RECENT TRENDS IN MEDICAL IMAGING - SHAPING THE FUTURE OF RADIOLOGY AND IMAGING

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Abstract- The primary goal of this article is to present a synopsis of future radiology trends and the potential effects of new technologies. Changes in radiology have resulted from a combination of new technologies and creative ideasIn addition to allowing radiologists to provide better imaging services to patients in less time, ongoing improvements in medical Technology have also helped decrease the incidence of stress among radiologists. Therefore, radiologists who want to make the most of these advantages should learn about the tools at their disposal and acquire the cutting-edge technologies and expertise that will allow them to maximise their potential. The Internet and the digitalisation of medical information are two significant developments that have played a crucial role in this change. We will look at the various forms of technological progress that are reshaping radiology worldwide.

Index Terms- Radiology, Imaging informatics, Extended Reality, Portable CT, Hybrid imaging, Artificial Intelligence, 3D Printing

I. INTRODUCTION

Radiology is the branch of medicine concerned with the use of radiological imaging in diagnosing and treating disorders of the human body. It uses imaging techniques that deal with ionising and non-ionising forms of energy. Radiology plays a crucial role in diagnosing and treating a wide range of illnesses. Radiologists are medical professionals who focus their careers on imaging diagnostics. In the past few decades, thanks to specific noteworthy shifts in computer and correspondence innovation, the boundaries of imaging informatics have been pushed beyond traditional limits. It has grown to become a crucial component of our market. The dissemination of radiological administrations has advanced significantly with innovations, such as the World Wide Web's remote accessibility and, more recently, the informal organisation's crucial development.[1] The Internet is indispensable when it comes to "e-Health," the electronic transmission and sharing of information on medical conditions and treatments.[1] There is a plethora of new e-Health options available right now. Electronic health record (EHR) is being implemented in many hospitals and medical centres to provide a continuous and comprehensive digital history of a patient's medical history.[2] Diagnostic and therapeutic imaging are the two subspecialties that make up the field of radiology.

Diagnostic Radiology & future developments

To keep up with the rest of medicine and modern scientific and technical developments, radiography must also become more interdisciplinary. Soon, this will increase the use of hybrid imaging techniques like PET/CT and sonography in a wide range of procedures, including interventional procedures conducted with robotics. In the long run, radiography and all other clinical controls will extensively use the atomic age and its many advantages. Customisation and foresight are on the way. The first signs of this change are appearing now. Genetic indicators are still in their infancy but have already altered treatment strategies for disorders like cystic fibrosis. The next decade and beyond will witness an even faster rate of imaging evolution as new understanding about metabolic processes is learned and tracers that reveal the mechanisms of metabolic processes are generated, improving our ability to gain and use new knowledge. These tracers are expected to be developed for PET/CT and future MR/PET technology, combining the benefits of newly found tracers with the benefits of endless MR imaging sequences and MR spectroscopy.[3] Combining genetic markers with molecular imaging has the potential to provide new, robust avenues for personalised therapy.

Interventional radiology & future developments

The field of interventional radiology is transitioning as it increasingly uses all available imaging tools for guidance, integrates them for improved accuracy, and applies them with various treatment advances.[4] Body and neurointerventional radiology will soon become a significant remedial instrument in body and cerebral oncology, providing minimal removal with an infusion of focused restorative specialists, all thanks to the precise guidance of ever-improved catheters and the expansion of atomic and hereditary markers. Image-guided therapies are expected to grow due to the presence of genetic markers in radiology.

Computer-Aided Design

One of the most recent developments in this field is the increasing use of computer-aided design and printing in medical imaging. They can create accurate replicas of inside body structures, useful for preoperative planning of complicated operations.

Cases can be explored in depth thanks to using this Technology to create digital medical images into three-dimensional prototypes. The examples are:

1. Custom-made prosthetics.
2. 3D development of surgical instruments.
3. 3D printed models that assist in surgery.

Advancement in Radiology

Soon, radiologists' ability to improve patient care has been dramatically expanded, and radiologists have finally realised their long-held aim of working in the centre of medical attention, where they can best serve patients and their fellow doctors.

Imaging procedures in medicine are crucial parts of the diagnostic process. Medical imaging, from ultrasounds to MRIs and CT scans, is crucial for radiologists in diagnosing and treating infections[5]. Specialists also use medical imaging advancements to determine whether or not a treatment has been successful in patients.

Medical imaging technology has made tremendous strides in its capabilities in recent decades. There have been several advances in medical imaging technology due to basic research and mechanical advancements. This development is crucial for making more accurate diagnoses and providing better patient care. In addition to advancing greater procedural efficiency in the planning and implementing of patient care, the intensity and computerisation of these advancements pave the way.[6] From massive data in medical imaging to the prospective implications of 3D imaging, here are four significant trends that portend the future of medical imaging technology.

Nuclear Imaging

Despite having several adverse side effects, radiation therapy has helped treat neurological diseases and tumours. Because of this, the demand for nuclear imaging is skyrocketing. Between 2016 and 2021, the market is forecast to expand by a compound annual rate of 10%.

There will likely be a rise in the number of imaging technologies and computer programmes used to diagnose cancer as the number of cancer patients increases worldwide. The most prevalent types of nuclear imaging gear are:

1. SPECT
2. PET

Noiseless and preoperative MRIs

As anyone who has undergone an MRI will attest, the experience is unpleasant. With the help of a "big magnet, radio waves, and a PC," magnetic resonance imaging (MRI) may provide a cross-sectional image of internal organs and structures at very high resolution.[7,8] The machines often look like large cylinders with a table within them. Traditional MRI scans, especially for patients with claustrophobia, have generated much anxiety. No one would willingly put up with the buzzing noises and feeling trapped. These days, MRI scanners can be found in "open" configurations that are less obstructive from all sides. Modern scanners, in contrast to their less sophisticated forebears, can easily accommodate users of all sizes.

As a next step, engineers at Japan's Railway Technical Research Institute have fashioned a superconducting magnet framework small enough to fit in the palm of a hand. Conventional MRI scanners are cumbersome and stationary due to the massive superconducting magnet required for operation. Flexible and transportable magnetic resonance imaging (MRI) machines may soon be a reality thanks to these new, modestly-sized magnets. These advancements in medical imaging are noteworthy because they allow for more thorough and efficient diagnoses while reducing patients' worry.

MRI

Recently developed improvements to MRI technology have been in the realm of software, even though it has been available for quite some time. In order to evaluate tissue's mechanical properties, researchers in several fields of non-invasive technologies are inventing new methods and tools.

Patients with liver disease can have their fibrosis and hepatic stiffness evaluated with the help of these apps. Elastography is one such method, as it is used to determine how rigid various body tissues are. It generates a visual map by fusing MRI images with sound waves.

Magnetic Resonance-Guided Ultrasound

It is a therapeutic method that uses ultrasonic pulses generated by an MRI to eliminate the desired tissue. Its most common use is in neurosurgery and treating neurological disorders like Parkinson's. The patient's core body temperature is continuously monitored using thermal imaging technology, and treatment is administered as needed.

Big Data and Analytics

Analytics in medical imaging has a great deal of promise for the future, which is to be expected given that big data is generally revolutionising social insurance. The University of Cincinnati academics said, "the consistent development of big data and data mining will give radiologic experts constant data during the imaging operation," leading to fewer errors and more individualised care.[9,10] Analytics, for instance, are frequently employed to identify patterns characteristic of a given ailment. Focused analysis of these examples in a modern image allows imaging calculations to infer measures, and the resulting scores can be used to support the radiologist's investigations and lead to more rapid, precise diagnoses.

Dhaval Shah and Prashanth Kollaikal of CitiusTech discuss the intriguing potential of big data in symptomatic imaging in an article published on ITN. Key performance indicators (KPIs) for the whole project can be gleaned from a wide range of pre-existing resources. Then, these Key Performance Indicators are used to fit the provider's needs, with consideration given to factors like clinical effectiveness, operational efficiency, and the comfort of the patients. Although these key performance indicators (KPIs) have been employed for streamlining for quite some time, the mechanical fitness of equipment, expanded modalities, improved programming frameworks, and mobile phones have easily been able to estimate and dramatically enhance efficiency.

3D Technology & Printing

Ultrasounds are widely used in the medical industry, although they have low resolution and can't take precise images. Using 3D Technology, ultrasound goals can be refined and patient care can be elevated. Better images can be created with 3D advancements in symptomatic radiology, leading to innovative outcomes. [11] As it turns out, scientists at UC Berkeley and the Universidad Autonoma de Madrid in Spain have been contemplating the consequences of using 3D metamaterial to achieve deep subwavelength imaging. Initial findings indicate that a factor 50 improvement in ultrasound aims is possible.

CareStream Health is an industry leader in advanced clinical arrangement and IT framework for healthcare insurance, and its experts have been looking into 3D imaging capabilities, particularly those of CT scans. Their OnSight 3D Extremity System "builds the intricacy of delicate tissue and reduces the permeability of metal curios compared with conventional CT photos." [12] Together, these advancements allow for precise 3D design and lead to a deeper understanding of patient health.

To better aid in diagnosis and communication with referring clinicians, there is a need for DICOM images to be rendered as 3D printed models that provide tactile input and palpable depth information regarding anatomical and pathologic states. With their long history of use in the arts and humanities, 3D-printed models are quickly gaining popularity in the medical field and among the general public. Particular difficulties, including training, materials and equipment, and guidelines, arise when 3D printing is used from pictures created and analysed by radiologists. The clinical benefits of establishing a 3D printing lab should outweigh the associated costs. The use of 3D-printed models created from DICOM images in surgical planning and implant fabrication is predicted to increase rapidly in the following years. It is recommended that all radiologists have a basic understanding of 3D printing and how it applies to their field, radiography, the clinical benefits of using 3D-printed anatomic models, and the various 3D printing technologies and materials that have been used to generate such models.

Digital 3D Mammography & Ultrasonography

The detection of breast cancer has changed with the introduction of digital 3D mammography. Digital mammography, which does away with the need for film and X-rays, offers a significantly higher level of detail than traditional methods while yielding results identical to those of traditional mammography. The New England Journal of Medicine reports that "digital mammograms are more productive than conventional ones,", especially for women with dense breast tissue, those nearing menopause, premenopausal women, and younger women under the age of 50. [13]

Digital breast tomosynthesis (DBT) is a series of images taken in succession to construct a three-dimensional representation of the breast. By separating the two images, radiologists can get a more detailed look at the individual tissues and make earlier disease diagnoses.[14] Thus, there were fewer needless corrections and inspections. Finally, eliminating radiation from mammography is being pursued in tandem with efforts to improve the diagnostic accuracy of digital mammography by incorporating ultrasound and magnetic resonance imaging techniques.

Clinical imaging has made tremendous strides in the past few decades, but it still has a ways to go. Ionic contamination is one of the risks associated with developing better healthcare equipment. Contamination is a barrier to therapeutic device development since it can distort outcomes and invalidate judgments. Pioneers in digital medical solutions are responsible for safeguarding medical equipment from abuse. The future of clinical imaging can be altered by establishing relevant recommendations, allowing these solutions to be made publicly available for the benefit of everybody.

Disruptive Innovations

The rapid development of new e-Health administrations is greatly influenced by the later prevalence of cell phones combined with the exponentially growing accessibility of portable applications. The field of radiology, where digital tools are integral to the daily workflow, stands to benefit significantly from the increasing availability of flexible computing equipment and software. In today's digital environment, where websites, mailing lists, and newsgroups have their roots, patients must be encouraged to share their health information with anybody who needs it quickly. These "problematic" developments are gradually replacing the current technical infrastructure. [15]

Redefining Future Radiology

More and more people are actively monitoring and managing their health, and social insurance providers are responding by developing new services to aid in this endeavour. Patients can have more say over who has access to their health information by creating a unique electronic key to share with their preferred health insurance provider. As more and more data can be collected from a wide variety of wearable devices and this data can potentially be mined via cloud-based tactics, the concept of personalised medicine is gaining traction. Patients' clinical actions and drugs will be individualised according to their anticipated infection responses. Radiogenomics, an emerging technology that combines morphologic data from clinical images with genomic information, will also make it possible to make such decisions.[16] More specifically, "radionics" refers to using new cloud-based profound learning procedures to transform radiological images into mineable data. "radiogenomics" describes linking radionics data with a patient's or disease's genomic (hereditary) information.

As our ability to collect data from a wide variety of wearable devices grows, so does our potential to mine this data using cloud-based methodologies, giving rise to personalised medicine. Patients are becoming more active in the process of monitoring and managing their health, and health care providers are responding by expanding patient-focused services. Patients can have more say over who has access to their medical records by having a unique electronic key created for them to share with the health insurance provider of their choice, which can significantly improve care. Clinical interventions and medications will be tailored to specific individuals based on their expected reactions to the infection. Such decisions may also be made via "radiogenomics," combining morphologic data from clinical images with genomic information.[15,16,17] "radiomics" refers to the automated morphologic analysis of radiological images using cutting-edge cloud-based profound learning methods that transform these images into mineable data. The term "radiogenomics" is commonly used to connect radiomics data with genomic (hereditary) information about a disease or patient.

Hybrid Imaging

Imaging techniques such as computed tomography (CT) and magnetic resonance imaging (MRI) provide for clear visualisation of morphologic features (size and form) in the scan. Nonetheless, it offers no insights into inflammation or proliferation.

Thus, doctors need both anatomic and functional data for a conclusive diagnosis. By combining multiple imaging methods, a more refined scan pattern is created that can more accurately pinpoint the source of the issue. As an example of their usefulness, hybrid pictures can be:

1. Planning surgical procedures
2. Second, directing both minimally and maximally invasive treatment strategies.
3. Keep an eye on how a patient is responding to treatment.

Artificial Intelligence (AI) and Machine Learning (ML)

Already existing machine learning technologies will soon allow AI to automate a few key areas.:

1. Mechanised picture division, injury identification, estimation, marking, and correlation with verifiable photographs. Presently being held in Chicago, this year's RSNA annual meeting is where this Technology first had its commercial debut. [18]
2. Making a radiological report: most radiology reports are written in exposition rather than in records; therefore, radiologists need to spend considerable time writing and transcribing to produce truthful and grammatically correct reports. Assembling a group of images using artificial intelligence is a far more difficult task. Natural language processing (NLP) and Natural language maturation (NGL) would assist alleviate this problem to a large extent by either enhancing the state-of-the-art Technology for discourse recognition or by generating reports from images already existing on the sweep.
3. Finding grammatical errors in reports: Natural language processing (NLP) might be useful for comprehending the content of a radiology report and getting a sense of the information the radiologist is trying to convey to the clinical staff. It might therefore function as a secondary per-user to alert the radiologist to possible semantic errors before finalising the report. The Mayo Clinic found that radiology reports generated using discourse recognition contained errors in 9.7 percent of cases, with 1.9 percent of those errors considered "material importance. [3,17,19]
4. Data mining for science: reliable radiology reports are stored in electronic health record systems worldwide, representing a veritable treasure trove of information. Using natural language processing (NLP), this data might be mined to create publicly accessible databases categorised by different disease-related features, thoughts, catchphrases, and estimations. This would allow for a robotised, modest, and prone to information input errors clinical study of all the data points needed to answer research hypotheses.[20]

Machine learning and artificial intelligence are constantly developing. For radiologists, the emergence of ML will be as transformative as the introduction of cross-sectional imaging. ML entails various formidable tools that can significantly boost the information extracted from pictures. However, a rigorous and systematic study is required before AI is included into ordinary clinical care. However, machine learning's astounding success in so many -human disciplines suggests that cautious optimism is warranted.[21]

Conclusion

Innovative IT, Imaging Informatics, PACS, Image analysis and representation, Precision Medicine, 3D Printing, Extended Reality, Digital Twins, Biocomputing, 5G, and the Internet of Things are just a few of the developing themes that will define the future of radiology. Persistent unrest is occurring, and it is what is driving the dramatic shift currently taking place in diagnostic imaging. Radiologists and IT professionals are beginning to create the future of radiology worldwide through complete integration and cooperation. If radiologists pay close enough attention to the continuing revolution in their field, they can take advantage of the new possibilities that arise and enhance the efficiency with which they deliver patient care.

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