SHORT REVIEW

Radiology and Imaging - Growing Leaps and Bounds with Possibilities Unlimited

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Since the simple beginning of non-invasive medical imaging more than a century ago when Wilhelm Roentgen invented the X-rays, till this date, the most advances in this important field of medicine have happened over the past few decades. As computational power of computers increased exponentially so did the clarity of medical images produced by various imaging modalities and their possible uses. Rapidly developing technology has placed exceptional tools at the disposal of radiology to produce immaculate images of the human body and the diseases which affect it.

The basic two-dimensional X-rays continue to be part of most medical workup. The changes seen in this modality are related to the speed of acquisition, ease of viewing, and transmission in soft copy format which gives us the ability to edit viewing parameters (images can be zoomed, contrast and brightness adjusted, easier measurements made, etc.) to squeeze out more information. In most of the modern centers the world over, there is no more darkroom film processing. The hard copy films viewed on backlit view boxes with limited ability to further manipulate images have been vastly replaced. These changes are made possible by the advent of computed radiography and the more expensive and newer digital radiography. These new technologies have given us the power to overcome the limitations of conventional radiography related to exposure with image post-processing. Digital analysis, storage, and transmission of acquired images have several obvious advantages and at the same time calls for stricter regulations to protect patient confidentiality.

Ultrasonography is usually the next widely used imaging modality due to its availability, real-time/dynamic image acquisition and viewing, safety (no ionizing radiation/X-rays used), and cost-effectiveness. This imaging modality is backbone as of today in obstetrics and non-invasive cardiac imaging. It is also widely used to image all parts of the body from solid organs, hollow viscera (endoscopic ultrasound can access virtually all tubes in the body from gastrointestinal tract, respiratory tract, and blood vessels to name a few), and superficial soft tissues to musculoskeletal structures. Limited penetration of cortical bone and poor conductivity through air remains its weakness. It can be used as a guidance tool for most of the surgical and non-surgical interventions and for tissue sampling. The greatly improved resolution of acquired images, ability to do so in real-time three dimensional (called 4D- four dimensional) along with developments in the use of micro-bubble contrast, and tissue elastography are the important newer developments. Fetal imaging is demanding and ultrasound technology has not failed to deliver. Detailed imaging allowing early detection of congenital anomalies has become possible with improved resolution of newer ultrasound systems.

Cross-sectional imaging using computed tomography (CT) and magnetic resonance imaging (MRI) entered mainstream radiology several decades ago and are today gold standards for most non-invasive diagnosis. These have seen phenomenal growth due to faster computing power and rapid improvements in image acquisition technologies. Images are acquired faster (some in single breath hold by patients) with better resolution and with lesser radiation (for CT, MRI does not use ionizing radiation). The huge volume of data produced per imaging study allows near seamless reconstruction of the imaged volume (in some cases the entire body) and its reconstruction in various planes. This helps in precision surgical planning and better understanding of the disease pathology. Storage of these massive amounts of data needs appropriate methods which are again widely available and portable. The transmission of large datasets

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also demands high bandwidth internet connectivity which is again steadily growing. Although most of the CT and MRI scanners continue to be very large, expensive to procure and operate, evolving technology has tried to address some of the issues. These include dedicated MRI scanners for musculoskeletal imaging which are smaller and tailored for specific use. With improvements in technology, we can expect greater portability of these equipments and more possibilities/uses with the images produced. 3 tesla MR scanners are commonly used nowadays which produce images of the brain with close resemblance to histological sections and thereby enable the study of diseases which were previously undetected when imaged on lower tesla machines.

Teleradiology is no longer a new entrant to how images are handled, and it has shown us over the past decade how productive and cost-effective this 'new avatar' (transformation) of radiology can be In Teleradiology there is spatial separation of the reporting radiologist from the location when a patient is imaged. So the most obvious advantage of telereporting in radiology is round the clock expert coverage. Since, the limitations of time zones and distances are virtually eliminated. From the economic perspective, teleradiology has been saving time and money for several health-care institutions around the globe. Internet is the backbone of this technology-driven radiology workflow. A simple example illustrating how Teleradiology can impact patient care would be as follows-A patient who undergoes an emergency CT scan to rule out brain injury or bleed following a road accident in the Americas on a late Saturday night will have his or her scan reported by radiologists sitting in Indian subcontinent during daytime within a span of <30 min and the report relayed to the treating physicians to administer appropriate care. The need to recruit expensive night cover radiologist in low-volume centers is taken care of by teleradiology. Similarly, in far-flung locations with limited medical specialties, teleradiology is the solution to this problem. Like all innovations, this new branch of radiology also has cautious opponents. Mobile telereporting is seeing its birth in today's increasingly mobile work environment. Software in cellular phones and tablet computers allow radiologist to view images virtually anywhere with adequate cellular coverage. These can be reported and send out again from anywhere. Can we say welcome to the mobile radiologist? Obviously, more improvements are needed and they are already happening.

Voice recognition is being widely adopted in all parts of our daily life and radiology is no exception. The final outcome or accomplished objective of any radiology investigation is a report by the reading radiologist which has steadily transformed from handwritten to type to soft copy digital reports of today. This component can be achieved by self-writing or having someone type or transcribe the report. Voice recognition software is an innovation which enables the computer to convert the dictated report by a radiologist to its digital format. Although it is not foolproof or completely devoid of errors, it does have a great potential and is the way forward at least in places where trained manpower is scarce and expensive.

All the above-mentioned developments in radiology can be essentially summed up as "technology-driven advancements leading to digitising radiology." This digitized form of radiology is read, stored, and transmitted using the picture archival and communication system (PACS) to be finally used by the end users, namely the treating doctors. The radiology information system and hospital information system work along with PACS to enable digitisation of all patient information. Several platforms are now in use which integrates all these different systems into one creating a giant database with seamless workflow allowing easy patient tracking and follow-up.

The latest buzzword is artificial intelligence (AI) and it has invaded radiology too! The use of computer-aided detection (CAD) has already been in use in radiology for some time. One of the examples is lesion detection in mammograms. There are several ongoing researches in the use of CAD for radiology reporting from lung nodule detection on CT scans to delineation of tumor size or volume of brain tissue involved in stroke to name a few. These will enable us to get more reproducible quantitative data for precise intervention and patient follow-up. With AI coming in huge databases are being collated in an attempt to teach computers "machine learn" and in turn help/aid radiologists with reporting. In the not so distant future, AI may even go a step further and give "preliminary" report itself in some subset of specific cases.This (machine generated reports instead of by the Human Radiologist) has obvious opponents and sceptics, both within the radiology community and intellectual society. However if these systems mature enough over time to become adopted as the main stream radiology work flow then the face of radiology will change forever. Only the pace of technological development can predict when and if this would happen.

Radiology is all about image presentation. 3D printing of radiology images is a new way to deliver radiology to help better surgical planning and for educational needs.

All said and done, radiology is essentially an indispensable arm of the physician which enables one to look into a patient with disease in the least invasive manner to enable correct treatment targeted to achieve desirable outcome. With developments and innovations constantly changing how radiology images are acquired, analyzed, and used, the need is to embrace this change with openness and caution because patient privacy and rights need to be addressed and protected through all these happenings. Although developments have been rapid, not all of them have stayed but only the most usable and economically viable ones. The important ingredient which drives change is need for improvement and this has to be fuelled by adequate funding. All sectors including health care have to balance these. Besides economic viability, newer health-care regulations which mandate basic minimum requirements of essential care have also forced change and improvements in radiology to ensure better patient care. Many of the developments which were considered fancy or luxury about a decade ago are routine in today's radiology practice. As they say, "change" is a journey, not a destination, and it is here to stay. Today as it stands - radiology is the branch of modern medicine at the forefront of rapid change and improvements.

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