies. [9]

. Molecular diagnostics has also undergone remarkable revolution including the biochemical tools. Despite the invention of blood tests that indicated biomarkers and the discovery of PCR, great progresses was made in detecting disease and the disease causing pathogens at the molecular level. For instance, molecular diagnostic methodologies have over time been adopted as routine diagnostic tools for inherited disorders, predictive testing for specific diseases, and guiding treatment in cancer. These advances have been accentuated by next generation sequencing (NGS), which can do genomic scans in hours.[10] In more recent years, another development has come across the horizon in the shape of diagnostics technology and artificial intelligence. The advancement of machine embodied intelligence means that today's big data algorithms are capable of ferreting out patterns that the human brain may very well miss as well as rendering diagnoses far more rapidly and efficiently than would otherwise be possible. For instance, in the field of radiology a number of experimentations have been conducted AI based systems are as good if not better than the human experts in diagnosing early stages of cancer by analyzing different medical images. Consequently, using wearable devices and m-Health application, diagnostics have become easily accessible to the patient to assist him or her to take vital signs, glucose levels, and heart rhythms at his or her convenience.[11] In the same sense the constant enhancement of the diagnostic tools has for instance enhanced the efficiency of early diagnosis, accurate diagnosis and subsequent treatment. Some of these challenges include; Accessibility, Cost and ethical issues of use of data among other challenges. Nevertheless, the nature of the challenges indicates that the course of diagnostic progress remains one to encourage hope. It can be expected that future solutions will bring even more numerous and advanced forms of innovative solutions like nanotechnology in diagnostics and unity of artificial intelligence with a personalized approach to the paradigm of modern medicine and global health.

How Technological Advancements Are Shaping Laboratory Practices

Technology has revolutionized laboratory in many ways to improved precision, effectiveness and flexibility as demanded by the modern world. Pathology and laboratories which were earlier a manual based section of the organization has indeed evolved into a technology enabled

advanced section, which is producing speedy and accurate results. These changes have not only beneficial in improving the diagnosis, but also in the effectiveness of the working process, the minimization of mistakes and widening the range of received tests by laboratories.[12,13] Automate is widely recognized as one of the', most monumental achievements of technology in laboratories. Routine and sophisticated tests Including blood chemistry, hematology automation, and microbiology are undertaken through automated analyzers with little or no operator interference. These systems improve the handling of samples, shorten time to results and enable laboratories to offer more tests that are equally accurate. For example, in blood banks, automation can help accomplish crosshatch as well as screening processes to provide a safer chain. In addition, the level of accuracy increases, as errors made by people, who work with equipment, are excluded.[14,15]

Another revolutionary change is the acceptance of molecular and genetic testing as regular service offerings in clinical laboratories. PCR and NGS technologies have brought drastic improvement in laboratory diagnosis, identification of causal pathogens, and gene variations, and clinical diagnosis at molecule level. It has been most successful in the areas of personalized medicine where successive treatment procedures are determined by the patients own genetic make up. Centres that have investment on molecular diagnostic technologies are now in the frontline responding to infectious diseases including the recent COVID19 by offering accurate tests.[16] AI and machine learning have however taken laboratory practices to another level by embracing them. Machine learning algorithms process large amounts of data, and help in disease diagnosis and, in particular, in the detection of diseases in their early stages. For instance, in pathology AI algorithms can consider digital images of tissue samples to diagnose malignancies with appreciable accuracy. In clinical chemistry, AI helps in result analysis and furnishes advice to the providers that are actionable. Unlike general technologies which just improve the functionality of the laboratory, these technologies also enable the forecasting of diseases, or tracking of the development of chronic illnesses.[17,18] Digitization and connectedness are also noted to have significantly impacted current laboratory practice. Electronic data systems of various types have been implemented into the health care institutions to enable tracking of test results and to disseminate the results to physicians. Such continuity of information flow enhances appropriate clinical decisions and consequently enhances the outcomes of patients. Also, the telemedicine and remote diagnostics on the firm's digital platform helps extend the laboratories' access to underserved regions, improving the general provision of healthcare services.[19] However, there are still some issues to address: the high price in introducing new technologies; the staff training problem; the questions of ethical use of information. Yet the advantages are much more significant than the shortcoming when new technological advancements are constantly improving the capabilities of laboratories. The advent of the next generation technologies such as nanotechnology, automation through artificial intelligence and real time diagnostics the pivotal role of the laboratory in the provision of accurate and timely healthcare solutions will continue into the future.[20,21]

Cutting-Edge Innovations in Clinical Laboratory Diagnostics

Technological advancement is seeing clinical laboratories inundated with the newest technologies that are changing the face of diagnostics in diseases. They have been preceded by the growth and evolution in the technology, cooperation with representatives of different fields and need for more effective, quick and affordable health solutions. Molecular diagnostics, artificial intelligence, and other developments of this kind are becoming the pioneers of new benchmarks for laboratories and patients' outcomes.[22] One of the biggest revolutions in the more recent past is use of **Next Generation Sequencing (NGS) in diagnosis. Through NGS, labs have been able to make a vast number of genetic alterations, organisms, and hereditary disorders' diagnoses with incredible efficiency. It remains one of the key technologies of personalized medicine because it offers clinicians information which can guide the selection of the appropriate treatment for individual patients. For instance, NGS is in the process of discovering cancer molecular markers that help in the development of personalized therapy that increases patient's survival.[23,24]

Another such advancement is that of **Point of Care Testing (POCT)** instruments which centralize diagnostics near patients. Such convenient and movable equipment allows a fast check and receiving results without delay in emergency or remote situations when there is no full-fledged laboratory nearby. Specialized POCT devices are used in blood glucose, infectious diseases, and cardiac biomarkers that help to cut the time required from diagnosis to treatment. These devices have continued to improve and with the advancement, their accuracy and coverage have become relevant parts of today's healthcare system.[24,25]

Another related area impacting laboratory diagnostics is Artificial intelligence (AI) and machine learning that has improved the rate of data analysis. Big data that is fed to an AI program can contain millions of records that the computer can look for patterns and signs that the human operator might not notice. For instance, digital pathology applications of AI can interpret tissue samples to establish early-stage malignancies' presence, which is faster and more accurate. Thirdly, AI is implemented in LIS and now it automatizes different processes and improves the distribution of resources in laboratories to minimize expenses.[26] Clinical diagnostics have been taken to another level by the introduction of liquid biopsy technology. While conventional tissue biopsies involve the physical removal of cells or tissues, liquid biopsies sample circulating tumor DNA (ctDNA) and other molecules in a patient's blood. This noninvasive approach enables the identification of the cancers at higher stages and yields useful data about tumor progression and resistance to the treatment. Liquid biopsy is most useful in the oncology where it is rapidly changing the approach to cancer surveillance and monitoring. [26,27]

Another type of innovative diagnostics, challenging conventional approaches is microfluidics – a technology which involves a manipulation of small volumes of fluids in order to carry out a range of tests on a single microchip. Microfluidic devices allow multiple testing since laboratories can test several biomarkers with the same volume of a sample. They include infectious disease diagnostics where this technology provides quick

identification of varieties of pathogens enhancing treatment decisions.[28] Nevertheless, there are issues like, the costly nature of converting into an adaptive design, specialized skills required for this design, data protection issues that are still areas of concern. Nevertheless, the constant development of these technologies offers a great potential for the development of laboratory diagnostics in the future. These technologies will have a significant impact and increase their availability in clinical practice, thus will determine the further development of clinical laboratory medicine as a part of the diagnostic process. [29]

The Role of Advanced Diagnostics in Enhancing Laboratory Accuracy

The new technologies have brought about dramatic changes that have improved the clinical laboratory in as regards to the accuracy, dependability and speed of diagnosis. Previous techniques depending on conventional laboratory procedures involved using plain methods and simple instruments which were more delicate to precise but more prone to human interference. These challenges have been met with the introduction of sophisticated diagnostic technologies to provide accurate and reproducible laboratory data as the foundation of evidence based medicine.[30] There is evidence that advanced diagnostics have enhanced laboratory efficiency; particularly concerning testing processes automation. Automated systems involve a less amount of human input, this makes it hard for errors such as transcription mistakes, sample identification errors, and inconsistent execution of tests to occur. These systems incorporate highly sensitive and selective detectors to quantify small changes of biological matrices with acceptable accuracy and precision for even intricate measurements. For instance, fully automated cell counters do more than simply count blood cells, but they also indicate any abnormalities that may require further analysis to determine hematological disorders.[31] Molecular diagnostics has also been central in improving accuracy of laboratories for instance through automation. Molecular diagnostics includes methods that PCR, next-generation sequencing (NGS), and are capable of detecting genetic mutations, pathogens and biomarkers with tremendous accuracy. They are especially important in early diagnosis since other techniques may not be able to spot changes at that level. For example, the molecular diagnostic tests can distinguish between closely related species or strains of the pathogens, thus eliminating incidences of wrong prescription of antibiotics thus combating the problem of resistance. The Integration of artificial intelligence (AI) and machine learning into laboratory work has also helped in improving correctness of diagnosis. Technological systems, based on artificial intelligence concepts, may help to find patterns, trends, and abnormality in the large sets of data which is not easy to discover by human intervention. AI systems, for instance, apply computer vision to digital slides in an attempt to evaluate cancerous cells, an endeavor in which they demonstrate sensitivity and specificity often higher than that achieved manually. This doubles the likelihood of accurate results and subsequent actions to enhance a patient's experience from the medical field. [32]

The other way, through which accuracy has been enhanced is through the use of automated data management and sharing systems that are enhanced through latest digital technology. Limes systems furnish a solution for tracking sample, documenting the result and maintenance of quality control measures with the help of a central database. This digital infrastructure helps to avoid the common mistakes, which can be made, maintaining the paper records and guarantee the correspondence of the data, stored in the records, to the actual data. In addition, LIMS works in concert with other sophisticated diagnostic instruments by minimizing sample transfer /interface issues and assuring high quality testing data. [33] advancement particularly in high throughput diagnostic platforms has enhanced the comparability and accuracy in so many tests. Such platforms will allow laboratories to handle large volumes of samples at once while exercising great control over factors like reagents' concentration and conditions of the assay. This kind of capability is valuable in scenarios encountered in public health facilities as a result of outbreak diagnoses that require quick and accurate analytical results. The use of advanced diagnostics has improved the laboratory results to an unparalleled level, converting clinical approaches into additional tools and stepping up the quality of health care services to a high level. The technology is still however associated with few disadvantages including high implementation costs, need for special training and others but the advantages of such technologies overwhelm their limitation in this aspect. In other words, the enhancements of the Lab can contribute towards the achievement of improved patient results in improved levels of disease diagnosis, cure and general quality of patient's health.

From Traditional Methods to Modern Technologies: A Laboratory Transformation

This shift from traditional analysis to using technologies now considered state-of-the-art is a revolutionary change in approaches to laboratories and the analysis of samples used to diagnose conditions. In the past laboratories used a lot of manual methods and simple tools to work on the samples and help clinicians with diagnosis. Although these methods formed a starting point in the practice of diagnostic science, they were it me consuming, labor intensive and contained flaws. Advanced technologies have altered this landscape to give lab processes much higher accuracy, speed and possible scale than previously.[34] Old fashioned methods of analyzing samples in the laboratory involved techniques like microscopy and chemical analysis that needed a lot of effort from the human brain and often times a keen eye. For instance, when doing a blood smear or tissue sample the accuracy obtained depended with the technician or the pathologist. Of course, these approaches were helpful in some cases but lacked sensitivity in unrelated instances and were not always sufficient to reveal all pathological changes or yield comprehensive information. In the same way, the routine manual chemical tests for glucose, proteins, or enzymes also had elaborate preparations and potentiate especially interpretations that were not well fixed and varied considerably. Introduction of the automation system signified a boundary between old and new age for laboratory diagnosis. Machines replaced manual items in that laboratories were able to analyze the samples quickly but with equal precision. Blood counts were done more rapidly and accurately by these machines apart from biochemical tests and coagulation profiles. Automation not only improved the efficiency but also the effectiveness at the same time Labs staff can now put their experienced mind to decisions making and problem solving things that only requires analytical skills.[35]

Molecular diagnostics and digital imaging have taken laboratory transformation to new heights through new technology. Some of the method used are Polymerase Chain Reaction (PCR) and Next Generation Sequencing (NGS). permit the quick identification of genetic material, pathogens, and mutations giving an increased accuracy in disease diagnosis. For instance, PCR was found to be an ought to tool in diagnosis of infectious diseases since it can identify very low concentration of usual DNA of a virus or bacteria. In contrast, NGS has opened new the doors to genomics by offering the possibility of gaining insights from the whole or particular region of the genome to establish a particular approach to a patient's treatment.[36] Digital technologies have also responsive to Pathology and Histology field as well. Digital slide scanners take physical slides and digitize them into resolution images that can then be analyzed with better software programs. This change has made it possible for pathologists to review samples and their interpretation all from the comfort of their offices while promoting convergence of experts in the field from across the world. Further, AI is applied to digital pathology to support diagnosis by detecting malignancies like cancers with high precision and within the shortest time. [21]

One of the most important advances has been the introduction of point of care testing (POCT) along with portable diagnosing apparatus. These technologies enable the clinician to perform the test at the patient's bed side or wherever with out the need for central laboratory. POCT instruments types include glucose monitoring, cardiac markers, and diagnosis of infectious diseases and the output is obtained within minutes. This decentralization of diagnosis has improved accessibility and patients' outcomes compared to the earlier centralized models, especially in TERMS of rural healthcare delivery. [22] Routing of work from traditional methods to modern technologies has also enhanced the aspects of standardization and quality control of laboratory works. Today, LIMS control workflows, evaluate and collect samples, and adhere to strict quality guidelines to guarantee the reliability and repeatability of the results as well as compliance with the relevant norms and standards. These systems affiliate well with sophisticated diagnosing tools and hence form a network that increases general efficiency and accuracy.[23]

The Impact of Diagnostic Advancements on Laboratory Efficiency

Recent upgrading of clinical laboratories by incorporating sophisticated diagnostic tools have greatly improved their productivity to become efficient systems. Prior methods used in laboratory settings provided were less efficient compared to current throughput, time-consuming, and prone to errors. But these difficulties were counterbalanced by further development of diagnosis tools and processes that let laboratories actualize larger volume of work in faster time and with lesser error rates. Diagnostic improvements are still one of the most significant markers associated with the automation of all repetitive procedures, Automated instruments have thus drastically changed activities like counting of blood, biochemical third-party reclamation, and immunologic tests that earlier needed a lot of manual work. Because these machines can analyze several hundred samples at once, they greatly shave down the turnaround time as well as the laboratory. This has also reduced human error which is important in case of diagnosing patients and formulating pathetic for patients with various illnesses. [24,25]

Another factor that according to the model has a positive impact on efficiency is the use of high throughput diagnostic platforms. These systems are capable of handling several tests at once and sometimes many hundreds or thousands of samples at one time. For instance, NGS platforms can sequence whole genomes or large venture gene panels in batch, which averts a great deal of time in embezzlement genetic investigation. This capability is especially important in a research environment and especially during an epidemic, a pandemic or pestilence where speedy and accurate results are desirable and often life-saving.[26] POCT has also enhanced the efficiency of diagnostic tests through the decentralization brought by the adoption of the technologies. Carry-on and hand held devices enable tests to be done on site where the patient is, thus no transport of samples to central laboratories is required. It provides especially significant assistance in such circumstances as emergency diagnosis, where timely decision can be a life-saver, and in regions with a low density of healthcare infrastructure. POCT devices deliver immediate results, enabling faster initiation of treatment and reducing the burden on traditional laboratories.[27]

. These advanced diagnostic technologies in parallel with data management and communication has also made use of the Laboratory Information Management System (LIMS). They include sample tracking systems, result recording systems, and quality control systems that make the operations efficient and eliminate much paperwork. LIMS also play a role in relating the laboratory data with Electronic Health Record, or EHR, which helps the clinicians to get the report and interpret the result quickly. This interconnected ecosystem helps to increase interaction between individuals working in the laboratory and clinicians, thus improving the work at large.[28,29] AI & Machine learning are doubling up lab efficiency by automating complicated analysis that was time ingesting. With data analysis, several advanced methods are that have the ability to process strokes of data, find out patterns, and then develop insights faster than humans. In diagnosed imaging for example, AI systems can go through slides or scans to look for signs that could not take as long as it would if they assigned to a physician. In the same way, the effectiveness of equipment in laboratories is enhanced through the use of AI in maintaining machines thereby reducing on times that a machine may be out of order.[30] Other improvements in laboratories include miniaturization and micro fluidic technologies. Microfluidic chips allow the examination of small sample volumes at low concentration variations hence saving reagents. These systems are most advantageous in conditions where costs and sustainability top priorities are essential in any country with limited resources. Also, the compact structure enables one to combine the several tests in single system, extending the range of diagnostics possible in parallel.[31]

it becomes clear that such improvements as diagnostic technologies have radically changed the laboratories for the better, improving their speed, accuracy and economic efficiency in labs. Thus, it is possible to underline that it remains professed to solve the increasing needs of healthcare thanks to the automation of routine tasks, introduction of integrated systems, and application of rather effective tools in modern laboratories. In the future, with development in engineering, the clinical laboratories can only be expected to enhance their performance, essential components of the healthcare delivery systems.[32]

Emerging Technologies in Clinical Laboratory Science

The clinical laboratory science is on the verge of new advances in technology that will change the ways in which diagnostic procedures will be completed in the future with better precision and turnaround times. These innovations are revolutionizing traditional laboratory processes making it possible to treat individual patient based on his or her genotypes and also possible to diagnose even more diseases. These new technologies ranging from the molecular diagnostics to artificial intelligence (AI) are revolutionizing the future of clinical labs.[33] Another from a list of important advances in clinical laboratory science is the Next Generation Sequencing (NGS, which is transforming genomics and molecular diagnostics. As a massive parallel sequencing technique, NGS makes it possible to sequestrate and analyze massive numbers of DNA samples or focus on specific genomic regions of interest that can reveal the genetic mutation, genetic disorders, and cancer signatures . This technology allows clinicians to conduct additional testing for genetic disorders, which allows for providing a better understanding of their genetic causes. It has a significant function in the context of targeted therapies in oncology because it defines certain genetic markers related to the disease's treatment process. It is expected that the continued decrease in the cost and time to undertake NGS will further improve the use of genomic testing in clinical practice.[17,18] Other emerging technologies include the CRISPR-Cas9 gene editing technology they are still at their early stages of influencing clinical laboratory science. While initially designed as a tool for researchers, the new directions for CRISPR include its use as a diagnostic tool and, oddly enough, as a treatment for the genetic disorders in question. Several laboratories are currently testing methods of using CRISPR for characterizing certain genomic variations with high sensitivity and specificity. Moreover, the advancement of gene-editing technologies such as CRISPR can create mega opportunities for laboratories to treat genetic diseases at the molecular level, there for making it one of the most promising clinical investigations in the realm of precision medicine.Artificial intelligence (AI) and Machine learning are now starting to become tools that are very useful to clinic laboratory scientists. It being the case that flow data is too large to be manually analyzed, advanced diagnostic platforms are utilizing AI to handle the algorithms. this including images or genomic data can be implemented, analysed and interpreted more efficiently and accurately by the system than their human counterparts. In radiology and pathology, the AI algorithm can distinguish minimally invasive biomarkers, such as tiny nodules, which may hint at worse diseases like cancer, thus aiding pathologists and clinicians make their diagnoses. AI is also improving the efficiency in a laboratory by streamlining tasks, predicting when equipment in a laboratory will need repair, and checking if the results produced by laboratories are within acceptable quality standards. The implementation of AI in clinical laboratories represents a factor that drives the improvement of timely, accurate and efficient diagnostic procedures.[19] equally revolutionary as AI in diagnostics is point-of-care testing (POCT) device. POCT devices help to make testing at or close to the patient, therefore obviating the relative or distant laboratories. These devices provide fast test outcomes, thus proving highly useful in acute care centres and where resources are limited. It shows that POCT is more and more utilized in chronic diseases including diabetes, cardiovascular diseases and infectious diseases for constant monitoring and early intervention. As more patients are diagnosed and treated with POCT devices the effectiveness of diagnostics is allowing for quicker decisions and beginning of treatment. [20]

Conclusion

The adoption of new technologies In the practice of clinical laboratory science is revolutionizing diagnostics In medicine. Advanced technologies like Next generation sequencing, CRISPR Cas9, Artificial intelligence, Point of care diagnostics, Micro fluidics are emerging in diagnostics and is making diagnosis quicker, affordable and accurate. They make laboratory work more efficient and are critically important to the creation of the use of pharmacogenomics or, in other words, the optimization of medication for individual patient's needs and benefits. As these technologies are advanced, they are expected more to transform clinical laboratory science and benefit the health care providers by giving them more effective tools to achieve improved patient's results. The continuous advancements of these technologies present promising future in the advancement of diagnostics by providing new techniques that will act as methods to early diagnose, prevent and enhance the health of the international health care systems.

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